BOSTON UNIVERSITY

COLLEGE OF FINE ARTS

Dissertation

AN EXAMINATION OF 7th-GRADE COMPOSERS' STRATEGIES AND PROCESSES AND THE COMPOSITIONS THEY CREATED USING MUSIC TECHNOLOGY IN A CONSTRUCTIONIST-ORIENTED LEARNING ENVIRONMENT

by

STEVEN P. DZIEKONSKI

B.M., Berklee College of Music, 1984
M.A., California State University, Northridge, 1992

Submitted in partial fulfillment of the

requirements for the degree of

Doctor of Musical Arts

2020

Approved by

First Reader ______________________________

Jay Dorfman, Ph.D.
Associate Professor of Music Education
Kent State University

Second Reader ______________________________

André de Quadros, Ed.D.
Professor of Music, Music Education

Third Reader ______________________________

Karin S. Hendricks, Ph.D.
Associate Professor of Music
Chair, Music Education

DEDICATION

This dissertation is dedicated to the memory of Dr. Susan Wharton Conkling, an inspiring scholar, music educator, and mentor.

ACKNOWLEDGMENTS

I would like to thank my dissertation supervisor, Dr. Jay Dorfman, for his unrelenting support, wise advice, and invaluable expertise throughout this process. Also, thank you to committee members Dr. André de Quadros and Dr. Karin Hendricks, for their valuable insight, supportive comments, and extended time.

Thank you to Dr. Martha Dreskin, Dr. Janet Robbins, and Dr. Sandra Nicolucci for their years of moral support and encouragement. Special appreciation goes to my husband, Raymond, who gave so much of himself to help me complete this dissertation. His love and inspiration made this journey possible.

AN EXAMINATION OF 7th-GRADE COMPOSERS' STRATEGIES AND PROCESSES AND THE COMPOSITIONS THEY CREATED USING MUSIC TECHNOLOGY IN A CONSTRUCTIONIST-ORIENTED LEARNING ENVIRONMENT

STEVEN P. DZIEKONSKI

Boston University College of Fine Arts, 2020

Major Professor: Jay Dorfman, Ph.D., Associate Professor of Music Education, Kent State University

ABSTRACT

The purpose of this study was to examine 7th-grade composers' strategies, processes, and perceptions, and the compositions they created using music technology in a constructionist-oriented learning environment. This embedded multiple case study examined the composition activities of eight 7th-grade students with varied musical backgrounds. During the 10-week data collection period, participants composed music using Hyperscore software underpinned by a constructionist-oriented theoretical framework. Hyperscore facilitates intuitive music composition and enables a composer to notate music with graphic notation without the need for understanding conventional music notation.

I found that novice composers with relatively little to no formal musical training or experience creating original music could produce compositions emulating the strategies of professional composers. I also concluded that participants relied on inspiration as do professional composers and were able to intuitively and successfully create compositions including multiple sonic elements with minimal guidance and

instruction. Participants exhibited evidence of thinking *in* and *about* sound.

Findings also alerted future music educators and researchers to the potential of graphic notation software such as Hyperscore to undermine thinking in sound because of its unique sketch-oriented design that might emphasize symbol (i.e., drawing) before sound. I found that technology effectively scaffolded two participants' processes. Contrastingly, in two cases and possibly more, results showed that participants might have benefited from more situated and responsive scaffolding by the instructor. My study also supported previous researchers' findings that a balance between freedoms and constraints is essential to a novice composer's success.

Participants expressed general skepticism of themselves as bona fide composers, a desire or need for more time to develop their compositions, and value of agency, originality, and prior experience. Participants conveyed that individual and collaborative composition processes each had advantages and disadvantages; however, overall, they preferred collaboration over individual work. Participants attempted to reconcile their knowledge of traditional notation with graphic notation and drew from prior instrumental experience, familiar music, and their previous compositions to develop their pieces. I also discussed the extent to which and how particular Papertian, Piagetian, and Vygotskian theoretical constructs revealed themselves in my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Historically, composition, which Paynter (2002) referred to as “making up music” (p. 224), has not been a widespread activity in the general music classroom, with listening and performing receiving greater emphasis (Webster, 2002b). Riley (2009) surveyed pre-service music teachers about implementing composition into their curricula and determined there is a desire to include composition but uncertainty surrounding how to do so. Similarly, Hickey (2012) contended that in-service and pre-service music educators tend to view music composition as a specialized field that requires years of focused education and practice. This perception of composition as an activity reserved for those with specific training as composers may help to explain its relatively obscure place in school music education compared with performing and listening activities.

John Cage (1961) contended that the dominance of traditional notation in Western music artificially elevates composers above other musicians. This perception of composing as an elitist activity reserved for ‘serious’ musicians may contribute to its relatively limited role in school music education. Various music education scholars have suggested that using non-traditional graphic notation or avoiding notation altogether may be a more effective way of engaging children in composition (Hickey, 2012; Kaschub & Smith, 2009; Louth, 2013; Wiggins, 2009). Learning traditional music notation can be overly abstract, complex, and time-consuming for students who possess minimal or no formal musical training, and this can be an obstacle when students must use this system to compose.

My study illuminated the processes and products of a particular group of 7th-grade composers as they created original music using non-traditional graphic notation software. Operating under the assumption that "young musicians learn to compose by composing" (Kaschub & Smith, 2009, p. 8), participants in this study engaged in the process of composition with technology rather than being taught how to compose. Also, I hoped to help music educators consider the role that music notation and composition with technology play within the general music classroom.

Problem Statement

Wiggins (2009) asserted that the primary objective of music learning should be to empower students with musical understanding that will result in musical proficiency and independence. It is in this spirit that well-intentioned music educators, already accustomed to working with traditional notation, may expect students to understand this arguably abstract system before learning to compose music (Berkley, 2001; Kaschub & Smith, 2009; Schiff, 2015). Such well-intentioned requirements may paradoxically hinder novice composers because "traditional notation can have limiting factors [that] can be found overwhelming" (Kaschub & Smith, 2009, p. 53) and counterproductive to learning.

The abstract symbols associated with Western music are difficult to comprehend for those who do not understand the concepts related to them. It might be advisable for children to delay learning traditional notation until "after they have established a strong base of prior experience with the concepts behind the ways in which musical ideas can be written down" (Wiggins, 2009, p. 43). Also, emphasizing notation at a young age might "discourage children's powerful and appropriate intuitive responsiveness…" (Bamberger, 2005, p. 145), thereby potentially hindering the creative process. Requiring students to use an abstract symbol system too early in their musical development process may also cause confusion or meaningless rote learning (Hickey, 2012).

Conversely, allowing novices to compose with nonstandard notation can make composition more accessible and successful for novices who want to preserve their compositions through notation (Emmons, 1998; Folkestad et al., 1998; Kaschub & Smith, 2009; Upitis, 1992). Furthermore, it has been asserted that notation should be used primarily as a memory tool for young composers (Carlin, 1998), which reflects the original purpose of music notation mostly as a mnemonic device (Louth, 2013). Much highly valued music in the world has been composed without notation, which makes the argument for learning notation before composition “rather feeble” (p. 145). After considering the potential pitfalls of using traditional notation prematurely with children, I was interested in examining the processes and products of 7th-grade composers in the *absence* of abstract standard notation.

Graphic notation as an alternative to standard notation was also a phenomenon of interest for me. Novice composers who utilized non-traditional graphic notation have exhibited more diverse strategies and produce more creative compositions than those who used traditional notation (Auh and Walker, 1999; Nelson, 2002). It has also been asserted that students of all ages benefit from composing with non-traditional notation (Auh, 2000; Bamberger, 2003, 2005; Barrett, 2002, 2006; Christensen, 1992; Daignault, 1996; Jennings, 2009; Parry-Jamieson, 2015; Rosenbaum, 2015; Stauffer, 2002) and that insisting on traditional notation may “inhibit musical exploration of sound and creative expression” (Nelson, 2002, p. 308). Influenced by the aforementioned scholars’ observations and assertions and operating under the assumption that novice composers can create music "that far exceeds their notational skills" (Kaschub & Smith, 2009, p. 109), I examined the processes and products of 7th-grade students who used computer software and non-traditional graphic notation to create original musical compositions.

Scholars outside the field of music education have expressed similar concerns about how educators sometimes expect students to grasp abstract content and warned educators about overvaluing abstract thinking. For example, Papert (1993) warned that a "perverse commitment to moving as quickly as possible from the concrete to the abstract results in spending minimal time where the most important work is to be done" (p. 143). Similarly, Ackermann (2004) emphasized the importance of giving learners the opportunity "to dwell into their creations" (p. 13) through experimentation, play, and reflection, which are often underutilized in education.

Piaget (1973) argued that mathematics educators should value "the principal operations spontaneously employed by the child" (p. 18) more than imparting abstract concepts through instruction. Papert, who expanded on Piagetian *constructivism* with *constructionism* (Papert & Harel, 1991), described Mathland as a place where students learn to be mathematicians rather than being taught how to *do* math (Papert, 1972a): "Being a mathematician, again like being a poet, or a composer or an engineer means doing [emphasis his], rather than knowing or understanding" (p. 1). I examined a *mathetic* (Papert, 1980a, 1993) constructionist environment in which participants experimented, played, and reflected—and experienced *doing* composition rather than being instructed to compose methodically.

Rationale for the Study

The above discussion about potential pitfalls associated with using traditional music notation could apply to numerous music learning contexts. For my study, I chose to place this tension within the context of 7th-grade participants' music composition activities based on my particular interest in expanding composition activities in my music classroom, and my interest in exploring how technology and non-traditional graphic notation might function as a composition tool for 21st-century learners. In the following section, I discuss the various rationale for designing and implementing this study of 7th-grader's composition strategies and processes.

Composition is one of the three fundamental ways that humans engage in musical activity (Upitis, 1992; Webster, 2002b), and the act of creating, which includes composition, is considered one of the core artistic processes in arts education (National Coalition for Core Arts Standards, 2013). Various music education scholars (e.g., Burnard & Younker, 2002; Hickey, 2003, 2012; Kaschub & Smith, 2009) have espoused the benefits of including composition in the music curriculum, advocated for further research on this topic, or suggested possible reasons why composition may be an underrepresented musical activity in the classroom. My study aimed to contribute to a growing body of literature suggesting that music researchers and educators believe composition (i.e., making up music) is a fundamental human activity (Hickey, 1995, 2013). Hopefully, this study helped to underscore composition as integral to a child's music education.

Including composition in the curriculum can “guide [music educators’] development of more appropriate educational goals and activities (Kratus, 1989), and could *increase* musical intelligence as well as the likelihood of creative achievement in general (Webster, 2013). Providing insight into what students do when they are asked to compose may help make composition a more effective and integral part of music teaching and learning (Wiggins, 2003), and studies such as mine could help expand music educators’ limited understanding of music composition teaching and learning.

Various researchers have asserted that many music educators lack experience with composition and consequently do not have enough confidence in their ability to include composition in the music curriculum (e.g., Barret, 2006; Kaschub and Smith, 2009, Kennedy, 2002; Hickey, 2012; Winters, 2012). In my study, the use of constructionist-oriented software explicitly designed for composers with no formal training in music aimed to shed light on an approach to composition that might help challenge the notion that “real composing is what other, specially talented people do” (Paynter, 2000, p. 25). My study also challenges the idea that children do not have the expertise required to compose music. Although children may not be ready to compose a symphony, “they can certainly engage in the process of creating original musical ideas” (Wiggins, 2002, p. 103).

I placed the tension associated with requiring students to use traditional notation within the context of “renewed attention toward teaching music composition in school music” (Hickey, 2013, p. 33). My own desire to include more composition activities in my music classroom inspired me to seek out non-traditional approaches to music composition teaching and learning. My study examined how novice composers experienced composition in a constructionist environment, one in which they used technology and graphic notation that circumvented the need to manipulate abstract musical symbols associated with traditional notation. I intended to illuminate and understand participants' composition processes and products emanating from a classroom that reflects Papert's (1999b) eight big ideas (link to Appendix A) behind a constructionist learning environment.

Theoretical Framework

While considering the most appropriate epistemological stance for an examination of novice composers' strategies and processes, it became apparent to me that a constructivist-oriented position aligned well with my study. Constructivist theorists all share a primary aim—to understand development. Despite their interest in relations between social factors and cognitive development, scholars tend to categorize and isolate theories. The result is often that similarities among theories may be disguised, and relationships among them ignored (Tudge and Winterhoff, 1993). The theoretical framework for my study underscores the importance of considering connections among constructivist theorists rather than isolating them (Cole & Wertsch, 1996; Salomon & Perkins, 1998). I was drawn to the ideas of three particular learning theorists whose principles fell within the realm of constructivism and resonated strongly with one another for this specific study: Papert, Piaget, and Vygotsky. The research questions for this study reflect various tenets of Papertian *constructionism,* Piagetian *cognitive constructivism,* and Vygotskian *social constructivism* relevant to my study.

An exhaustive discussion of the learning principles associated with Papert, Piaget, and Vygotsky is outside the scope of this dissertation; however, a combination of particular concepts associated with each of these educators provided the theoretical framework for this study. These concepts, discussed in further detail later in this chapter, include Papert's (1980, 1993, 1996) ideas of *instructionism, bricolage, hard fun, syntonic learning,* and *mathetics,* and Turkle and Papert's (1990, 1991) concept of *epistemological pluralism*. Also considered are the Piagetian cognitive constructivist ideas of *genetic epistemology* (Devries, 1997; Kitchener, 1980; Papert, 1980, 1999; Piaget, 1973; Shayer, 2003; von Glassersfeld, 1982, 1997) and *disequilibrium* (Ackermann, 1996, Kitchener, 1980; Piaget, 1997), which certain scholars have referred to as *socio-cognitive conflict* (Applefield, Huber, & Moallem, 2000; Kaschub, 1999; Lourenço, 2012; Tudge & Rogoff, 1989; Tudge & Winterhoff, 1993). The Vygotskian (1978) social constructivist concepts associated with my study are *interpsychological* and *intrapsychological* development, and *Zone of Proximal Development*. Also, I identified *metacognition* and Perkins' (1992) concept of *cognitive complexity* as complementary to Papertian, Piagetian, and Vygotskian ideas and relevant to my study. The following sections contextualize these concepts for this study and consider intersections among Piagetian, Vygotskian, and Papertian perspectives.

Intersections Among Papertian, Piagetian, and Vygotskian Perspectives

The following three sections consider Piagetian, Vygotskian, and Papertian perspectives in pairs. The purpose of the first section is to contextualize Piagetian and Vygotskian concepts that are particularly relevant to this study. In the second and third sections, I discuss how certain Papertian concepts relate to ideas set forth by Piaget and Vygotsky, respectively. My examination of these intersections strongly influenced the research questions, design, and methods adopted for my study.

Papertian and Piagetian perspectives. Papert, who personally studied with Piaget for five years in Geneva, formulated the idea of constructionism by combining his understanding of Piaget's cognitive constructivism with his own observations about how children learn (Papert, 1980a, 1993, 1996, 1999). Papert's seminal work, *Mindstorms* (1980a), contributed to the development of constructionism as put forth by him and his followers. The concept of a *microworld* comes from Papert, who described it as "a subset of reality" (1980b, p. 204). In a microworld, students program computers to help them learn to solve problems virtually and create public artifacts. Papert conceived of the microworld as an environment in which students focus on learning how to learn, not merely on learning how to master skills and content deemed important by an instructor. To Papert, "The kind of knowledge children need is the knowledge that will help them get more knowledge" (1993, p. 139). In a microworld, computers are students' *objects to think with*, which they "can make theirs for themselves and in their own ways" (1980a, p. 11). To Papert, objects to think with are essential in helping students learn how to learn. In my study, objects to think with were the graphic elements within the non-traditional music notation software that participants used while creating original music.

Papert's constructionism reflects Piaget's cognitive constructivism in the belief that children actively construct their own knowledge during interaction with their respective worlds (Papert, 1980a, 1980b, 1993, 1999). Ackermann (1996, 2001, 2007), a

Papert contemporary who also studied with Piaget, asserted that children construct knowledge by balancing stability and change, which Piaget referred to as negotiating *assimilation* (incorporating events and objects into existing mental structures) and *accommodation* (modifying existing knowledge structures to accommodate new information). According to Ackermann, “knowledge is experience, in the sense that it is actively constructed and reconstructed through direct interaction with the environment” (1996, p. 3).

Music educators sometimes associate constructivism and knowledge construction with Piaget’s learning stages of cognitive development (e.g., Swanwick & Tillman, 1986). However, my study specifically draws on Papert’s *adaptation* of Piaget’s stages of cognitive development. Piaget’s stages of cognitive development are commonly described as a gradual transformation from concrete to abstract thinking, with abstract thinking considered “the ultimate form of knowing” (Papert, 1993, p. 146.) Papert instead asserted that the different ways of knowing described by Piaget are “far more important than quibbling about whether they neatly follow one another chronologically” (p. 153). Furthermore, Papert (1993) distinguished himself from Piaget by saying:

> My perspective is more interventionist. My goals are education, not just understanding. So, in my own thinking I have placed a greater emphasis on two dimensions implicit but not elaborated in Piaget’s own work: an interest in intellectual structures that *could develop* [emphasis added] as opposed to those that actually at present do develop in the child, and the design of learning environments that are resonant with them. (p. 161)

As an alternative to a learning environment informed by Piaget's discrete stages, Turkle and Papert (1990, 1991) set forth the concept of *epistemological pluralism*, which they described as related to Piaget's (1973) concept of *genetic epistemology*, but differing on one important point: "Where [Piaget] saw diverse forms of knowledge in terms of stages to a finite end point of formal reason, we see different approaches to knowledge as styles, each equally valid on its own terms" (p. 129). Turkle and Papert (1990, 1991) contended that computers are ideal tools for supporting epistemological pluralism, which values informal concrete learning as much as formal, abstract thinking.

In Papert's (1993) view, "a methodology that will allow us to stay close to concrete situations" (p. 150) is essential. Papert went so far as to assert that Piaget "failed to recognize [concrete thinking as] not confined to the underdeveloped" (p. 151). Papert argued that even sophisticated learners rely on concrete thinking for complex problem-solving. It is also important to note that as much as Papert advocated for revaluation of the concrete, he did not underestimate the value of abstract reasoning. Rather, he advocated for learning experiences through which formal, abstract thinking is "on tap, not on top" (p. 146). I applied Turkle and Papert's (1990, 1991) concept of epistemological pluralism and their call for "revaluing the concrete" (p. 188) by examining novice composers' various ways of constructing knowledge while using constructionist-oriented, non-traditional graphic music notation software.

Piaget's constructivism holds that learners build knowledge structures regardless of the circumstances of the learning (Papert & Harel, 1991). Papert's constructionism adds to constructivism by emphasizing self-constructed knowledge that the learner develops and demonstrates by producing public artifacts. Papert and Harel contended that constructing self-knowledge “happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it’s a sandcastle on the beach or a theory of the universe” (p. 1). Also, Papert (1980) held that technology is a uniquely powerful tool for creating public artifacts and shifting the boundary separating concrete and formal thinking. In my study, the primary tool was non-traditional graphic notation software, and the public entities were musical compositions that participants created within a constructionist-oriented environment. The use of technology as a tool for “active, exploratory, student-directed learning” (Franz & Papert, 1988) is a central tenet of constructionism. Papert’s emphasis on creating public artifacts combined with Piaget’s constructivist ideas resides at the core of Papert’s constructionism approach to learning.

Papertian and Vygotskian perspectives. Papert’s idea of constructionism includes his belief that students learn more felicitously when they design and create public artifacts. Papert advocated creating such artifacts using the computer as a mediating tool. Similarly, Vygotsky (1978) discussed the significance of tools (e.g., language, writing, number systems) and their effect on child development. Vygotsky asserted that learning and development coincide; intellectual development is as reliant on mastery of tools as it is on maturation, and unity of both practical intelligence and mastery of tools comprise “the essence of complex human behavior” (p. 24). Vygotsky and Papert shared an emphasis on mediating tools and the view that learning is influenced by more than discrete developmental stages, making it apparent to me that Vygotskian *social constructivism* and Papertian *constructionism* are complementary. Duffy and

Cunningham (1996) asserted that Vygotsky proposed two mediational means: technical tools and semiotic tools. Furthermore, Duffy and Cunningham asserted, “The computer is a good example of a mediational means that has aspects of both tools and sign” (p. 11).

Vygotsky’s emphasis on the role of cultural artifacts such as tools and language and Papert’s emphasis on technology as a tool for producing public artifacts parallel one another (Ackermann, 2001). Papert was "interested in how learners engage in a conversation with their own or other people’s artifacts, and how these conversations boost self-directed learning, and ultimately facilitate the construction of new knowledge" (p. 1). Papert (1987) himself implicitly underscored the importance of Vygotsky’s idea of socio-cognitive development by contending that “everybody needs the help of other people and the support of a material environment, of a culture and society” (p. 13), thereby acknowledging that language and the computer are equally valuable mediating tools. Also, while advocating for the computer as a valuable tool for bringing about radically improved learning, Papert (1993) acknowledged the importance of “Vygotsky’s idea that conversation plays a crucial role in learning” (p. 15) and sometimes implicitly expressed a Vygotskian approach to learning. For example, when suggesting that education should resemble Brazilian samba schools in which experts and novices learn together, Papert (1980a) asserted:

> Thus, we are brought back to the necessity for the educator to be an anthropologist. Educational innovators must be aware that in order to be successful, they must be sensitive to what is happening in the surrounding culture

and use dynamic cultural trends as a medium to carry their educational interventions. (p. 181)

The notion of language and technology as equally valuable mediating tools supports my interpretation of Papertian and Vygotskian as complementary lenses. In my study, I was interested in examining novice composers' processes and products "as a total activity, of which some aspects could be influenced by the 'scaffolding' of a guiding adult, a helpful peer, or a probing researcher" (Harel, 1988, p. 32) in addition to their individual appropriation of mediating tools, and their unique thoughts, inventions, and constructions.

Various scholars have underscored the link between Papertian constructionism and Vygotskian social constructivism through their examination of novice composers individual and/or collaborative use of technology as "objects to think with" (Papert, 1980a, p. 11) within the context of a wider community (e.g., Duffy & Cunningham, 1996; Goldman, R., Black, J., Maxwell, J. W., Plass, J., & Keitges, M. J., 2012). These scholars either implicitly or explicitly implied a connection between Papertian constructionism and Vygotskian social constructivism. Various scholars outside the field of music education have also made connections between Papertian constructionism and Vygotskian social constructivism (Couturier, 2000; Goldman, Black, Maxwell, Plass, & Keitges, 2012; Harel, 1988; Mevarech & Kramarski, 1993; Shaw, 1995).

Piagetian and Vygotskian perspectives. Various scholars have debated intersections and divergences between Piagetian and Vygotskian tenets (Devries, 2000; Duncan 1995; Glassman, 1994; Lourenço, 2012; Shayer, 2003). Some of the main differences between Piaget and Vygotsky stem from their ideas about the primary cause for development and the way they conceptualized their theories; however, these differences are “more surface than systemic” (Glassman, 1994, p. 207). In spite of disagreements about the primary cause for development, Piaget and Vygotsky fundamentally agreed that there are two parts to development, ontogenetic, and socio-cultural (Glassman, 1994).

For my study, I aimed to create an environment in which individual development in the Piagetian sense and group dynamics in the Vygotskian sense interacted. Similarly, Shayer (2003) advocated for learning environments in which Vygotskian and Piagetian dynamics of development operate in tandem and found that the “range of mental development in any one-year group is far, far wider than anyone dreamed” (p. 468). In the Piagetian sense, such an environment enables all learners to make “revolutionary jumps in thinking” (p. 481) regardless of their individual levels of mental development. In the Vygotskian sense, the teacher “only intervenes to enhance group energy where it flags, or to drop the right question to induce cognitive conflict” (p. 483).

The research questions for my study reflect two of these resemblances in particular. First, Piaget and Vygotsky share a relational perspective on development, with both Piaget and Vygotsky affirming the importance of actual relations between individuals. Second, learning is a dialectical process, including the concepts of *assimilation* and *accommodation* associated with Piaget and *interpsychological* and *intrapsychological* development associated with Vygotsky. This aspect of my study was informed by Lourenço (2012) contended that although “Piaget’s approach is fundamentally-oriented toward an autonomous approach [and Vygotsky] appeals almost always to a heteronomous individual" (p. 284), there are at least seven particular resemblances between Piaget and Vygotsky that outweigh their differences.

Piaget is often said to have paid less attention to social influences than did Vygotsky (Tudge and Winterhoff, 1993). However, "Piaget's interest in biological foundations of development by no means precludes a concern with the role of the social world" (Tudge and Winterhoff, 1993, p. 62). For example, Piaget emphasized the importance of discussion between peers who bring different perspectives to a particular task, which he referred to as *disequilibrium*. Conversely, although Vygotsky paid more attention to social interaction than to individual development, and even criticized Piaget's contemporary position that children's development must precede learning (Tudge & Winterhoff, 1993), Vygotsky also acknowledged the existence of "two qualitatively different lines of development…, which are of biological origin, on the one hand, [and] of sociocultural origin, on the other" (Vygotsky, 1978, p. 46). Vygotsky contended that every function in a child's development appears twice, "first, between people (interpsychological), and then inside the child (intrapsychological)" (p. 56).

Piaget emphasized the importance of peer interaction and believed that discussion is more valuable for children and their peers than between adults and children. Vygotsky, however, contended that as long as one of the partners is more capable, interaction with either adults or peers can bring about cognitive growth (Lourenço, 2012; Rogoff, 1990; Tudge & Rogoff, 1998; Webster, 2011). According to Rogoff (1990), Piaget believed that cognitive restructuring required partners with a universal language and system of ideas and that adults are unlikely to influence thinking “because of the unequal power relations between adults and children” (p. 147). Vygotsky, on the other hand, believed that “ideal partners are not equal, but the inequality is in skills and understanding rather than power” (p. 148). My study was designed to facilitate both peer-peer and adult-child interaction, which underscored Piagetian and Vygotskian ideas alike.

Various distinctions notwithstanding, I noted two particular overarching common threads between Piagetian and Vygotskian, perspectives including the concept of knowledge as being constructed by the individual and the influence of social interaction on learning. Piaget and Vygotsky both described the learning process as “revolutionary rather than evolutionary [and] regarded the roles of the individual and the environment as inseparable” (Tudge & Rogoff, 1989, p. 18). Also, Piaget (1951) and Vygotsky (1978) described similar views on the role of play in learning that resonate with Papertian constructionism. After considering various scholars’ perspectives on Piagetian cognitive constructivism and Vygotskian social constructivism, I considered these complementary learning models, each of which resonates with Papert’s idea of constructionism.

Concept Dyads

My research questions for this study were inspired by and reflect particular principles of Papertian constructionism, Piagetian cognitive constructivism, and Vygotskian social constructivism. The following discussion defines certain theoretical concepts associated with these three learning frameworks and contextualizes them for this study. In my view, these theoretical concepts fall within three larger concept dyads: (a) constructionism-instructionism, (b) affect-cognition, and (c) concrete-abstract.

Constructionism-Instructionism. Papert (1993) defined *instructionism* as "belief that the route to better learning must be the improvement of instruction" (p. 139). Educators who embrace the principles of constructionism argue that a constructionist environment accommodates authentic learning (solving real-world problems) more effectively than an instructionist environment. This is not to say that instruction is unnecessary or inconsequential, but constructionists aim for a balance between direct instruction and *bricolage* (self-making, fixing, and improving mental constructions). Papert regularly discussed the tension between instructionism and constructionism in the field of mathematics education, and asserted, "the goal is to teach in such a way as to produce the most learning for the least teaching" (p. 139). Papert focused on the importance of providing students with time to use, think about, and play with mathematics, activities he claimed are underused in a predominantly instructionist environment. Also, Papert argued that technology is a powerful tool for facilitating bricolage, thinking, and play, which are fundamental to balancing constructionism and instructionism.

Bricolage and direct instruction. Lévi-Strauss (1962) likened the untrained mind to that of a bricoleur, who applies the "science of the concrete" (p. 11) and makes use of available, assorted tools to find one that will fit the problem at hand. Papert (1980a, 1993, 1996, 1997) integrated Lévi-Strauss's concept of bricolage into his work with children and conceived of bricolage as a metaphor for the old-fashioned traveling tinker who works with whatever tools they have at hand. Papert (1993) viewed bricolage as analogous to the student who solves problems in a heuristic manner and improves mental constructions along the way, without relying on direct instruction. In other words, bricolage is “an example of developing mathetic skill” (p. 144). Despite Papert’s metaphor of a traveling tinker, bricolage is not associated strictly with manipulating physical objects. According to Lévi-Strauss, the savage mind refers to sophisticated thinking that is possible regardless of any particular cognitive stage of development. This is similar to Bruner’s (1977) assertion that “any subject can be taught effectively in some intellectually honest form to any child at any stage of development” (p. 33). Constructionism aims to help learners at various stages of development interact with complex concepts through bricolage, rather than merely through direct instruction.

Scaffolding. For my study, I defined *scaffolding*, a concept articulated by Bruner and colleagues (Wood, Bruner, & Ross, 1976), as a process in which a more knowledgeable other (Ruthmann, 2006; Webster, 2011; Wiggins, 1994) *guides* a learner toward a personal objective rather than directly *instructs* a learner toward a well-defined end (Duffy & Cunningham, 1996). Although Vygotsky (1978) himself did not use the term *scaffolding* in his discussion of *Zone of Proximal Development* (ZPD), educators sometimes relate scaffolding and ZPD with one another. For example, Bruner and Haste (1987) associated scaffolding with ZPD when they described it as “the gap between what the child can currently do…and what she can achieve with intercession and scaffolding of adults or peers” (p. 6). Similarly, Duffy and Cunningham (1996) suggested that scaffolding functions as an interpsychological support system within ZPD by stating, “Success in the Zo-ped requires support for learning, and that support is called the scaffolding” (p. 15). It is also important to note ZPD involves creating conditions that will require the student to go beyond what they can currently do. To Vygotsky, “the only ‘good learning’ is that which is in advance of development” (1978, p. 89), and to educators such as Duffy and Cunningham, scaffolding promotes such good learning.

I expanded my definition of scaffolding based on Duffy and Cunningham (1996) and Wiggins and Medvinsky (2013) because their ideas of scaffolding resonate strongly with Papert’s concept of a *mathetic* environment, which is described further below. Scaffolding is a problematic metaphor because it “implies guiding…of the learner toward some well-defined (structural) end” (Duffy and Cunningham, 1996, p. 15). Duffy & Cunningham instead believed scaffolding “must be viewed as a learning environment—as supporting the growth of the learner” (p. 15) without determining a predefined structural end. Similarly, Wiggins and Medvinsky (2013) discussed collaborative learning and scaffolding within the context of music composition and advocated for approaching learning as “something the learner does rather than…something the teacher does *to* the learner” (Wiggins & Medvinsky, 2013, p. 111).

Mathetics. Papert (1993) developed the concept of *mathetics*, taken from the Greek máthēma meaning “that which is learnt” (“mathematic,” n.d.). Papert conceived of mathetics as the art of learning and being complementary to pedagogy, or the art of teaching. He described a mathetic culture in which children focus on learning rather than on being taught. Papert asserted that a mathetic environment is one in which a student takes something unfamiliar and relates it to something already known, and then makes something new by tinkering, playing, or building with it. Similarly, Piaget (1973) asserted, “To understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition" (p. 20). I attempted to establish a mathetic environment facilitating production and creativity for participants—one that regarded composition as a process that is "explorable and manipulable" (Papert, 1980, p. 129) rather than a formal instructional program.

Papert (1993, 1996) was careful to point out that constructionism does not devalue instruction. Instead, the goal of constructionism is to facilitate learning without overemphasizing direct instruction. Papert asserted that someone who becomes affectively involved with an area of knowledge could learn it without requiring explicit instruction. To Papert, a balance between instructionism and constructionism allows *epistemological pluralism* to flourish (Turkle & Papert, 1990). Similarly, Piaget (1973) discussed the distinction between encouraging children to construct knowledge and instructing them: "What is desired is that the teacher ceases being a lecturer, satisfied with transmitting ready-made solutions; his role should rather be that of a mentor stimulating initiative and research" (p. 16). Papert (1996) pointed out that computers are useful for both instructionist and constructionist approaches, but an overwhelming majority of educational computer use has been for "school-style learning" (p.47), which overvalues direct instruction. He contended that having children construct things *with* a computer rather than receiving instruction *from* a computer facilitates learning how to learn. The child should run the machine, not vice versa.

Affect-Cognition. A recurring theme in the literature on constructionism is its relation to learner affect and cognition. Meyer (1956) contended that affective experience is not the polar opposite of conscious cognition. Webster (2002b) pointed out that constructionists view affect as an essential aid to learning. Reimer (1989) asserted that humans experience music with “an intermingling of perceptual and affective cognitive processes, [and] it is becoming clearer that in art, affect functions cognitively” (p. 32). Likewise, Papert (1980a) discussed how his passion for learning and thinking about systems of automobile gears during his childhood was a critical affective experience, as important as the cognitive challenge of assimilating the abstract mathematical concepts associated with such systems.

Papert (1980a, 1993, 1996) emphasized the importance of affect within the context of mathematics education and constructionism and underscored the tendency of psychologists to set up a dialectical relationship between cognitive functions and “considerations of affect, of feeling, of sense of beauty” (1980a. p. 194). He developed the concept of *affective computing* as an expansion of Piaget’s concept of cognitive constructivism. Papert asserted that Piaget’s neglect of the affective aspects of learning “comes more from a modest sense that little is known about it than from an arrogant sense of its relevance” (1980a, p. vii). Papert combined Piaget’s concepts of assimilation and accommodation with his concept of affective computing to emphasize the importance of both cognition and affect. He described children who came to his Logo programming lab hating math but loving it by the end of their experience, which he partly attributed to integrating affective computing with cognitive challenges. Papert (1996) championed the computer as a way to change children’s relationships with topics about which they might otherwise see no personal connection. He advocated using the computer to “dissolve barriers to learning" (p. 24) by transforming learning from a primarily cognitive experience to a combination of cognitive and affective learning. Similarly, I was interested in examining to what extent using constructionist-oriented software, and a constructionist approach to composition might influence novice composers' affect.

Syntonic learning. Papert described another prominent feature of constructionist environments as *syntonic learning*. He borrowed this concept from clinical psychology to describe learning that contrasts with dissociated, conceptual learning (1980a), which he claimed is partly responsible for math-phobia. Papert theorized constructionism as facilitating both *ego-syntonic learning* (that which is coherent with children's sense of themselves as people with intentions, goals, desires, likes, and dislikes) and *body-syntonic learning* (that which is firmly related to children's sense and knowledge about their bodies). He frequently noted syntonicity while observing children learning to program computers and robots. In some of his earliest applications of constructionism, Papert regularly observed children using bodily motion and gestures to reflect actions they aimed to program for a robotic turtle using the LOGO computer language. Papert believed a student could understand (and predict and reason about) the turtle's motion by imagining what they would do if they were the turtle.

Papert's child programmers demonstrated body-syntonic reasoning, indicating a connected, affective response to their environment rather than a purely cognitive, dissociated relationship. To Papert, experiencing math in the extra-logical, affective sense is just as important as doing so in logical terms. I was interested in how body-syntonic reasoning such as moving, humming, and vocalizing manifested themselves in my study, and how ego-syntonic learning emanated from participants' expression of their intentions, likes, and dislikes while composing music.

Hard fun. Papert (1996) posited that microworlds could facilitate *hard fun*, which he believed to be "widely present in children's thinking" (p. 53). Hard fun is one of Papert's (1999b) eight big ideas behind a constructionist environment (see Appendix A). According to Papert, the best fun is hard fun, and learning is not merely enjoyable because it is easy (Stager, 2005). Papert's (1996) concept of hard fun resonates with Vygotsky's (1978) and Piaget's (1951, 1997) discussions of play. Vygotsky (1978) asserted, "Subjection to rules and renunciation of impulsive action constitute the path to maximum pleasure in play" (p. 104). The type of play to which Vygotsky referred is purposeful and includes rules and demands that lead to development: "In play, it is as though he [the learner] were a head taller than himself. As in the focus of a magnifying glass, play contains all developmental tendencies and is itself a major source of development" (Vygotsky, 1978, p. 102). To Vygotsky, it is inaccurate to think of play as an activity without purpose.

Play. Similarly, Piaget (1951) pointed out, in spite of the visions of great educators, play has been considered "pseudo-activity without functional significance, and even harmful to children, keeping them from their homework" (p. 151). However, Piaget himself saw play as a phenomenon leading to cognitive development—an activity particularly compatible with the process of assimilation. Piaget identified three forms of play—practice play, symbolic play, and play with rules (Nicolopoulou, 1993). In his discussion of play with rules, Piaget (1997) distinguished between play for ordinary pleasure from “that into which there enters an element of obligation” (p. 23). I interpreted Vygotsky’s and Piaget's ideas about purposeful play as complementary to Papert’s concept of *hard fun*.

Metacognition. Metacognition is also a fundamental tenet of constructionism, although scholars use various terms to describe a similar process. Papert famously asserted, “You can’t think seriously about thinking without thinking about thinking about something” (1980a, p. 10), and emphasized the importance of metacognition in the constructionist environment (1993, “Personal Thinking"). Although Piaget and Vygotsky did not use the term metacognition (Tarricone, 2011), various scholars have related certain Piagetian and Vygotskian concepts to metacognition. For example, scholars have discussed Piaget’s concept of reflective abstraction, which facilitates accommodation and cognitive structural changes through critical thinking, (Cobb, 1994; Fosnot, 2005; Von Glassersfeld, 1982, 1997). According to Cobb (1994), Piagetian reflective abstraction involves concretizing conceptual activity while engaging in cultural practices, often while interacting with others. In my study, the cultural practice is the act of “making up music” (Paynter, 2000, p. 25). Vygotsky (1978) asserted that cognitive development in children includes the transformation of external and egocentric speech into inner speech.

The gradual transition from interpersonal, communicative external speech to intrapersonal, reflective inner speech underscores Vygotsky’s assertion that “every function in the child’s cultural development appears twice…first *between* people (interpsychological) and then *inside* the child (intrapsychological) [emphases in original]” (p. 57). The capacity for inner speech is not achieved until adolescence (Fox &

Riconscente, 2008), at which point the next challenge is to apply such newly acquired metacognitive skills "to new concrete situations that must be viewed in these abstract terms—a kind of transfer usually mastered only toward the end of the adolescent period" (Vygotsky 1986, p. 142). In my study, 7th-grade students had the opportunity to practice metacognition by thinking aloud, listening to their compositions and reflecting, and engaging in dialogue and semi-structured interviews with peers and me.

Various educational psychologists and philosophers have underscored the significance of metacognition within the context of constructivism. Ackermann (1996) referred to *perspective-taking* as essential for negotiating disequilibrium and eventually arriving at accommodation. People need to "become their own observers, narrators, and critics…to reach deeper understanding" (p. 9). Perkins (1992) emphasized that an effective constructivist environment relies on engaging students in thinking about content and reflecting on their learning process. (p. 164). Gunstone (2000) asserted that constructivists have not yet sufficiently considered Dewey's (1910) concept of reflective thought, which Dewey defined as "active, persistent, and careful consideration of any belief or supposed form of knowledge" (p. 6). Dewey suggested that reflection inspires looking for evidence and facts to serve a purpose. Duffy and Cunningham (1996) preferred the term *reflexivity*, that is, to turn something back on itself. In a constructivist environment, "human reflection is the key to understanding and creating anew a world in which we coexist with others" (p. 13). Participant reflection on composition as both a process and a product was an integral part of my study.

Socio-cognitive conflict. Piaget discussed the role *disequilibrium* plays in cognitive development, a term which is sometimes referred to in the literature as *socio-cognitive conflict* (Applefield, Huber, & Moallem, 2000; Kaschub, 1999; Lourenço, 2012; Tudge & Rogoff, 1989; Tudge & Winterhoff, 1993). Socio-cognitive conflict in the Piagetian sense refers specifically to peer interaction and initial differences of perspective between peers. Socio-cognitive conflict consists of discussion in which children “see that there is a different perspective that may not easily fit into their own preexisting perspectives” (Tudge & Rogoff, 1989, p. 20). According to Piaget, socio-cognitive conflict is likely to be more productive when it occurs between peers, rather than between a child and an adult. The adult may be perceived by the child as an authority figure and not an equal learning partner, and cognitive growth may, therefore, be inhibited (Devries, 1997). I applied the concept of socio-cognitive conflict in a manner similar to Kaschub (1999), who adopted a Piagetian perspective in which “children share an equality and point of view that does not exist in an adult-child relationship” (p. 32) and are therefore more likely to interact as equals, experiment with new ideas, and question each other.

Cognitive complexity. A common criticism of constructionism is its association with counterproductive *cognitive complexity*. Dick (1992) contended that constructivists are apparently "not concerned that the gap will be too great between the schema of some students and the tools and information that they are provided” (p. 96). Perkins (1992) was struck by how little attention has been paid to constructivism as learners experience it, particularly in terms of cognitive load, and suggested a *conflict-deferred* approach, fine-tuned scaffolding, and increased metacognition as possible solutions. Kirschner, Sweller,

& Clark (2006) asserted that a constructivist environment could be "highly complex [and] may generate a heavy working memory load that is detrimental to learning" (p. 80). Kirschner et al. contended that heavy working memory load is particularly problematic in the case of novice learners who lack proper schema to integrate new information with prior knowledge. They suggested that novice learners need more guided instruction than a constructivist environment typically provides.

Concrete-Abstract. Piaget's idea of learning as a gradual transformation from concrete to abstract thinking has been contrasted with Papertian constructionism that holds concrete and abstract thinking as equal partners in a dynamic relationship (Ackermann, 2001): "Papert's approach reminds us that…concrete thinking is no less important than figuring out things 'in the head'" (p. 7). Relatedly, Turkle and Papert (1990, 1991) elaborated on the process of negotiating the concrete and abstract, which they referred to as *epistemological pluralism.* Built on Piaget's concept of *genetic epistemology* (Kitchener, 1980; von Glassersfeld, 1982, 1997; Papert, 1980; Turkle & Papert, 1990), epistemological pluralism holds that concrete and abstract thinking, and all gradations in between, are equally valid ways of knowing. This is an alternative to the Piagetian idea of formal, abstract thinking as the ultimate way of knowing the world. According to Ackermann (2001), although both Piaget and Papert viewed children as builders of individual cognitive schema, they differ in their views of children as explorers. Piaget's explorer is an "inner-driven, very curious, and independent character," whereas Papert's explorer is "more relational and likes to get in tune with others and with situations" (p. 9). Similarly, Dewey (1910) suggested that schools are more devoted to abstract thinking, thus doing injustice to the majority of pupils. Turkle and Papert's (1990, 1991) concept of epistemological pluralism challenges the often-assumed dichotomous relationship between concrete and conceptual thinking.

"A person's development is not a smooth, incremental progression from concrete to abstract, from fusion to separation, from connectedness to autonomy" (Ackermann, 1996, p. 3). Ackerman described a metaphorical dance of diving in and stepping out as a way to negotiate the transition from Piagetian assimilation to accommodation. Ackermann presented assimilation and accommodation as analogous to stability and change and asserted a learner cannot maintain balance throughout this metaphorical dance if they remain wholly immersed in their process at all times.

Papert (1993) fervently discussed balancing the abstract and concrete. As a mathematician who admittedly took pleasure in the power and "marvels of abstract reasoning" (p. 146), Papert just as passionately advocated for revaluation of the concrete and being on the lookout for "insidious forms of abstractness" (p. 146). Placing the preceding discussion within the context of learning to make music within a constructionist environment, I proceeded on the assumption that the novice composer needs sufficient time to work concretely using objects to think with, reflect on the composition process both intra- and interpsychologically, and dive back into making music.

The Distinction Between Constructionism and Constructivism

Papert and Harel (1991) distinguished constructionism from Piagetian constructivism by explaining:

> Constructionism…shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe. (p. 1)

A major difference between constructionism and constructivism lies in how constructivism overlooks the role of manipulating media (Ackermann, 2001). Also, constructionism shifts from universal ideas about learning to individualized learning using "objects to think with" (p. 4) such as computers. Constructivism holds that the building of knowledge structures occurs in one's head, but constructionism is "the best way to ensure that such intellectual structures form…through the active construction of something outside of one's head, that is something tangible, something shareable" (Stager, 2005, p. 2).

Various music education scholars have aimed to contextualize constructivism and constructionism within the music learning process (e.g., Bamberger, 2003, 2005; Downton, 2015; Jennings, 2005; Rosenbaum, 2015; Webster, 2011; Wiggins, 2009). According to Webster, scholars both in and outside of music education often treat constructivism and constructionism with little distinction and frequently use the terms interchangeably (P. Webster, personal communication, June 16, 2014). Webster (2011) defined four primary tenets of constructivism: (a) knowledge is formed through active interaction with the world, (b) knowledge exists less as external abstract artifacts to be absorbed, and more through active construction, (c) meaning is constructed with this knowledge, (d) learning is, in large part, a social activity. With the exception of Papert's added emphasis on using technology as building material, Webster's characterization of constructivism is consistent with Papert's (1999b) description of a constructionist setting (see Appendix A).

Papert and his colleagues (Papert, 1980a, 1999; Papert & Harel, 1991; Turkle & Papert, 1990) frequently discussed Piaget's cognitive constructivism and its influence on, as well as distinctions from constructionism. Also, although Papert himself rarely referenced Vygotsky in the literature, various other scholars have either implicitly or explicitly linked Vygotskian perspectives with Papert's view of the computer as a mediating tool (Duffy & Cunningham, 1996; Goldman, R., Black, J., Maxwell, J. W., Plass, J., & Keitges, M. J., 2012). Numerous scholars from various disciplines have elaborated on resemblances and distinctions among Piagetian cognitive constructivism, Vygotskian social constructivism, and Papertian constructionism. The theoretical underpinning for my study considers these as three complementary approaches to learning rather than separate lenses, and the research questions for this study focus on theoretical concepts identified as particularly relevant to this examination of 7th-grade composers' processes and products.

Purpose of the Study and Research Questions

The purpose of this study was to examine 7th-grade composers' strategies, processes, and perceptions, and the compositions they created using music technology in a constructionist-oriented learning environment. The research questions for this study were:

- What composition strategies and processes do participants display or express while composing music within this constructionist-oriented environment?
- What are the participants' displayed or expressed responses to the composition process and the compositions they created within this constructionist-oriented environment?
- To what extent and in what ways do the affect-cognition, constructionism-instructionism, and concrete-abstract concept dyads manifest themselves within participants' composition processes?

Overview of Design and Data Collection Methods

Embedded Multiple Case Study Design

I applied an embedded multiple case study design as described by Yin (2009, 2015). Sources of data in this study include videoed observations, videoed think-alouds, (Burnard & Younker, 2002; Ericsson & Simon, 1993; Carlin, 1998; Jonassen, 1999; Kosak, 2014; Papert, 1980a, Younker, 1997), screen-captured composing activity (Seddon & O'Neill, 2003), video-stimulated recalls (Erickson, 2006; Kosak, 2014; Pirie, 1996; Smith, 2004), and semi-structured interviews with participants (Miles, Huberman, & Saldaña, 2013; Merriam, 2014). Also, I compiled field notes related to each composition session, which helped integrate my observer as participant perspective (Merriam, 2014, p. 124).

Participants and Setting

I selected eight participants from a population of 68 7th-grade students in a West Coast, independent, college preparatory school. The chosen site's daily schedule allowed participants to compose for 40 minutes once or twice weekly for 10 weeks. Before the 10-week study began, I briefly instructed participants how to navigate the tools provided within Hyperscore (Farbood & Pasztor, 2004). During the 10-week data collection phase, each participant composed both individually and collaboratively. Consistent with previous researchers' designs (e.g., Bamberger, 2003; Hickey, 1995), there were no time limits or specific guidelines imposed within the 10-week scope of the study.

Data Collection Methods

Data for research question one were collected and analyzed by focusing on a subset of four participants. Data for research questions two and three were collected and analyzed by taking into account all eight participants' composing activities and products. Data included videoed observations, screen-captured activity, think-aloud data, semi-structured interviews, and my field notes. In my role as observer as participant, I "observe[d] and interact[ed] closely enough with members to establish an insider's identity without participating in those activities constituting the core of group membership" (Merriam, 2014, p. 124). I did not engage in music composition; however, I offered participants help as needed and encouraged participants to talk with each other and answer questions I posed. Participants' screen-captured composing activities and think-aloud data helped me make inferences about their strategies, processes, their response to the process and their compositions, and manifestations of the three concepts dyads derived from the theoretical framework.

Limitations of the Study

This study is an examination of the composition processes and products of eight 7th-grade participants chosen through purposeful sampling from a population of 68 students in one particular West Coast, college preparatory, independent school. Demographically speaking, the school is predominantly white, ranging from upper-middle to upper class, and suburban. I am aware that similar studies within different contexts would likely produce different results, and I did not attempt to generalize results from this study to other populations. However, this does not preclude the possibility that results from this study may resonate with other similar situations, settings, or populations.

I limited participants to using one particular software program chosen for its distinctly constructionist-oriented nature. Hyperscore (Farbood & Pastor, 2004) is graphic music notation software developed at Massachusetts Institute of Technology (MIT) Media Lab and, in the Papertian sense, provides novice composers "objects to think with." Hyperscore limitations included the relatively small number and low quality of timbres available to users. The software incorporates 128 general musical instrument digital interface (MIDI) timbres, which sound particularly synthetic. The ability to make tempo and dynamic changes is minimal. Despite the limitations associated with Hyperscore, I chose this particular software because of its inextricable link to the constructionism learning approach. I made no claim that the results of this study would be similar if participants had used other graphic notation software or technology. In short, the use of Hyperscore itself may have precipitated specific results.

Other than considering participants' experience with private music lessons and creating original music outside of school, there was no attempt to ascertain participants' other types of formal or informal musical training (e.g., 'garage band' experience, music theory study, use of digital audio software). The choice to include private music lessons and creating original music outside of school as factors in the purposeful sampling process emanated from my particular curiosity about how these experiences (or lack of) might manifest themselves within this constructionist-oriented composition environment, especially considering Hyperscore was designed particularly for novice composers with limited or no musical training.

The theoretical concept dyads on which the third research question focused are solely a reflection of my relative level of curiosity about particular theoretical tenets as I researched the literature on constructionism, cognitive constructivism, and social constructivism. Many other constructionism-oriented concepts could have been selected for this study. However, those delineated in the third research question resonated with me strongly as I reflected on these learning approaches and their potential implications for music education. I did not claim that these particular concepts collectively epitomize Piagetian constructivism, Vygotskian social constructivism, or Papertian constructionism, respectively, or as a group.

Although embedded multiple case studies provide the opportunity to wholly examine several participants' processes and products within the same context, they typically produce extensive and diverse data that is challenging to winnow and manage. This study generated a large amount of data, including over 80 hours of classroom video and screen-capture video, researcher field notes, and participant interviews. In multiple case studies, the researcher encounters many considerations when deciding which data to include for analysis. At best, the final report in this embedded multiple case study is a vivid snapshot taken from a larger scenario, interpreted by me as the single observer.

Trustworthiness

Internal Validity

Creswell (2012) delineated eight validation procedures and recommended that researchers engage in at least two of these. My analysis process utilized six of Creswell's recommended procedures: clarifying researcher bias, triangulation, prolonged engagement with persistent observation, member checking, peer-review, and negative case analysis, or discrepant evidence. The rigorous application of the constant comparison method (Harding, 2018; Merriam, 2014) also enhanced validity. In addition, including multiple participants' viewpoints in this study resonated with Richardson and Whitaker's (1994) concept of crystallization. I will elaborate further on these procedures in Chapter 3.

Reliability

I adopted Merriam's (2014) and Creswell's (2013) definitions of reliability for qualitative research, which focus on consistency and dependability rather than replicability. To Merriam, the goal is not to ensure that circumstances can happen twice, "but whether the results are consistent and dependable within the data collected" (p. 221). The multiple methods of data collection, triangulation, prolonged engagement, and constant comparison method employed in my study helped to make data analysis consistent and dependable. To Creswell, dependability is established through the auditing of the research process, which requires a clear audit trail. Yin (2009), Merriam, and Creswell discussed the importance of increasing reliability by creating a data trail delineating all research activities. Therefore, I maintained a detailed account of all research decisions and procedures, which described how data were collected and analyzed. I integrated this chain of evidence with video data and researcher notes using NVivo (Version 12, 2018) qualitative data analysis software. Dillon (2001) also suggested procedures for maintaining a data trail, which I consulted for guidance.

Generalizability

As stated earlier, I am aware that similar studies within different contexts would likely produce different results and did not attempt to generalize results from this study to other populations. However, this does not preclude the possibility that results from this study may resonate with other similar situations, settings, or populations. Merriam (2014) contended that including multiple cases enhances external validity and asserted, “It is the reader, not the researcher, who determines what can apply to his or her context” (p. 51).

Miles, Huberman, and Saldaña (2013) contended that conducting cross-case analyses such as those in my study could enhance transferability to other settings. Other music researchers have established cross-case analysis as an effective way of enhancing generalizability (e.g., Burnard & Younker, 2004; Emmons, 1998; Kosak, 2014). Yin (2012) claimed that *analytic generalization* could be as valuable as statistical generalization, with its emphasis on “using a study’s theoretical framework to establish a logic that might be applicable to other situations” (“Generalizing from Case Studies,” para. 3). Similarly, Burnard and Younker (2004) contended that their claims emanated from theoretical inference and are not meant to be overstated or widely generalizable. Likewise, the research questions for my study were meant to facilitate theoretical deduction, not wide generalization.

Chapter Summary

This chapter presented the problem statement, and the rationale, theoretical framework, purpose, and research questions for my study. I discussed how some well-intentioned music educators emphasize understanding of traditional abstract notation as requisite knowledge for engaging in composition, which could be a misguided approach (Berkley, 2001; Kaschub & Smith, 2009; Schiff; 2015). I was particularly interested in using technology and graphic or non-traditional notation to make composition more accessible to novice composers. This interest resonated with several previous scholars' application of technology (e.g., Dammers, 2010; Nelson, 2007; Ruthmann, 2006; Tobias, 2010) or non-traditional notation (e.g., Auh, 2000; Bamberger, 2003, 2005; Barrett, 2002, 2006; Christensen, 1992; Daignault, 1996; Jennings, 2009; Parry-Jamieson, 2015; Rosenbaum, 2015; Stauffer, 2002) as composition tools for novice composers.

I described the theoretical framework of the study as an amalgam of Papertian constructionism, Piagetian cognitive constructivism, and Vygotskian social constructivism, and included a detailed discussion of intersections and divergences among ideas set forth by Papert, Piaget, and Vygotsky. I identified the purpose of this study, which was to examine 7th-grade composers' strategies and processes, their response to the process and their products, and the compositions they created using music technology in a constructionist-oriented learning environment. The three research questions emanating from the purpose of this study focused on my investigation of participants' composition strategies and processes, analysis of participants' displayed or expressed responses to the composition process and the compositions they created, and examination of how the three concept dyads discussed in this chapter manifested themselves in my study.

CHAPTER 2: REVIEW OF RELATED LITERATURE

The literature reviewed in this chapter informed my study from three broad perspectives, which are reflected by the three sections in this chapter. First, I cite studies within and outside the field of music education underpinned or influenced by constructionist-oriented theoretical concepts. Studies cited in the first section of this chapter inspired my interest in constructionism as a framework for this particular study and helped to inform the design, data collection, and analysis aspects of this study.

Second, because the constructionist approach to composition applied in this study incorporated software that enabled participants to compose with non-traditional graphic notation, I was interested in examining previous research that incorporated graphic or invented music notation as a mediating tool (Duffy & Cunningham, 1996; Goldman, R., Black, J., Maxwell, J. W., Plass, J., & Keitges, M. J., 2012) in the composition process. Therefore, in the second section of this chapter, I discuss previous studies that examined graphic or invented systems of music notation.

The third section of this chapter focuses on studies that examined novice composers' composition processes and products. Previous research of such processes and products informed the design and data collection methods for this study.

Constructionist-Oriented Studies

The theoretical underpinning of this present study is an amalgam of Papertian constructionism, Piagetian cognitive constructivism, and Vygotskian social constructivism. For the remainder of this dissertation, I use the term *constructionism* to represent the combination of theoretical concepts that frame my study. Constructionism in the Papertian sense is often associated with learning environments and research studies outside the field of music education, such as mathematics and science education. However, I was interested in how Papert's concept of Mathland, which consists of an environment where students learn to be mathematicians rather than being taught *how* to do math, might manifest itself within a music classroom where students learn to be composers rather than being taught *how* to compose.

Constructionist-Oriented Studies Outside of Music Education

By first reviewing literature outside the field of music education, I aimed to identify ways in which constructionism might underpin this study of novice composers. Also, I was interested in looking for problems addressed in mathematics and science education research that paralleled the problem of overemphasis on abstract musical notation and the rationale for contextualizing this study within music composition activities. After examining constructionist-oriented literature outside of music education, I looked for applications of constructionism within music education, specifically within the context of composition, which had the potential to inform the design and methods used in my study.

Studies completed under Papert's supervision. Three studies reviewed in this chapter (Harel, 1988; Shaw, 1995; Stager, 2005) were completed under Papert's supervision and informed my study in various ways. Because I was significantly influenced by Papert's concept of Mathland and how it may apply to music education, I reviewed these studies to further inform my vision of a constructionist-oriented learning atmosphere. The following three studies not only informed the conceptual framework of my study, but influenced the research questions, design, and methods as well.

In a case study examining the daily learning experiences of 4th-grade computer programmers in a distinctly constructionist setting, Harel (1988) asserted that learning environments need to foster an understanding of concepts and skills by exercising them in complex contexts, and by asking learners to teach others about them. Harel concluded that students in the experimental group became far better programmers than those in the control groups who learned fractions and Logo programming in a traditional classroom setting. Also, students in the experimental group improved their scores on the fractions post-test by twice as much as one control group and two-and-a-half times greater than the second control group. Harel found that an interesting mixture of Piagetian and Vygotskian processes, and Papert’s and Perkins’s perspectives emerged. Harel noted that students who worked side-by-side on a common project over a long period in a constructionist setting were strongly motivated.

The purpose of Stager’s (2005) study under Papert’s supervision was to engage learning disabled youth in technology-rich, personally meaningful projects using concepts from math, science, computer science, engineering, and the arts. Stager observed that long-term, routine use of computers and technology-enabled participants to engage in serious intellectual work, and experience feelings associated with being mathematicians, scientists, engineers, and filmmakers. Stager found that participants in this qualitative study developed a sense of personal power, potential, and intellect required to meet a wide range of challenges. Stager also asserted that constructionism is a viable theoretical framework for designing productive learning environments not only for at-risk teens but for the broader learning community.

Applying a framework he referred to as *social constructionism*, Shaw (1995) implemented a combination of Papertian *constructionism* and Vygotskian *social constructivism,* to a study in which he created a computer network to improve communication within an inner-city neighborhood. Shaw's premise was that building meaningful relationships within an inner-city community depended on the interplay between one's cognitive constructs and the social constructs shared by the community. Shaw designed a computer networking system based on constructionism principles and included technology as a tool for helping members of a low-income urban community become interdependent and active participants who shaped their social setting. As a result, 11 different neighborhood projects developed, such as a summer jobs program for neighborhood teenagers, a crime watch program, and a food cooperative. Similar to Harel (1988), Shaw found tenets of both Papertian constructionism and Vygotskian social constructivism to be appropriate for underpinning his study.

Studies involving computer programming. Three studies I reviewed outside of music education applied a constructionist framework within the context of a computer programming environment (Baytak, 2009; Boyer, 2010; 2014; Kafai, 1996). Although my study does not involve computer programming, the five studies cited herein provided me with models for establishing a constructionist-oriented environment in which participants used computers to create personally meaningful artifacts. Similarly, the novice composers involved in my study created artifacts in the form of musical compositions, which paralleled the computer programs created by the young mathematicians in the studies discussed herein.

During a study in which 4^{th}-grade students designed educational computer programs for use by younger children, Kafai (1996) explicitly applied a Papertian constructionist theoretical framework. Kafai's study is similar to Harel's (1988) in which participants designed software to teach fractions to others. The primary difference between their two studies is in the research design. Harel used a combination of quantitative and qualitative methods, whereas Kafai's study was strictly qualitative. Kafai noted two kinds of development, one incremental in terms of coding ability, and the other was in shifts in approach to the overall design of games. Participants learned how to adjust their design expectations to realistic timelines and available skill sets. Kafai's starting assumption that some participants would be planners and others would be bricoleurs was confirmed through her observations. Kafai concluded that game design allowed children with various thinking and learning styles to express themselves and that an extended period for a constructionist-oriented project is essential to students' development.

In a multiple case study in which 5th-grade students used the Scratch programming language to design computer games for younger students, Baytak focused on how learners constructed games that reflect science content understanding. Baytak's study is similar to Harel's (1988) and Kafai's (1996) studies because of their mutual interest in how a constructionist environment might influence skill development and content mastery. Baytak's (2009) theoretical framework was similar to Harel's (1998), which he described as a combination of internal, constructivist Piagetian concepts combined with external, constructionist Papertian concepts. Baytak (2009) also asserted that game design appeared to be an effective means for students to take ownership of their learning, promotes community engagement, fosters conceptual knowledge of science and programming, and encourages learners to reformulate understanding.

In another study in which participants used the Scratch programming language to apply their understanding of mathematical concepts, Boyer (2010), similar to Baytak (2009), Harel (1988), and Kafai (1996), was interested in participants' content mastery and skill development over time. Boyer applied a constructionist theoretical framework as he examined fifth-grade students' understanding of geometric solids while they used the Scratch programming language. Boyer's (2010) conclusions indicated that no increases in content learning were identified; yet, Boyer asserted that this approach might be a useful alternative form of assessment. Boyer concluded that using Scratch leads to mixed results in terms of students' ability to display content mastery, depending on the learning preferences of the individual.

Summary of constructionist-oriented studies outside of music education. The studies reviewed outside of music education provided a model for the type of constructionist laboratory that I envisioned for my study, one in which participants engaged in music composition rather than receiving direct instruction. A prevalent theme among these studies is the importance of participants creating personally meaningful artifacts, which is also a significant component of the theoretical framework applied to my study in which participants were encouraged to create music that sounded good and was pleasing to them personally. Also, this study is similar to those reviewed outside of music education with its focus on the processes and strategies participants displayed and expressed while constructing personally meaningful artifacts. The primary contrast between the studies discussed above and mine is in the assessment of participants' content knowledge and skills. In this study, I did not attempt to assess whether or not participants' content knowledge or skill level increased or improved over time.

Constructionist-Oriented Studies within Music Education

Papertian constructionism is a conceptual framework that may be associated more often with research in the fields of mathematics and science education than music education. However, because I was interested in constructionism and its application to music education, I reviewed a number of music education studies that either explicitly applied Papert's constructionist ideas or applied various tenets of Papertian constructionism, Piagetian cognitive constructivism, or Vygotskian social constructivism.

Studies closely associated with Papertian constructionism. In this section, I reviewed six particular studies that were influenced by Papert's ideas about learning and his emphasis on using the computer as a mediating tool (Duffy & Cunningham, 1996; Goldman, R., Black, J., Maxwell, J. W., Plass, J., & Keitges, M. J., 2012) for engaging children in *mathetics*, or "the art of learning" (Papert, 1993, p. 84). In one additional study reviewed in this section (Dillon, 2001), participants did not use computers during composition activities. However, Dillon argued that Papertian constructionism is nevertheless a viable lens for examining students as "makers" of personally meaningful music during project-based learning. In the following section, I discuss these eight studies and the tenets of Papertian constructionism that these scholars found applicable to examining novice composers' processes, or the process of making music in general. These particular studies stood out to me as having strong ties to Papertian constructionism within the context of music composition by novice composers.

In an examination of college students' intuitive ability to create a "sensible tune" (p. 7) using Impromptu software, Bamberger (2003) emphasized three particular characteristics of a constructionist environment for music composition. These traits were (a) unrestricted composition, (b) students working at their own pace, and (c) lack of time constraints. Bamberger's (2003) model for the quasi-experimental design was partially informed by Vygotsky (1978), who asserted, "the experiment must provide maximum opportunity for the subject to engage in a variety of activities that can be observed, not just rigidly controlled" (pp. 11–12). Bamberger suggested that the elemental characteristics of tonal structure are part of musically untrained students' intuition, and musically untrained students can produce coherently structured tonal melodies as long as they are given time and an opportunity to play with the given material.

Informed by Bamberger's extensive research on musical intuition, Rosenbaum (2015) was interested in using self-designed software to facilitate intuitive music-making by novice composers. Rosenbaum completed a case study of middle school students as they tinkered with MelodyMorph, a researcher invented iPad app, and MakeyMakey, a musical invention kit that Rosenbaum co-created. The purpose of the study was to characterize concepts of musical tinkering, musical landscape-making, musical backtalk, and musical inquiry. Eleven themes emerged from data analysis: anchoring, exploring, iterating, transforming, formalizing, mapping, emoting, storytelling, positioning, collaborating, and co-creating. Rosenbaum (2015) observed processes analogous to Piagetian assimilation and accommodation, which he defined as anchoring and transforming in his study. Rosenbaum concluded that tinkering led to participants developing new attitudes about their musical identities and that tinkerers “inevitably bump into ideas about music that resemble what one might learn in a more traditional approach to music education” (p. 165).

Musical intuition was also the focus of Downton’s (2015) study of 36 elementary school composers. In addition to building on Bamberger’s previous research related to music composition and intuitive development, Downton centered on the Papertian idea that learning happens best when the learner has the opportunity to make a personally meaningful product. Also, Downton drew on Vygotsky’s (1978) discussion of speech as a mediating tool, and asserted, “another way to make the abstract more concrete is to allow children to talk while engaged in activity” (Downton, 2015, p. 17). One of Downton’s major qualitative conclusions was that the barrier between novices and professionals could be removed when both actively engage in an activity that includes communication relative to the new knowledge domain, and that asking simple, open-ended questions prompted high-level responses from participants. Downton also concluded that asking students to reflect on their processes *in action* (i.e., talking during the process) promoted more music-related responses than reflecting *on action* (i.e., writing in journals later).

Socio-cultural constructionism framed a study by Downton, Peppler, and Portowitz’s (2010) study in which they examined how 60 elementary school composers developed musical understanding through cross-cultural, technology-based composition activities. Downton et al. proposed an extension of constructionism intended to ascertain understanding both individual and community development. The researchers were not only interested in musical concepts children encountered while constructing artifacts, but also children’s cultural contexts and how context affects musical understanding and development. Participants were asked to reconstruct and remix music of other cultures such as Chinese, Arabic, and American folk songs, with their own and then compose an original piece of music using Bamberger’s Impromptu software. Final compositions were shared cross-culturally between American and Israeli students. Findings by Downton et al. suggested that participants developed an understanding of musical concepts such as rhythm, pitch, and melody, as well as the cultural differences in other styles of music. The researchers claimed that constructing and reconstructing tunes helped participants express their musical intuition and become more aware of cultural differences among various musical traditions.

Focusing on a musically untrained child’s composition process using a distinctly constructionist approach, Jennings (2005) used Hyperscore software as a Papertian *object to think with* (Papert, 1980a). The 10-year old composer had never studied a musical instrument and did not read standard music notation. Jennings found that the composer first engaged in a period of *bricolage* (Lévi-Strauss, 1962) before honing in on particular musical concepts such as melodic contour or repetition and variation. Jennings also found that the musically untrained composer in his study could engage successfully with musical elements of note value, pulse, rhythm, melody, and texture. Also, the researcher found that Hyperscore allowed the composer to create music with ease and speed, which facilitated free-flowing dialogue between the student and teacher.

The idea of music learning as experiential rather than something delivered through instruction was the lens for Dillon's (2001) study. Composition was one activity he observed within the context of school music in general, which included performance, listening, improvisation, and composition. Dillon investigated the personal meaning of school music and perceived of participants as makers learning *how* to learn rather than traditional students learning *from* a teacher. Dillon concluded that allowing students to be makers facilitates deeper learning, accommodates a wide range of learning styles, and facilitates lateral thinking rather than hierarchical processing. His analysis led to a proposed definition of the role of music in the general classroom that included (a) a wide variety of music-making experiences and types of ensembles, (b) making music from a wide range of historical periods and cultures, (c) composing music individually and in groups, and (d) students learning to reflect on and be perceptive about the music they are making.

Studies informed by constructs associated with Papert, Piaget, or Vygotsky. Downton, Peppler, and Portowitz (2010) asserted, "constructionism is still a framework largely overlooked and understudied in the field of music education" (p. 1). The literature reviewed for my study supported Downton et al.'s assertion and revealed that few studies within music education are underpinned exclusively by Papert's idea of constructionism. However, in addition to the six studies reviewed above that focused heavily on Papertian constructionism for theoretical support, other studies drew on various Papertian concepts, as well as Piagetian and Vygotskian tenets for support. The six studies reviewed in the next section incorporated concepts by Papert, Piaget, and Vygotsky to varying degrees into their theoretical frameworks.

In her examination of differences between participants’ evaluations of their individual and collaborative processes and products, Kaschub (1999) drew on Papertian, Piagetian, and Vygotskian perspectives. Her investigation centered on the composition processes and products of 39 6th-grade students working both individually and collaboratively. Despite participants’ lack of access to computers, Kaschub contended that Papert’s idea of constructionism nevertheless informed her study because constructionism values both individual and collaborative learning. Although constructionism in the Papertian sense is more focused on Piagetian cognitive constructivism than Vygotskian social constructivism, even Papert once asserted, “Each individual must reconstruct knowledge. Of course, not necessarily alone. Everybody needs the help of other people and the support of a material environment, of a culture and society” (1987, p. 13). Therefore, it is clear that Papert embraced the socio-cognitive aspects of learning in addition to the internal cognitive processes of constructionism, and the two lenses are complementary.

Kaschub (1999) also emphasized two particular ideas set forth by Piaget as being pertinent to her study. Kaschub viewed her study of 39 6th-grade students as an opportunity to examine novice composers negotiating the bridge from concrete to formal operations, as well as to observe peers negotiating conflicting perspectives during the composition process. Kaschub referred to this as cognitive dissonance (referred to as *socio-cognitive conflict* in my study), which is based on Piaget’s notion of disequilibrium.

Vygotsky's ideas also played a significant role in Kaschub's (1999) study. In particular, Kaschub asserted that dialogical interaction between peers allowed them "to enter into new cognitive worlds" (p. 44), and that Vygotsky's concepts of *intrapsychological* and *interpsychological* development were particularly appropriate to underpin a study of novice composers' strategies and processes.

The purpose of Nelson's (2002) study was to examine children's composition processes and their developing musicianship while using technology. Nelson's theoretical framework was drawn primarily from principles set forth by Piaget, Vygotsky, and Bruner. Nelson completed an instrumental case study of two elementary school students composing with technology, and within- and cross-case analyses informed by Vygotsky's views about creativity. Nelson concluded that participants demonstrated engagement in four processes, including creating, performing, listening, and evaluating, all of which developed during the study. Nelson determined that creating music was recursive, and it did not occur in discrete stages. One student revised heavily while the other relied more on trial and error. Nelson concluded that processes used by the two elementary school participants often aligned more with Piaget's concept of a concrete preoperational stage than his idea of a formal operational stage.

Reminiscent of Piagetian stages of child development, Swanwick and Tillman (1986) theorized that musical development proceeds through four age-oriented stages: mastery (controlling sounds), imitation, imaginative play, and metacognition. Swanwick and Tillman also drew a parallel between their stages of imitation and imaginative play, and Piagetian assimilation and accommodation. Also, Swanwick and Tillman theorized that musical development progressed from a primarily individual process to a more socially influenced process. Swanwick and Tillman asserted that the participants in this study seemed to move through discrete stages of development based on age, but also conceded that these stages could apply at any age depending on the particular musical skill. Swanwick and Tillman also suggested that the richness of the musical environment could determine how quickly one moves through these stages.

In an examination of novice composers' cognitive processes and their social interactions, Wiggins (1994) observed two fifth-graders as they engaged in collaborative composition activities. Wiggins applied theoretical constructs set forth by Vygotsky and Rogoff to view these interactions through a social-constructivist lens and claimed that observing peer interactions through this lens "provided a rich source of data regarding the nature of the children's musical cognitive processes" (p. 234). Wiggins concluded that children tended to approach composition in a three-stage manner, from whole to part, and back to whole. Participants also perceived of final products holistically while they interacted with peers to evaluate their compositions.

Homing in on the nature of feedback and compositional intent as participants composed with technology, Ruthmann (2006) examined the relationships among sixth-grade students, their peers, and their teacher collaborating within an exploratory music technology course. Ruthmann identified two emerging thematic tensions, one between formal and informal learning and another between teacher control and learner agency. Ruthmann found that learner agency was sometimes inhibited when the teacher asserted much control over learning parameters. However, learner agency was at times fostered when the teacher valued and connected to students' prior understanding and experience.

Similar to Kaschub's (1999) study that examined both individual and collaborative processes, Kosak (2014) observed 4th-grade students' composition processes through a socio-cultural lens. Kosak's analysis focused on how the compositional process was influenced by the socio-cultural relationship between the composers and any perceived intended audiences. Kosak concluded that the primary source of intrapersonal-cultural influence was teacher approval. Also, Kosak concluded that the creative decision-making processes for participants were guided by expectations of the assigned task, which he categorized as an interpersonal-cultural influence on the compositional process. Another conclusion made by Kosak was that intrapersonal-interpersonal relationships exhibited the strongest influence on the compositional process.

Summary of constructionist-oriented studies within music education. The constructionist-oriented studies I reviewed within music education included six that had explicit ties to Papert's idea of constructionism. Dillon (2001) advocated Papertian constructionism as a lens for examining students as "makers" of personally meaningful music. Bamberger (2003) and Rosenbaum (2015) emphasized the importance of creating constructionist-oriented environments in which novice composers can create music intuitively. Using Bamberger's Tune Blocks software, Downton, Peppler, and Portowitz (2010) integrated novice composers' intuitive music-making process with exposure to cultural differences among various musical traditions. Downton (2015) centered on the Papertian idea that learning happens best when the learner has the opportunity to make a personally meaningful product. Jennings (2005) used Hyperscore software as a Papertian *object to think with* (Papert, 1980a), and found that the musical untrained composer he observed could engage successfully with musical elements of note value, pulse, rhythm, melody, and texture.

Six other studies were informed by constructs associated with Papert, Piaget, or Vygotsky that provided the amalgamated conceptual framework for my study. Kaschub (1999) incorporated all three theorists' perspectives into her theoretical framework, which supported Harel's (1988) assertion that Vygotskian and Piagetian perspectives seem to be compatible with Papertian constructionism. Nelson (2007) and Swanwick and Tillman (1986) did not include Papertian tenets of constructionism as part of their conceptual frameworks but did include ideas set forth by Vygotsky and Piaget. Three researchers, Kosak (2014), Ruthmann (2006), and Wiggins (1994) considered neither Papertian nor Piagetian constructs for theoretical support; however, their studies helped me gain perspective on which tenets of Vygotskian social constructivism may play a role in my study of novice composers' processes. These three studies helped to affirm my sense that the Vygotskian constructs of *interpsychological* and *intrapsychological* learning would be compatible with Papertian constructionism and Piagetian cognitive constructivism for an examination of novice composer's processes.

Studies Involving Novice Composers Using Non-Traditional Notation

The constructionist approach to composition applied in my study incorporated software that enables participants to compose with non-traditional notation. In Hyperscore, icons and curvilinear shapes are 'objects to think with' that composers use to represent their music graphically (Figure 1).

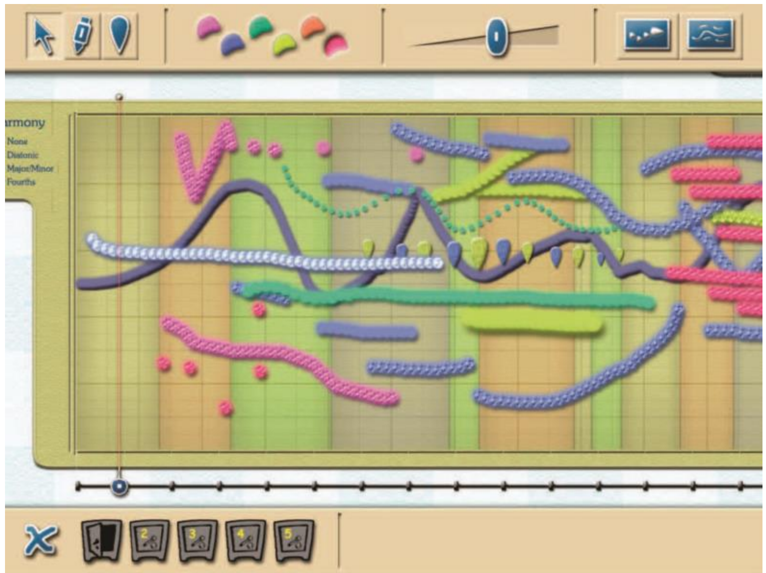


Figure 1. Hyperscore sketchpad for combining various motives.

The Hyperscore approach to composition spurred my interest in non-traditional graphic notation as a mediating tool (Goldman, R., Black, J., Maxwell, J. W., Plass, J., & Keitges, M. J., 2012) in the composition process, which ultimately led to the genesis of this study. The studies discussed in this section focus on novice composers who used non-traditional notation.

Davidson and Scripp (1988) asked, “Is it possible that young children’s invented marks or pictures could contain any musical meaning?” (p. 195). Over three years, Davidson and Scripp observed 39 children with no previous music notation experience who were asked to recall a short, unfamiliar song and notate it on paper so that someone who does not know the song could sing it. Davidson and Scripp concluded that, over time, participants were increasingly able to represent phrase structure, pitch contour, and rhythmic pulse and grouping using invented notation. The researchers asserted that even without specific training in traditional notation, children could display sophisticated musical understanding with invented notation.

In a study intended to develop a protocol for assessing students' musical understanding, Christensen (1992) observed fourth-graders compose with invented notation. Christensen concluded that when students were asked to draw visual representations of their compositions, it promoted deeper thinking and increased musical understanding. Over the eight weeks of her study, Christensen noted that participants' perceptions of music moved beyond mere recognition or elementary use of the elements of music. Christensen recommended a portfolio approach to assessment that includes evidence of students' metacognitive responses to their products and the composition process.

Examining children's notational strategies as a representation of musical knowledge, rather than as an interim stage in the progression toward conventional music notation, Barrett (1997) conjectured that an unconventional view of children's notational strategies might emerge. Twenty kindergarteners produced five different types of notation including (a) random drawings that seemed to have no relation to the sounds being created, (b) pictures of the instruments being played, (c) pictures of instruments along with some references to musical elements such as pitch or rhythm, (d) graphic notation representing gestures made while playing the instruments, and (e) symbolic patterns in which each symbol represented a discrete sound. A small number of children consistently used the same system, but most used several strategies over the eight weeks of the study. Barrett also noted that several children in this study were able to recreate their music a week or more after composing and notating it and that this suggests children can create and retain meanings and relationships among invented symbols, pictures, or graphics.

In a later study, Barrett (2002) examined the invented notations of two kindergartners who were asked to create and perform both original and familiar songs, and then figure out a way to represent them on paper so they would remember them, or so others could figure out how to play or sing them. Barrett concluded that abstract symbols created by the children were more effective than iconic (pictorial) representations of songs in helping children recall and recreate tunes. Barrett also suggested that the linguistic content of songs (i.e., the lyrics) are incompatible with iconic notation, which may have influenced the children in her study to use more abstract notation.

Centering on “the ever present danger of notational imperialism” (Bamberger, 2005, p. 168) examined children’s various notational approaches and the influence of those approaches on musical perception and performance. Bamberger aimed to elucidate how the syntax of notation influences the process of musical communication. Bamberger was interested in exploring how teachers can nurture rather than discourage children’s musical responsiveness utilizing invented notation while also valuing the benefit that modern musical notation can provide.

In her cross-case analysis, Bamberger (2005) noted that all participants in her study demonstrated going beyond the limits of notation by “probing for, engaging, integrating, and projecting through performance, responsiveness to context and function” (p. 168). Bamberger’s analysis led her to contend that introducing traditional notation too early in a child’s musical development may inhibit intuitive music-making ability. Bamberger acknowledged the advantages of fixed symbol systems but suggested that music educators focus more on developing musical responsiveness rather than prematurely expecting children to master traditional notation.

Investigating the relationship between action knowledge and symbolic knowledge as children played and made things was Bamberger's (2013) objective. She observed children composing in The Laboratory for Making Things 0LMT), and the role of the computer as a mediator between action knowledge and symbolic knowledge. There was a wide range of activities available to children that included designing and building with various materials, engaging in basic electronics projects, experimenting with gears and pulleys, playing musical instruments, and programming computers with Logo and Music Logo. Bamberger's observations focused primarily on six 8- and 9-year-old children who invented notations for their drumming patterns so that someone else could play their pieces. Bamberger noted three overarching themes after observing action-symbolic interaction including: (a) the concept of *procedure* initially developed using the computer was useful to students when designing hand-made products, (b) the tendency to look for patterns while engaged in hand-made designing seeped into computer designing, and (c) the concept of *chunking* that grew out of working with musical objects crept into designing other objects.

In her examination of children's invented notations interpreted through Vygotskian and Piagetian lenses, Carroll (2007) investigated children's use of their available resources (e.g., computers, peers, language, symbol systems) as mediating tools for drawing on previous knowledge and constructing new knowledge. Carroll asserted that examining both process and product is necessary to "better understand the complexity of human cognition" (p. 53) and supported her assertion with Vygotsky's contention that analysis should be both *phenotypic* (product-oriented) and *genotypic* (process-oriented). Carroll found that invented musical notations can be powerful mediating tools for revealing what one already knows about music and can reveal metacognitive understanding and strategies as well. Carroll noted instances of invented notation functioning as a "generator of consciousness" (p. 175), and cited examples of social co-construction of knowledge between children who collaborated on their invented notations.

After implementing an experimental design to compare learning satisfaction between two groups of composers, Huang & Yeh (2015) found that the learning satisfaction of the experimental group (computer users) was significantly higher than that of the comparison group (pencil and paper users) in every dimension: richness of teaching materials, learning tools' ease of use, teacher guidance and interaction, student needs including sense of accomplishment and being respected. The researchers found that virtually all of the participants who used a computer program to compose with graphic notation "realized that music composition was simpler than they had imagined" (p. 82) and was a highly rewarding activity. The comparison group (pencil and paper users) exhibited less positive reactions to composition than the experimental group. Both groups exhibited improvement in understanding musical concepts, attitudes toward learning, and skillfulness. However, the researcher found there was a statistically significant difference between the *extent* of the two groups' increase in understanding musical concepts, learning attitude, and skillfulness.

Summary of Studies Involving Novice Composers Using Non-Traditional Notation

Each of the studies discussed above focused on the use of invented notation by novice composers as an alternative to traditional notation. Although the Hyperscore users in my study did not invent entirely original notation systems, Hyperscore's sketchpad function allowed participants to draw freely in much the same way that participants in the previously discussed studies were free to create non-traditional notation to represent their compositions. Most of these studies indicated that invented notation appeared to be an effective way for novice composers to demonstrate musical understanding, memory, or creativity (Bamberger, 2005, 2013; Barrett, 1997, 2002; Carroll, 2007; Christensen, 1992; Davidson & Scripp, 1988).

None of the studies reviewed in this section implied that invented notation is a more effective preservation system than conventional notation for novice composers. Also, none of these studies suggested that children should engage only with non-traditional notation. Relatedly, Bamberger (2013) observed children who invented notation that somewhat resembled traditional Western notation. Each of the studies in this section shed light on the potential *value* of using invented and graphic notation to make the composition process more accessible to children. Also, these studies indicated that non-traditional notation might be an effective tool for helping students merge concrete and abstract musical thinking and ways of knowing and suggested the possibility of assessing children's musical understanding through their invented notations.

Studies Focused on Novice Composers' Processes and Products

My study contextualized the problem of overvaluing traditional music notation within the composition activities of novice composers, supported by a constructionist-oriented theoretical framework. Also, because constructionism focuses both on the learning process and creating a meaningful personal product, I was interested in examining composition as both a process and product. Arguably, composition processes and products are inextricably linked. However, various music education scholars have focused primarily on process, while others have included close examinations of processes *and* products in their studies. My first research question centered on the composition processes of novice composers and the second research question focused on process and product alike. Therefore, in the following section, I reviewed studies in which previous scholars examined the composition processes and products of novice composers to varying degrees and with various approaches.

Studies Focused on Novice Composers' Processes

Younker and Smith (1996) considered "two fundamental problems facing the profession: (a) our lack of knowledge about the process of musical creation and (b) the need to augment our understandings of how to teach music composition effectively to students of all backgrounds and in all settings" (p. 26). Four composers, one adult expert, one adult novice, one high school expert, and one high school novice, were asked to talk aloud while composing a 14-measure melody. Younker and Smith developed a model of the composition process and suggested there was a progression from the high school novice's note-to-note approach to the adult expert's, gestalt-like, whole-part-whole approach. Similar to other studies (Daignault, 1996; DeLorenzo, 1989; Ladanyi, 1995; Parry-Jamieson, 2006; Swanwick & Tillman, 1986), Younker and Smith's model of the composition process suggested that composers exhibited comparable learning and working styles (e.g., tactile, visual, aural), or progress through developmental musical stages affected by age, or both. Younker and Smith found that composers in their study moved from an "atomistic, note-to-note [approach to] a gestalt-like, whole-part-whole manner" (p. 31).

The relationship between socio-cultural factors (enculturation and general maturity) and four musical strategies (exploration, making choices, shaping structure, coherence) was the focus of Carlin's (1998) study. Verbal reports (i.e., thinking aloud) was accomplished by pairing children and asking them to talk about everything they were doing as they composed. Data analysis involved the researcher first reviewing and reflecting on the data for the three case studies, and then matching data with the socio-cultural factors and musical strategies mentioned above. Carlin developed an interpretive framework matrix for each case study and concluded that the study showed a "correlation between the complexity and variety of musical strategies and socio-cultural factors of enculturation and maturity" (p. 177), with these factors appearing to affect students' expressed level of satisfaction with their compositions.

Verbal reports were the sole focus for Major (2007), who was interested in how secondary school composers talked about composition. Major developed a typology of talking about composition that included exploration, description, opinion, affective response, evaluation, and problem-solving. Major integrated a Vygotskian tenet that suggests social sharing and dialogue increase levels of critical thinking and improve problem-solving. Major found that children's capacity to talk about composition is far more limited than the understandings demonstrated in their music.

Hypothesizing that individualized learning in a computer-assisted environment might provide more authentic music-making activities and create an "intrinsically motivating environment" (Hickey, 1997, p. 56), Hickey suggested that computer-assisted individual composition may be an effective alternative to group-oriented music activities. Hickey noted that group activities tend to be perceived as more practical for music educators. Hickey analyzed the composition processes of two 11-year-old boys composing independently while using researcher-designed composition software, and Hickey noted that the two participants in her study were perceived by their regular music teacher as below average in musical ability, yet surpassed previous achievements and expectations. According to Hickey, her study implied that the best environment for supporting motivation and creative output is one in which the individuals *perceive* that external rewards are low, and surveillance is minimal.

In a single case study with a 12-year old student in New Zealand, Bolton (2008) utilized GarageBand software within the context of a project called Compose that made composition instruction available online to students where composition opportunities have not previously existed. The researcher used a personal narrative approach to document his experience as well as stories provided by the student. Bolton noted that the student acquired composition skill and knowledge became increasingly innovative and able to create compelling pieces and developed a positive self-concept about his ability to compose. Bolton also contended that the computer environment was pivotal to the participant's motivation to learn and that her study corroborated Hickey's (1997) assertion that the computer environment might help reveal musical potential that otherwise might not surface.

Based on his semi-structured interviews with nine secondary school music teachers, Wise (2016) found that technology has the potential to enable students with no formal understanding of traditional notation and theory to create sophisticated and intricate pieces of their own. He also concluded that students lacked creative focus in three of the four schools due to the "fundamentally traditional and procedural" (p. 293) nature of the experience. Wise attributed this conclusion to teachers' "reluctance to explore potential affordance offered by digital technology" (p. 293) and their concern about meeting achievement standards of the national examination. In one of the four schools, students were free from any particular procedural limitations and demonstrated they were able to "write well-structured work almost instinctively" (p. 291).

Informed by learning models set forth by Swanwick and Tilman (1986), Emmons (1998) investigated the music composition processes of six 7th-grade students using computers and considered the appropriateness of applying models of creativity to middle school composers. Participants used both graphics-based sequencing software and traditional notation software, and the learning environment examined was highly structured and followed a predetermined curriculum. Emmons observed students in his study exhibiting behaviors comparable to those described by Swanwick and Tilman. Emmons found that certain students preferred to notate their compositions on paper before using the computer and noted numerous instances of students making creative decisions to please the teacher.

In a study in which 82 6th-grade composers completed teacher-defined composition assignments, DeLorenzo (1989) observed four types of problem-solving processes including: (a) perceiving the problem itself, (b) searching for musical form, (c) finding musical possibilities, and (d) committing to the task. DeLorenzo also found that when fewer choices were available for completing the task, student involvement declined. When participants were allowed to make more choices within the context of the problem-solving activity, they seemed to explore musical ideas in more depth. Also, DeLorenzo concluded that students need as much experience in *thinking about* music as in *making* music.

In her investigation of four high school students' composition strategies using technology, Ladanyi (1995) incorporated a case study design. Ladanyi based her cross-case analysis on Swanwick and Tillman's (1986) proposed stages of musical development. Three types of compositional processes emerged from Ladanyi's cross-case analysis, which included: (a) archetypal (b) style emulator, and (c) the technician. Ladanyi also concluded that participants' composing processes resembled those described by numerous professional composers. Ladanyi asserted that technology was a useful tool for allowing students to construct their own methods of learning, with minimal intervention from the teacher.

Burnard's (2000) objective was to provide her interpretation of 18 12-year-olds' composition and improvisation processes, and to "reveal the meanings constructed" (p. 9) by the participants. Burnard aimed to describe “the meanings given to intentional acts that characterize improvising and composing, as manifest through the actions and reflections of the children” (p. 9). Based on her data analysis, Burnard found that participants’ “underlying intentions resulted in different ways of experiencing improvisation and composition” (p. 20). Burnard used her analysis to create a model of children’s experience with improvisation and composition that included: (a) improvisation and composition as ends in themselves, (b) improvisation in the service of making a composition, and (c) improvisation and composition as indistinguishable inseparable forms. Burnard also found that musical training was less a factor in children’s perceptions of improvisation and composition than creative intention.

Another study in which improvisation was a key factor in the composition process was completed by Savage and Challis (2001), who studied British pupils in years 7-10 while they composed with a range of technologies. The researchers noted that digital processors were a particularly successful tool for the novice composers in this study because they opened up a new world of sounds for participants, who consistently commented on how digital processors added feeling and depth to their music. Savage and Challis concluded that participants in their study were highly motivated to explore and improvise because of the technology available. The researchers’ other major conclusion was that technology empowered pupils by giving them the means to express ideas that did not rely on traditional instrumental skills and attracted students who typically did not perform in musical events at the school.

In a meta-analysis of three case studies, Savage (2005) was interested in the impact of Information and Communication Technology (ICT) on the ways children aged between 11-16 composed music. Savage asserted students were interested in manipulating "the very core of sonic material" (p. 172) and did so extensively before creating structure with the sounds. Savage contended that inspiring starting points are vital to the composition process so that students can move quickly into the experimentation stage. Savage also found that during the experimentation stage, technology facilitated time and space for playful exploration and "allowed pupils to generate many sound ideas fairly rapidly" (p. 173). The researcher concluded that structuring of sound came later in the process, but that "on a number of occasions pupils were keen to move onto these considerations [of structure] at too early a stage" (p. 176). Finally, Savage found that composers were preoccupied with a "good final compositional product as much as the process of getting there" (p. 177), which they demonstrated by engaging in extensive reflection, evaluation, and revision.

Prompted by their interest in comparing strategies of those with formal instrumental music training (FIMT) to those without training, Seddon and O'Neill (2003) studied the composition strategies of 48 teen-aged composers using Cubase Score. The researchers identified three phases in the composition process, which they labeled as exploratory, rehearsal, and construction. The main difference found between the FIMT group and those without training was that of time spent using exploratory behavior. Those with formal instrumental training spent significantly less time in exploratory behavior, a conclusion based on the results of a chi-square analysis ($p < .001$). The researchers suggested that formal instrumental training itself might have been the factor that led those particular composers to a more convergent approach and suggested future research in this area should include asking participants specifically if they think in terms of their performance skills when they are composing.

Elucidating the degree (quantitatively) and nature (qualitatively) of *collaboration* between pairs of novice composers was the purpose of Hewitt's (2008) study. He observed children working *both* individually and collaboratively. Hewitt examined the potential relationship between five variables and the extent to which pairs engaged in collaboration while composing with computers. These variables included: (a) the perceived relationship as friends within pairs, (b) prior experience working together, (c) tendency to lead, (d) academic ability, and (e) level of familiarity with working together. Hewitt's analyzed transactive communication (i.e., talk that develops or extends previous ideas) and non-transactive communication (i.e., talk that is unhelpful or detrimental to the task) as well as the nature of the transactive dialogue that occurred.

According to Hewitt (2008), non-transactive communication is neither "unhelpful [n]or detrimental to the task; rather, it indicates that the speaker is not truly collaborating with their partner" (p. 14). Hewitt (2008) quantified the amount of transactive dialogue present in collaborative pairs and concluded that "transactive dialogue formed a fairly substantial part of the total pupil talk during the study" (p. 23). However, Hewitt found that none of the background variables had a statistically significant relationship to the amount of transactive dialogue exhibited by pairs. From a qualitative point of view, Hewitt asserted that "transactive forms of communication occur spontaneously and frequently [in his study and], based on a social constructivist view of learning, is a positive thing" (p. 24). Hewitt concluded that the children in his study were able to develop and extend their own ideas and those of their partners. Hewitt also concluded that "no consistent pattern could be found in the data that supported the notion that the extent to which individual pupils tend to engage in transactive dialogue is dependent on a particular role" (p. 17).

Building on previous research by Burnard and Younker (2002) and Wallas's (1926) stage theory, Chen (2012) was interested in mapping the strategies and processes of three college-aged novice composers with varied musical backgrounds who used technology as a tool for composition. Using a deductive approach, Chen looked for manifestations of Burnard and Younker's three composition pathways (linear, integrated, and self-regulated) and Wallas's stage theory of the creative process (preparation, incubation, illumination, and verification). Chen analyzed data sources, which included participants' MIDI files, reflective journals, and responses to individual semi-structured interviews. Subsequently, for each composer, Chen traced their pathway using Younker and Smith's model and superimposed Wallas's four stages of the creative process.

Chen's (2012) primary conclusions were (a) the linear composer moved through stages without moving back to previous stages, (b) the integrated composer moved among the stages freely, as did the self-regulated composer, and (c) the self-regulated composer also created self-imposed boundaries and chose to limit his compositional options. Chen also concluded that participants used technology as a tool for improvising, experimenting, refining, and recording at various times in their processes.

In her effort to suggest "effective strategies for implementing composition activities [and] demystify the art of composition” (p. 96), Kennedy (2002) studied the composition processes of four high-school-aged novice composers. Participants in Kennedy’s study completed two composition tasks, one structured and one open-ended. Significant themes emerging from the data were matters of time, including: (a) time for thinking, (b) procrastination time, and (c) time for revision. A cross-case analysis highlighted that listening to music for influences was the most prominent aspect of the composition process for all four composers. Kennedy also found that students tended to procrastinate and complete their pieces quickly without much revision. Participants emphasized the importance of taking time to think about the process and the need for a quiet atmosphere. Kennedy proposed a model for the composition process that included: (a) listening to prepare, (b) time for thinking, (c) listening for inspiration, (d) experimentation, and (e) finishing off.

Before participating in Airy and Parr’s (2001) MIDI composition study, participants expressed feeling alienated from their school’s music program because of the strong emphasis on performance skills. The researchers asserted that their study produced a side effect that emphasized the alienation experienced by some students. The researchers were interested in examining participants’ perceptions of the usefulness of composing music with MIDI software. Findings included students identifying their musical voice, especially if it aligned with ‘techno’ and ‘dance’ music. However, other styles of music were noted by participants as difficult to emulate with MIDI. Participants also found using a MIDI controller keyboard unfavorable, especially for creating drum patterns.

Through his interviews with 25 high school seniors, their teacher, and the school principal, Bolden (2009) gathered data about their various experiences in a technology-based composition class. Emergent themes included authentic assignments that related to real-world situations such as making music for animated videos, integrating theory with practice, and using a “diagnose and fix” approach to developing compositions. Bolden found that theoretical knowledge provided students with shortcuts for reaching compositional goals and that assessing compositions-in-progress was a prominent aspect of this constructivist-oriented environment. Bolden also found that participants in this study placed a high value on bringing their personal knowledge and interests into their compositions.

Summary of studies focused on novice composers’ processes. For this study, I examined the composition strategies and processes of 7th-grade composers from two perspectives. First, I was interested in deductively analyzing participants’ processes while focusing on particular *variables of interest* (Miles, Huberman, & Saldaña, 2013; Yin, 2009) explicitly underpinned by the constructionist-oriented theoretical framework for this study. Miles, Huberman, and Saldaña (2013) stated that identifying patterns of interrelationships can be accomplished both deductively and inductively, and I used both to analyze the processes of novice composers in my study. Similarly, Chen (2012) utilized Burnard and Younker’s (2002) musical pathways to map composers’ processes deductively. Carlin (1998) predetermined two socio-cultural factors and four musical strategies, which she used to deductively complete part of her data analysis. Second, I inductively analyzed participants’ composition strategies and processes using think-aloud, video data, or both as in several of the previously mentioned studies (Bamberger, 1977; Carlin; 1998; Hewitt, 2008; Parry-Jamieson, 1998; Younker, 1997).

Other studies reviewed in this section also informed my first research question, which focused on strategies and processes displayed or expressed by novice composers. Kennedy's (2002) conclusions about issues of time, Hewitt's (2008) observations of children composing in pairs, and DeLorenzo's (1989) assertion that open-ended tasks motivated novice composers, and Bolden's (2009) observations about making personally meaningful compositions provided valuable perspective about how to contextualize composition activities for novice composers within my study. Also, Airy and Parr's (2001) interest in participants' *perceptions* informed my second research question related to participants' responses to the process and their products.

Savage's (2005) suggestion that technology should be used to develop musical dimensions within music education that would be impossible without technology informed the lens through which I examined participants' processes. Major's (2017) conclusion that "children's understanding is greater than their talk may suggest" (p. 176) had implications for my use of verbal reports as data. Wise's (2016) finding that composition activities mostly prepared students to be competent software-users and undermined freedom of expression has major implications for using technology within a constructionist-oriented environment. Finally, five studies using computers as mediating tools for children to use while engaged in composition implicitly reflected the constructionist-oriented theoretical framework of my study (Emmons, 1998; Hewitt, 2008; Hickey, 1997; Ladanyi, 1995; Seddon & O'Neil, 2003). These studies involved computers in much the same way that Papert conceived of the computer as an *object to think with*.

Studies Focused on Novice Composers' Products

Two of the studies I reviewed focused primarily on final products rather than the composition process. Although I perceived novice composers' processes and products as complementary and inextricable, I was interested in how studies of novice composers' products might inform the research questions, design, and methods for my study. The two studies discussed here resonated strongly with the constructionism-based theoretical framework for my study.

Centering on individual composition and paying particular attention to social influences from outside the classroom, Stauffer (2002) completed a six-year longitudinal study of six 6th-grade composers through a socio-cultural lens in which she examined connections between the students' life experiences and their compositions. Participants chose from four software programs that allowed them to compose without conventional music notation and work individually for the duration of the project. Stauffer chose a non-intervention protocol because of her objective to observe what children do as they create music on their own. She provided no instruction was provided and assigned no specific tasks. Four primary themes emerged from Stauffer's study, which were: (a) instrumental influences, (b) familiar melodies, (c) media, school, and home influences, and (d) ensemble experiences. Stauffer found that instrumental music training and ensemble experience appeared to have influenced certain participants' compositions, and familiar melodies often served as starting points for participants' compositions. Also, participants displayed evidence of media and home influence on compositional style and titles of pieces. Stauffer also presented disconfirming evidence related to each of the four emergent themes. Not all compositions exhibited evidence of influence by instrumental music experience, ensemble participation, familiar melodies, media, home, or school.

In one of the few studies I located that included children's own opinions of their finished products, Seddon and O'Neill (2001) collected the computer-based compositions of 32 10-year old children with and without formal instrumental music training (FIMT) and enlisted three groups of evaluators to adjudicate the quality of the compositions. Seddon and O'Neill analyzed the compositions to evaluate participants' use of melodic and rhythmic repetition and development. Participants were asked to compose a piece of music that sounded good to them, and they were not given any other particular instructions.

Seddon and O'Neill (2001) found that children with formal instrumental training rated their compositions significantly higher than children without such training ($p < .05$); however, there were no significant differences between the two groups of children in their opinions about the effect of instrumental training on quality of compositions. Seddon and O'Neill contended that their analysis indicates instrumental training "may influence children's levels of confidence in their ability to compose" (p. 17) and suggested that this confidence "could be counteracted by classroom teaching materials, methods, and evaluations…where children with and without FIMT can attribute success to effort and strategy rather than fixed musical abilities" (p.17).

Summary of studies focused on novice composers' products. The constructionist-oriented theoretical framework adopted for this dissertation led me to view process and product as inseparable components of composition. Although the two previously mentioned studies focused solely on products, they nevertheless informed my thinking about how and why to consider novice composers' products relative to their processes for this study. For example, Stauffer's (2002) examination through a socio-cultural lens implicitly underscored Papert's emphasis on the importance of enabling children to make personally meaningful public artifacts. Stauffer noted that "students composed on their own and in their own ways, creating music that was personally meaningful and satisfying to them" (p. 320). Seddon and O'Neill (2001) suggested that the learning environment can be used to counteract children's perceived inability to compose music, which resonates strongly with the constructionist-oriented conceptual framework of my study. A constructionist-oriented microworld is one that, according to Papert (1980a, 1993), can counter preconceived notions of one's ability in a particular subject area.

Studies Examining Novice Composers' Processes as Well as Products

My first research question centered on inductively examining the composition strategies and processes participants displayed while composing in a constructionist-oriented setting. My second research question focused on participants' perceptions of the composition process and the compositions they produced. The third research question for my study focused equally on novice composers' processes and products. Considering my interest in examining participants' processes as well as their products, I chose to review several studies in which previous scholars considered participants' processes and products.

In a study frequently cited in the literature on composition in music education, Hickey (1995) examined fourth- and fifth-grade novice composers' processes and products drawing on both quantitative and qualitative data and analysis methods. Hickey developed a HyperCard stack that guided students through a four-phase approach to composition. Hickey compared various participants' thought processes inferred from their MIDI data, utilized experts to assess the creativity of participants' products, and examined how eight process variables correlated with measures of creative music aptitude, performance experience, and professionals' ratings of creativity. Creative music aptitude was measured using Webster's *Measure of Creative Thinking in Music II* (MCTM-II). Professionals' ratings of creativity, craftsmanship, and aesthetic quality of compositions were assessed using Amabile's (1982) consensual assessment technique (CAT). However, Hickey asserted that aesthetic value is implicitly integrated with creativity, and that "perhaps aesthetic appeal as a rating dimension is neither useful nor necessary in further research on the creativity of children's compositions when using a consensual assessment technique" (p. 202). Therefore, Hickey did not include aesthetic appeal as a dimension of interest in her research questions.

Hickey (1995) found significant differences ($p < .10$) between the high and low MCTM-II groups in terms of the extent to which groups incorporated two particular processes (parameter changes and play/silence), but no significant differences in terms of the other six process variables (time spent, composition length, range of notes used, number of notes played, number of timbres, lead-up time). Hickey found significant correlation ($p < .10$) between the high and low CAT craftsmanship groups on two of the eight process variables (composition length and the number of notes played). Hickey found no significant correlation ($p < .10$) between overall creative music aptitude as determined by the MCTM-II and the eight process variables, although certain *sub-scores* on the MCTM-II correlated significantly with certain of the eight process variables. Hickey found significant correlation ($p < .10$) between musical experience and one process variable (number of notes played) and found no significant relationships among participants' creativity, craftsmanship, overall aptitude, and music experience levels.

Hickey's (1995) qualitative analysis consisted of "subjective description of the aural and visual MIDI data based on inductive inquiry" (p. 107). Hickey compared the high and low MCTM-II groups and found the high MCTM-II group experimented more fluently and developed a variety of musical motives, and their compositions emerged late in the process. The low MCTM-II group experimented less and tended to play non-descript musical fragments, and their compositions emerged at various stages in the process. Seven types of composers emerged from Hickey's qualitative analysis: (a) literal, (b) classical, (c) rebel, (d) non-creative, (e) fluent motivic, (f) development motivic, and (g) physical.

In a study similar to the design of Hickey's (1995) study, Daignault (1996) investigated the thought processes of upper elementary school composers, as well as the creativity and craftsmanship qualities of their final compositions. Daignault implemented his self-designed Computer-Supported Improvisational Approach to Composition

(CSIAC), which he used to distinguish between free-form and guided composing while observing participants in this study. Daignault extensively discussed the links between composition, improvisation, and the problem-solving process, which provided his theoretical underpinning and decision to examine both improvisation and the development stage of composition.

Quantitatively speaking, Daignault (1996) used a researcher-developed observation form and Amabile’s consensual assessment method (CAT) for rating creativity. Daignault grouped students into high, middle, and low groups for answering his research questions. Daignault generated quantifiable variables by examining video and MIDI data from subjects in the highest one-third and lowest one-third groups based on creativity and craftsmanship ratings. Daignault identified six quantifiable improvisation stage variables and six quantifiable development stage variables, which were similar to Hickey’s (1995) nine process variables. Mirroring Hickey’s (1995) approach to analysis, Daignault tested for significant differences between high and low creativity groups on each of the six improvisation and development stage variables. Daignault also tested for differences between high and low craftsmanship groups concerning the same variables. Daignault found no significant differences between high and low creativity groups on variables associated with the improvisation stage. During the development stage, there were statistically significant differences between high and low creativity groups in the number of timbres used ($p < .10$) and the number of notes used in the final product ($p < .05$). There were no other significant differences between high and low creativity groups during the development stage. Daignault found no significant differences between high and low craftsmanship groups on variables associated with the improvisation stage. During the development stage, there was a statistically significant difference ($p <. 05$) between high and low creativity groups in the number of notes used in the final product. There were no other significant differences between high and low creativity groups during the development stage.

From a qualitative perspective, Daignault (1996) looked for qualitative differences among composition processes used by those who produced higher quality compositions and those who produced lower quality products, focusing specifically on the dimensions of creativity and craftsmanship and how they related to participants' processes. Daignault found that the low creativity group was more process-oriented in their improvisations, meaning their improvisations lacked distinct musical units, such as phrases or motives. Those whose products were rated high in creativity were more product-oriented in their approach to composition, meaning that their improvisations included essential characteristics of a finished product. Similarly, those in the low craftsmanship group were more process-oriented in their improvisations while most of those in the high craftsmanship group were product-oriented in their improvisations. Also, Daignault concluded that piano training influenced the types of processes used by participants in this study, and the majority (71%) of the compositions rated as high in creativity and craftsmanship were produced by students with a year or more of private piano lessons.

Using Subotnick's Making Music software as the composition program, Stauffer (2001) followed the process and examined the products of one 8-year old girl, Meg, for seven months. Stauffer found that Meg began each composition session with experimenting and exploring, but over time developed an ability to think in sound and develop her musical ideas. Stauffer's conclusions indicated that composition had an effect on Meg's musical understanding and development over time. Stauffer concluded that time, tool, and technique are interactive in the composition process. Meg's seven-month experience combined with an intuitive tool and her improved technique of thinking in sound "appeared to be linked to her facility and familiarity with the medium for composing and her cumulative experience as a composer" (p. 18).

Based on her interest in children's views and perspectives of composition processes and products alike, Burnard (2006) contended that too little research includes children's accounts of the processes and products of compositional activity. Burnard's investigation was underpinned by a phenomenological framework in which the researcher describes "not only the activity itself but also the environment and those within the environment" (p. 116). Therefore, Burnard aimed to reflect how composing was experienced and what composing meant to the four 12-year-old participants. Burnard's role was to act as an agent for reflection. She identified four overall themes (meanings) that children ascribed to the composition process: composition as (a) circular, (b) a jigsaw puzzle, (c) cumulative, and (d) a place where ideas meet. Burnard also asserted that getting children to compose is not enough and, based on her conclusion that "children get great satisfaction out of talking about their own composing processes and compositions" (p. 137) music educators should help novice composers develop a language for talking about composition and themselves as composers.

In a case study comparing the composition processes of a novice high school composer with those of a college doctoral music composition student, Kennedy (1999) was interested in the composers' strategies, use of time, motivation, and structure of their final products. Both composers completed the same task, which was to set a poem to music for voice and piano. Similarities identified included doodling at the pianos, both composers referring to inspiration as being a significant component, and awareness of the need to manipulate materials to complete the piece. Both composers used their voices as composition tools, felt the need for revision, and spoke of conscious and unconscious phases in the composition process, and felt the need for revision. Neither composer seemed concerned about the imposed time limit.

Kennedy (1999) found that the processes employed by both composers were "strikingly similar" (p. 163), with the main exception lying in the manipulation of musical materials. The doctoral student exhibited a higher degree of craftsmanship. Kennedy also found that the novice composer's strategies resembled those of the professional's. Kennedy contended that the novice-to-expert models proposed by Younker & Smith (1996) and Swanwick and Tillman (1986) were also evident in her study. The high school composer's final product exhibited less structural sophistication than the professional's yet showed evidence of being past the mastery and imitation stages described by Swanwick and Tillman.

The revision processes of elementary, junior, and high school students of various levels of composition expertise were the focus of Guthmann's (2013) study. Guthmann examined the extent of influence that music teachers' and professional composers' comments had on students during the revision process. Guthmann also compared and contrasted the collaborative and independent composition processes. Guthmann found that students were mostly influenced by the professional composers who provided written, one-on-one online feedback. Guthmann found a relationship between approaches to revision and levels of compositional expertise and concluded that composers who worked in pairs evidenced a high level of interaction and that one person in each pair tended to be more dominant.

Relying heavily on participants' verbal reports as well as written reports and researcher examination of musical products, Burnard and Younker (2002) were interested in gaining an understanding of creativity during the composition process. Burnard and Younker attempted to bring greater understanding to children's composition processes by examining their reflective talk and individual engagement. Burnard and Younker examined the dialectical relationship between constraint and freedom and its impact on the composition process.

Burnard and Younker (2002) synthesized data in their roles as "interpretive researchers with a constructivist perspective" (p. 249) and compared processes of participants with and without instrumental music training. The researchers organized students' composition activities according to various decision-making strategies and used comparative analysis to place each case on a continuum of composing pathways (linear, recursive, and regulated). The linear composer demonstrated limited shifts across creative thinking stages as opposed to the recursive composer. The regulated composer applied self-imposed constraints and boundaries on compositional options. Burnard and Younker concluded that the lack of formal instruction in composition did not appear to affect participants' ability to think divergently or convergently.

In a study focused on how constraints affected the composing processes of two groups of novice composers ages 10–13, Breeze (2009) described how proscription (i.e., teacher-designed scaffolding) enabled him to examine how students stayed within constraints or worked outside of the boundaries. Breeze viewed proscription as the opposite of prescription, an approach that used "constraints in a proscriptive manner to enable generative activity" (p. 206). Breeze applied a multimodal approach that included multiple resources such as keyboards, worksheets, and computers. Breeze collected screen-capture video, interview data, and field notes and analyzed data with attention to linguistic, aural, spatial, visual, and gestural discourse at the micro-level. Breeze concluded that proscriptive activities were "liberating in that they provide a starting point and some alternatives" (p. 216). Corroborating Barrett (2003), Burnard and Younker (2002), and Kaschub and Smith (2009), Breeze concluded that composition seemed "to be most productive in terms of the pupils' transformation of musical ideas where [there is] an appropriate balance between constraint and freedom" (p. 216).

In a study aiming to understand compositional development by examining processes and products of composition and the social and cultural contexts that might influence classroom computer-mediated composing processes, Kirkman (2011) observed the composition processes of students between 14 and 16 years of age over twelve months. Kirkman found that as restrictions were placed on location, resource, and task, the ability to compose musical responses increased. Kirkman found that improvisation played an important role in the process and that computer-mediated composition is a distinct musical skill. The degree to which the resources supported and interacted with existing musical skills was important, which led Kirkman to conclude that "students need…the freedom to find and work with individual computer-mediated solutions that support their existing approaches to musical ways of working" (p. 120).

Redefining what behaviors can be called composition and proposing a model of compositional development as the basis for a pedagogy of composition were the two goals stated by Parry-Jamieson (2006) in their multiple case study of 13 elementary and middle school-aged composers. Similar to certain process-focused studies discussed earlier in this chapter (e.g., Carlin, 1998; Younker, 1997; Younker & Smith, 1996), think-aloud data was also a source of data for Parry-Jamieson as she aimed to redefine what behaviors constitute composition. The researcher developed the Composition Improvisation Development Model and outlined a development progression from novice to an expert composer. Also, Parry-Jamieson also analyzed mannerisms, expressions, body language, and analyzed final products for evidence of concrete and abstract processes and evidence of social, historical, or theoretical context articulated through the use of norms. Parry-Jamieson proposed a compositional development model that progressed from compositional play to composition as a developing skill, to composition as a self-actualizing activity and a craft, ending with complete music literacy. Parry-Jamieson's (2006) study supported other researchers' assertions that stages of musical development may be observable and definable (e.g., Swanwick & Tillman, 1986; Younker & Smith, 1996).

In contrast to other studies reviewed that included the *collaborative* composition process (Daignault, 1996; Hewitt, 2008; Kaschub, 1999; Van Ernst, 1993), Folkestad, Hargreaves, and Lindström (1998) focused solely on *individual* composition processes and products. Folkestad et al. complete a three-year study that aimed to describe adolescent composers' self-perceptions of the process of computer-based composition. Except for a brief demonstration of how to use the technology, participants were merely asked to make music in any way they chose. In contrast to other studies that created a more structured composition environment (e.g., DeLorenzo, 1989; Emmons, 1998), Folkestad et al. imposed no restrictions on participants and strived to create an informal learning environment by leaving out the teacher and educational context as much as possible. Folkestad et al. (1998) identified two primary types of composition strategies employed by participants, horizontal (considering all sections of the piece while composing and revisiting various sections for various purposes), and vertical (completing each section in its entirety before moving on).

Similar to Folkestad et al. (1998), Menard (2015) was also interested in student perceptions regarding music composition, which she investigated in two high school programs. One was a typical performance-based band program, and the other was a general music program for gifted musicians. The general music students were more critical of their compositions, likely because they were identified as 'talented' in music. However, general music students' attitudes toward composition were consistently positive before and after the composition activity. The band students expressed frustration about their lack of fundamental music knowledge needed to complete the composition tasks and their inability to notate what they were thinking. However, Menard found that "the process of composition improved the attitude of the band students toward composition" (p. 129) and led them to think differently about the music they performed.

Examining potential relationships between various levels of teacher-imposed structure and participants' compositional processes and products was the primary goal of Smith's (2004) study. Twelve 4th-graders used their recorders to create their compositions. Smith used stimulated recall, which involved participants watching videos of themselves and recalling what they were doing and thinking while engaged in composition. The researcher also asked participants to provide their perception about the difficulty of various tasks and to express their preferences for different types of tasks. Smith's use of stimulated recall is similar to other studies that relied on verbal reports of children's thought processes (Bamberger, 1977; Carlin; 1998; Hewitt, 2008; Parry-Jamieson, 1998; Younker, 1997). However, it is important to note as Smith conceded that participants engaging in stimulated recall might have trouble reporting accurately and, "some information will remain inaccessible" (p. 93). Ericsson and Simon (1984) suggested addressing this disadvantage by asking highly specific questions of participants when using stimulated recall, which may yield "more valid information" (p. xlix). In addition to Smith, other music education researchers have utilized stimulated recall as a data collection method (Burnard, 2006; Söderman & Folkestad, 2004).

Smith (2004) concluded there was a relationship between the type of task students were doing and the quality of the resulting product based on judges' ratings. Compositions with the least amount of teacher-imposed structure were often ranked low in quality. This conclusion is counter to Kaschub's (1999) finding that children rated their *own* compositions as higher in quality when the task was unstructured. Smith concluded that pieces of music set to poetry led to pieces of better quality. Also, music audiation skill, music literacy, and academic skill did not appear to impact the quality of final products, but there was some correlation between writing and math skills and the quality of final products. Except for test results related to tonal audiation and tonal literacy, "higher test scores did not correlate with higher-rated pieces" (p. 216). Also, previous instrumental skill and choral training had minimal impact on product quality in this study.

The time children spent on different types of tasks was not significantly different in Smith's (2004) study, and time spent did not seem to be a factor in creating higher quality products. This finding resonated with other composition-oriented studies in which the researcher found that time was an essential factor (Bamberger, 2003; Kafai, 1996; Kennedy; 2000; Kosak, 2014; Menard; 2009; Van Ernst, 1993; Younker, 1997). Smith's qualitative analysis revealed three styles of composition: auditory, visual, and kinesthetic, with greater use of repetition and practice, large amounts of writing, and extensive use of an instrument before notating music being the prominent features of each style, respectively.

With the goal of describing the creative processes of children engaged in computer-based composition, examine the products children produced, and reach a deeper understanding of what creative music-making means to children, Nilsson and Folkestad (2005) found that participants placed various aspects of the composition process in the foreground during the study. These aspects included the computer, personal emotions, playing the instrument, the music itself, and the task. The researchers also concluded that children without formal training were able to create music with form and structure and suggested that composition should be approached as a form of play, “not as a school task with rules” (p. 35). Conversely, Nilsson and Folkestad cautioned against making the task too open-ended because participants in their study often needed to draw on the task itself to create a meaningful context for their compositions.

In a study examining the extent to which participants adopted varying strategies, the relation of those strategies to formal instrumental training, and evidence of creative thinking skills, Mellor (2008) analyzed a group of 13–15 year-olds’ composition processes. Mellor relied on three data types, including a critical incident charting, retrospective verbal reports, and screen-captured data. Mellor concluded that all participants used a vertical composition strategy (i.e., completing each section in its entirety before moving on). The researcher also noted that, regardless of formal instrumental training, evidence of creativity was present in all participants’ responses. Mellor defined creativity in terms of divergent thinking and problem-solving skills, as described by Dillon (1982), Getzels (1975), and Webster (1996).

Similar to Mellor’s (2008) interest in examining creative thinking, Ward (2009) was interested in how technology-supported creativity and found that using information and communication technology (ICT) helped to make the creative process transparent. Ward based his definition of creativity on Robinson and Stern (1997), who emphasized that creativity leads to something original and of value. Ward asserted “that creativity was indeed at the centre of every activity,” and that ICT is a “powerful tool that revolutionizes the creative process" (p. 164). Ward found that although children were unable to describe their methods in detail, they were successful as intuitive composers.

Summary of studies examining novice composers' processes as well as products. The theoretical framework of this study informed my decision to examine participants' composition processes and products alike. Focusing discretely either on processes or products would have been incompatible with a study underpinned by tenets of constructionism. The studies mentioned above that examined processes, as well as products, had implications for this study in several ways.

The tension articulated by Papert (1993) between direct instruction and self-construction of knowledge was apparent in three of the studies reviewed (Burnard & Younker, 2002; Folkestad et al., 1998; Hickey, 1995), and promoted my interest in further exploring a constructionist-oriented approach to composition in the music classroom. Similar tensions between the nature of structured and unstructured tasks, and constraint and freedom emanated from several studies reviewed (Bamberger, 2003; Kaschub, 1999; Nilsson & Folkestad, 2005; Van Ernst, 1993; Younker, 1997). The tension addressed in these studies underscores Papert's discussions of "knowing-that versus knowing-how" (1980a, p. 135) and "instructionism versus constructionism" (1993, p. 137), and how learning through constructionism cannot be reduced to either term of such dichotomies. In other words, according to Papert, constructionism breaks down tension in dialectical relationships, such as those appearing in several of the previously mentioned studies.

A number of the studies discussed above informed my understanding of how verbal reports have been used in previous studies (Bamberger, 1977; Carlin; 1998; Hewitt, 2008; Major, 2007; Mellor, 2008; Parry-Jamieson, 1998; Smith, 2004; Younker, 1997), and other studies were particularly informative about issues of time (Bamberger, 2003; Kafai, 1996; Kennedy; 2000; Kosak, 2014; Menard; 2009; Smith, 2004; Van Ernst, 1993; Younker, 1997). Consequently, I considered participants' verbal reports as a potentially rich source of data and considered the implications of imposing no time limits on participants for completing composition tasks.

Although several of the studies discussed in this section did not explicitly articulate a constructionist-oriented theoretical framework, many of them did so implicitly. For example, Hickey (1995) perceived the computer as a mediating tool in much the same way that Papert (1980a, 1993) described the computer as a tool, and Vygotsky (1978) described how a culture's tools play a role in learning. Ward (2009) investigated how ICT could support creating original music using the computer "as a tool for articulating ideas" (p. 162). Kaschub (1999) also emphasized the importance of mediating tools, as well as the value of both collaborative and individual learning, which reflected tenets of Papertian constructionism, Piagetian cognitive constructivism, and Vygotskian social constructivism. Nilsson and Folkestad (2005) discussed the role of play, which was reminiscent of how Papert (1996), Piaget (1951, 1997), and Vygotsky (1978) commented on the importance of play in learning. Folkestad et al. (1998) warned that composition should not be taught with specific methods, which resonated with Papert's (1993) call for a balance between instructionism and constructionism.

Synthesis of Related Literature

In this synthesis of related literature, I discuss common themes that bound certain studies together and informed my study in particular ways. Certain studies resonated strongly with the theoretical constructs underpinning this study, while others supported my rationale for contextualizing the problem of overvaluing traditional notation within a classroom of novice composers. Certain studies underscored my research questions while others informed the design and methods of this study. This synthesis aims to illuminate how studies within and outside the field of music education influenced my thinking while designing a constructionist-oriented learning environment for novice composers.

Papert's Eight Big Ideas

Much of the literature I reviewed underscored several of Papert's (1999) eight big ideas behind constructionism (see Appendix A). While describing his first big idea behind constructionism, Papert asserted, "We learn best of all when we use what we learn to make something we really want" (p. 1). A common theme among much of the literature reviewed is the making of personally meaningful artifacts (e.g., Ainley et al., Boyer, 2010; Burnard, 2000; Dillon, 2001; Johnson, 2014; Lamberty, 2007; Nilsson & Folkestad, 2005; Stager, 2005; Stauffer, 2002). According to Papert, children learn best when they personally invest in making something public. In my study, the public artifact was a musical composition, and I encouraged participants to create a composition that reflected their interests, influences, and personal ideas. One finding of particular note was Nilsson & Folkestad's observation that, for some children, a particularly open-ended task made it difficult for them to establish context for their compositions. According to

Nilsson & Folkestad, some children may need assistance identifying a personal connection to the composition experience, which underscored my interest in examining scaffolding as a variable of interest.

Papert's (1999b) second big idea behind constructionism is technology as a building material. In addition to researchers outside the field of music education (e.g., Baytak, 2009; Boyer, 2010; Harel, 1988; Johnson, 2014; Shaw, 1995), a number of music education researchers explicitly incorporated the computer as a building material for children engaged in music composition (e.g., Downton et al., 2010; Emmons, 1998; Hewitt, 2008; Hickey, 1995, 1997; Ladanyi, 1995; Seddon & O'Neil, 2003). Learning how to learn (*mathetics*) is another of Papert's eight big ideas, which was implicit in several of the studies I reviewed (e.g., Bamberger, 2013; Folkestad et al., 1998; Ladanyi, 1995; Rosenbaum, 2015). Because constructionism strongly influenced the development of Hyperscore software (Jennings, 2005), I was particularly interested in examining how novice composers used it as a mediating tool to help them learn how to learn composition rather than as a supplement to a predetermined curriculum with expected outcomes.

Papert (1999b) emphasized, "taking time—the proper time for the job" (p. 1), which was a theme that emanated from a number of studies I reviewed (e.g., Bamberger, 2003; Hickey, 1997; Kafai, 1996; Kennedy, 2000; Kosak, 2014; Menard; 2009; Smith, 2004; Van Ernst, 1993; Younker, 1997). According to Papert and others, giving students sufficient time to immerse themselves in making a personally meaningful product and letting them learn to manage time for themselves are significant components of constructionism. This informed my thinking when designing my study and led to the decision not to require participants to complete any particular number of compositions within a specific amount of time, other than the 10-week time frame of the study.

I was interested in examining the phenomenon of composition within a constructionist-oriented environment rather than instructing students in composition. Similarly, Papert contended that constructionism means “we do not have a pre-conceived idea of exactly how this will work out” (p. 1). This reflects the dialectical relationship between self-constructed knowledge and direct instruction, which Papert (1992) referred to as “constructionism versus instructionism” (p. 137), respectively. A number of studies I reviewed considered similar relationships such as that between *teaching* composition and engaging children *in* composition (Burnard & Younker, 2002; Folkestad et al., 1998; Hickey, 1995), constraints versus freedoms (Bamberger, 2003; Nilsson & Folkestad, 2005; Van Ernst, 1993; Younker, 1997), or structured activities contrasted with unstructured composition tasks (DeLorenzo, 1989; Kaschub, 1999). Ackermann (2003), one of Papert’s contemporaries, encapsulated this idea by saying that teachers should be clinicians who help children “dance in-and-around a problem…to stretch their initial views of the world as far as they can naturally grow” (p. 7). This statement eloquently epitomizes my view that composition can be a challenging, creative problem-solving activity for children that helps them develop musicianship organically.

Papert once famously asserted, “You can’t think seriously about thinking without thinking about thinking about something” (1980a, p. 10). While reviewing the literature related to constructionism, the contention by Papert and others (Ackermann, 2005; Boyer, 2010; Caroll, 2007; Gunstone, 2000; Harel, 1988; Nelson, 2007; Tobias, 2010) that constructionism is particularly conducive to helping children think about how they learn stood out to me and influenced my research questions and data collection methods, which included children’s verbal reports as a significant source of data. Also, various music researchers have drawn attention to children’s metacognitive strategies in their studies of novice composers (Christensen, 1992; DeLorenzo, 1989; Swanwick & Tilman, 1986; Van Ernst 1993; Younker, 1997).

I aimed to gain insight into novice composers’ thinking by asking them to verbalize their thoughts while engaged in composition. Various authors of studies I reviewed had similar objectives and also relied on verbal reports for data (e.g., Burnard, 2006; Burnard & Younker, 2002; Carlin, 1998; Hewitt, 2008; Parry-Jamieson, 2006; Smith, 2004; Söderman & Folkestad, 2004; Younker & Smith, 1996; Younker, 1997). Wondering if questions may exist about the efficacy of verbal reports for accurately reflecting research participants’ thought processes, I reviewed the protocol analysis model set forth by Ericsson and Simon (1993), who asserted that subjects can verbalize cognitive processes “without changing the sequence of their thoughts and slowing down only moderately” (p. xxxii). Also, Wilson (1996) contended that think-aloud data is a useful research tool even if it cannot be claimed as insight into the human mind, and other researchers have contended that verbal reports may provide useful research data (Baumann et al., 1992; Collins & Dunn, 2011; Richardson & Whitaker, 1996; Young, 2005).

Epistemological Pluralism

Turkle and Papert (1990, 1991) argued for revaluation of the concrete and a modified version of Piaget's idea of *epistemologie genetique*, which they referred to as *epistemological pluralism*. Turkle and Papert contended that concrete ways of thinking such as that associated with using graphic notation for music composition should be valued as much as formal, abstract thinking such as that required for mastering traditional music notation. Although not explicitly stated, certain studies reviewed in this chapter underscored Turkle and Papert's concept of epistemological pluralism, which is a constructionist-oriented construct of particular interest to me. For example, Younker & Smith (1996) observed overlapping learning modalities, Lamberty (2007) hypothesized that using concrete materials would help children make connections between symbolic and concrete representations of their products. Downton (2015) asserted that constructionism "is about making new connections to the world by making the abstract more concrete" (p. 4). Kaschub (1999) suggested that during music composition activities, "students may encounter new ways of thinking as they transition from concrete operations to formal operation in the Piagetian view of development" (p. 31).

In my study, I was interested in how a mediating tool, such as Hyperscore software that characteristically values concretizing the music composition process manifested itself in a constructionist-oriented environment. Also, the studies reviewed in which children invented or used graphic notation (Auh & Walker, 1999; Bamberger, 2005, 2013; Barrett, 1997, 2002; Carroll, 2007; Christensen, 1992; Davidson & Scripp, 1988; Lee, 2013; Upitis, 1989) informed my thinking about Turkle and Papert's (1990,

1991) concept of epistemological pluralism. Music education scholars who advocate for the use of invented and graphic notation implicitly advocate for “revaluation of the concrete” (Turkle & Papert, p. 131), which is a central tenet of my study.

Learning how to Learn

The last overarching theme that emanated from this review of related literature is the idea of learning how to learn, which Papert (1980a) referred to as *mathetics*. According to Papert, a mathetic microworld is “a computer-based interactive learning environment where the prerequisites are built into the system and where learners can become the active, constructing architects of their own learning” (p. 122). Several of the studies I reviewed within music education (e.g., Bamberger, 2003; Downton, 2015; Folkestad et al., 1998; Ladanyi, 1998; Rosenbaum, 2015; Stauffer, 2002) and outside music education (e.g., Baytak, 2009; Boyer, 2010; Harel, 1988; Hewitt, 2008; Johnson, 2014; Kafai, 1996; Lamberty, 2007) informed my understanding of a mathetic microworld and the research questions and design of my study. Also, although specific studies involving novice composers did not incorporate computers (e.g., Burnard, 2006; Kaschub, 1999; Younker, 1997), their respective researchers immersed students in composition rather than teaching them to compose, which resonates strongly with Papert’s concept of mathetics and the theoretical framework for this study.

CHAPTER 3: DESIGN AND METHODOLOGY

The purpose of this study was to examine 7th-grade composers' strategies, processes, and perceptions about the compositions they created using music technology in a constructionist-oriented learning environment. In this chapter, I describe the design of the study and its relation to the purpose, as well as my strategies for collecting and analyzing data relevant to three research questions, which were:

- What composition strategies and processes do participants display or express while composing music within this constructionist-oriented environment?
- What are the participants' displayed or expressed responses to the composition process and the compositions they created within this constructionist-oriented environment?
- To what extent and in what ways do the affect-cognition, constructionism-instructionism, and concrete-abstract concept dyads manifest themselves within participants' composition processes?

Also, I discuss the research participants, my role as observer as participant, the constructionist-oriented setting, limitations of the study, and issues of trustworthiness.

For this study, I adopted an embedded multiple case-study design as described by Yin (2009). Yin asserted that a multiple-case design is "likely to be stronger than single-case designs" ("Abstract," para. 3) because evidence from multiple cases is often more robust and compelling than a single case. Yin's assertion influenced my decision to employ a multiple-case approach. More specifically, I applied an *embedded* multiple case study design as described by Yin, which involves more than one unit of analysis embedded within the same context. The units of analysis consisted of eight 7th-graders who composed individually for five weeks, and four collaborative pairs (formed from the same eight participants), who composed together for an additional five weeks. The context was a 7th-grade general music classroom.

My choice to adopt an embedded multiple case study design was also influenced by my interest in studying the phenomenon of interest (i.e., 7th-graders' composition experience within a constructionist-oriented environment) within its real-world context. My hope was that this examination might unearth "new learning about real-world behavior and its meaning" (Yin, 2009, "Case Studies as a Research Method," para. 1). Case study design is appropriate when research questions address descriptive questions (Yin, 2009) such as those for my study. I was interested in observing, describing, analyzing, and synthesizing what happened and how, as these novice 7th-grade composers created music using Hyperscore in a constructionist-oriented setting.

Case Study Defined

In my study, the phenomenon of interest was the composition processes and products of 7th-grade composers, and the real-life context was a constructionist-oriented 7th-grade general music classroom (Yin, 2009). Case studies are the preferred method when "the focus is on a contemporary phenomenon within a real-life context" ("Abstract," para. 2). Also, case study inquiry usually involves "many more variables of interest than data points…relies on multiple sources of evidence…[and] benefits from the prior development of theoretical propositions" ("Definition of the Case Study," para. 9). The case study approach aligned well with my research questions, which emerged from selected theoretically-oriented, qualitative ‘variables of interest.’ Although I did not explicitly state theoretical propositions for this study, I did focus on theoretical variables of interest. Also, these variables were meant to facilitate “insight, discovery, and interpretation rather than hypothesis testing” (Merriam, 2014, p. 42). Several other music education researchers have utilized case study design to investigate novice composers’ composition processes (e.g., Bamberger, 1977, 2003; Barrett, 2006; Burnard & Younker, 2002; Kennedy, 2002; Kosak, 2014; Nelson, 2007; Stauffer, 2002;), and studies by these particular scholars also influenced my decision to adopt a case study design.

A defining characteristic of case studies is in identifying units of analysis (Merriam, 2014). In the present study, there were 12 units of analysis, eight independent composers, and four sets of collaborators. Also, case studies could be further defined by one of three unique features, which she referred to as particularistic, descriptive, or heuristic (Merriam, 2014). This study’s unique feature is its heuristic nature, which was intended to “illuminate the reader’s understanding of the phenomenon under study” (p. 44). The phenomenon of interest in this study is 7^{th}-graders’ composition processes and strategies, and the compositions they created within the context of a constructionist-oriented learning environment. Heuristic studies could extend the reader’s experience, which aligned with my intent to provide the reader with a window into a constructionist-oriented learning environment for novice composers.

Participants, Researcher’s Role, Composition Activities, and Setting

Although the pool of potential participants was relatively small and homogenous in terms of socio-economic background and race, I chose to include some selection criteria to increase "the likelihood that the findings will reflect [at least some] differences or different perspectives" (Creswell, 2012, "Purposeful Sampling Strategy," para. 8). Maximum variation sampling helped me recruit a somewhat diverse group of participants in terms of gender, the extent of previous private music lessons outside of school, and the degree of previous experience creating original music. Other music education researchers have similarly considered musical background as a factor when examining the work of novice composers (Burnard & Younker, 2002; Hewitt, 2009; Seddon & O'Neill, 2001, 2003). To facilitate the maximum variation sampling process, I used a form similar to Menard's (2009) student data form to survey those who expressed interest in participating (link to Appendix B).

Participants

I selected eight participants from a population of 68 7th-grade students in a West Coast, independent, co-educational, college preparatory school. Although this study did not compare and contrast female and male participants' composition activities, my interest in being equitable led me to choose four female and four male participants. Four students had taken private music lessons for more than one year, and four had not. Three students indicated they had had some previous experience creating original music, and five had no experience doing so. Table 1 outlines the maximum variation strategy employed to establish the eight profiles represented.

Although additional demographic information could have been considered during the maximum variation sampling process, the relatively homogeneous nature and the small population of the 68 potential participants at the school where this study took place would have made it impractical to include more than the three participant characteristics. For example, the largest ethnic group of students at the research site was White (77.4%), followed by Asian (9.1%), Hispanic (5.2 %), Black (3.5%), students of two or more ethnicities (3.5%), Pacific Islander (1.0%), and Indian (0.3%). Consequently, the demographic composition of the student body hindered my ability to diversify the sample based on race. Also, although it may have been desirable to choose students who were already familiar with each other (Kaschub, 1999), including this factor would have been particularly prohibitive at the present study's particular site, which begins with 7^{th}-grade and enrolls students from more than 25 different elementary schools. Conversely, Hewitt (2008) indicated that neither friendship levels within pairs nor level of familiarity with each other affected the amount or quality of communication within pairs.

Among the 20 students who expressed interest in this study, there was at least one student who fit each of the eight profiles I was hoping to include. However, one volunteer, who happened to be the only one who fit one of the particular profiles, did not return parent consent or participant assent forms. Consequently, two participants in the study (Brittany and Emily) had the same profile. When there was more than one interested student who matched a particular profile, I chose that participant based on who submitted their parent consent, and student assent forms the earliest. The 12 volunteers not selected for the study were offered the opportunity to compose with Hyperscore during the school's weekly club period. None of the 12 non-participants took advantage of this opportunity.

Table 1

Maximum Variation Sampling Strategy

Participant	Gender	Private music lessons	Previous experience creating original music
Bri	Female	0–1 year	No
Brittany	Female	More than one year	No
Chelsea	Female	0–1 year	Yes
Draco	Male	0–1 year	Yes
Emily	Female	More than one year	No
Jeff	Male	More than one year	Yes
Josh	Male	0–1 year	No
Ryan	Male	More than one year	No

Researcher's Role

My observer role included note-taking during class time and extensive note-taking while reviewing video data outside of class time. Merriam described the observer as participant as a "peripheral membership role" in which "the researcher's observer activities, which are known to the group, are subordinate to the researcher's role as a participant" (p. 124). Therefore, another aspect of my role was to "observe and interact closely enough with members to establish an insider's identity without participating in those activities constituting the core of group membership" (p. 124).

In addition to observing participants' composition processes, I participated by scaffolding as described by Duffy and Cunningham (1996), Wiggins and Medvinsky (2013), and Wood, Bruner, and Ross (1976). I conceived of my participant role as helping the novice composers close "the gap between what the child can currently do…and what she can achieve with intercession and scaffolding of adults or peers" (Bruner & Haste, 1987, p. 6).

When students appeared to need or asked for assistance, I became directly involved in their process rather than merely observing. When I was unable to assist because I was interacting with another student, another participant (frequently Draco) sometimes helped by adopting the role of a Vygotskian (1978) "more capable peer" (p. 86). Also, as part of my observer as participant role, I intermittently offered advice, helped solve technical problems, and provided guidance or direct instruction as needed. I also encouraged participants to talk with me and each other, ask me for assistance as needed, and answer my questions about their strategies and processes, all of which are considered components of a constructionist-oriented. In summary, I *observed* as the researcher and *participated* as a member of a constructionist-oriented community of learners.

Composition Activities

The daily schedule at the chosen site enabled participants to compose music for 40 minutes once or twice weekly for 10 weeks, followed by 10-minute, semi-structured, individual interviews after each composition session. My previous experience introducing 7th-grade students to composing with Hyperscore indicated that novice composers learn to navigate Hyperscore's relatively simple graphical user interface quickly. Therefore, before the 10-week data collection period began, I led participants through one 60-minute class period, during which they learned how to manipulate the tools provided within Hyperscore. In addition, because encouraging learners to create personally meaningful products is one of the primary tenets of constructionism, I began the 60-minute orientation by asking participants to consider how they might create compositions that would reflect their personal interests. For example, if a student enjoyed playing a particular video game, I suggested they might consider creating music reflecting that specific interest.

The Constructionist-Oriented Setting

I was interested in examining 7th-grade composers' composition strategies and processes within the context of a *mathetic* microworld as described by Papert (1980a, 1993). According to Papert, learning a language involves acquiring new words and practicing "by using the word[s] in a sentence of our own construction" (Papert, 1980a, p. 120). Similarly, participants in the present study practiced composition by using elements of music and Hyperscore software to construct their own compositions.

My approach to creating a Papertian mathetic environment was also influenced by my interest in creating a Papertian "Musicland" (Rosenbaum, 2015) in which novice composers could create music and develop musical ideas organically. The mathetic microworld for the present study was one in which participants experimented, played, and reflected — and experienced *doing* composition rather than being taught to compose.

This study was situated in one of the computer labs at the selected site. Two discrete groups comprised of four females and four males, respectively, composed music for 40 minutes once or twice weekly for 10 weeks. They also participated in 10-minute, individual, semi-structured interviews (Merriam, 2014) after each composition session. The amalgamated theoretical framework drew on Papertian constructionism, Piagetian cognitive constructivism, and Vygotskian social constructivism. This framework underpinned the research questions for this study and precipitated my desire to create an environment in which novice composers worked individually as well as in collaboration with others. For these reasons, I asked each participant to create at least one individual composition and at least one collaborative composition with another student, which was the only expectation (Kaschub, 1999; Kaschub & Smith, 2009).

Consistent with previous researchers' designs (e.g., Bamberger, 2003; Hickey, 1995), there were no time limits or specific guidelines imposed within the 10-week scope of the study. Also, I assured participants that I would not assess the quality of their compositions, and they would not be graded on their composition activities or products. Assessment of student work was outside the scope of and irrelevant to this study.

Data Sources and Collection Methods

Typically, case study inquiry is more successful when built on collecting and analyzing data from multiple sources that provide depth to the case (Creswell, 2012; Merriam, 2014; Yin, 2009). However, multiple sources can lead to data overload, which was my experience. Beginning the analysis processes while collecting data helped mitigate the effect of data overload by managing and organizing data early in the study.

NVivo software helped facilitate simultaneous, preliminary analysis during the 10-week data collection period, as well as within- and cross-case analyses after data collection.

This study generated over 80 hours of video and screen-capture data in addition to my field notes, which reflected a similar number of hours in the classroom with participants. Therefore, it was essential to incorporate an iterative process of data winnowing, condensation, and preliminary analysis throughout the 10-week data collection phase of the study and beyond.

Data Sources

I aimed to design a study that included a reasonably wide range of data sources, and I determined that four types of evidence suggested by Yin (2009) and three suggested by Creswell would be the most appropriate for my study. The sources of data collected throughout the study were: (a) videoed researcher observations, (b) videoed think-alouds, (c) screen-captured composition activity, (d) videoed stimulated recalls), (e) videoed semi-structured interviews with participants), and (f) my field notes. Yin's and Creswell's suggested data sources aligned well with my researcher role (observer as participant), the important role of physical artifacts (compositions), and my desire to rely heavily on videoed data (audiovisual materials).

I uploaded all video data to YouTube, which were visible only to me, and used the transcribe function to download transcriptions of each videoed composition session, semi-structured interview, and stimulated recall session. I subsequently imported these transcriptions into NVivo software, which created an additional valuable source of data. Participants' compositions in the form of Hyperscore files were saved to each computer as part of the data trail for the study; however, they were generally not needed as a data source for analysis because composition activity was captured by Screencast-O-Matic software described in more detail below.

Data Collection and Winnowing

I winnowed the data for the first research question by identifying a subset of four participants. Purposeful sampling (Creswell, 2012) during the first three weeks of the 10-week data collection period assisted me in choosing a subset of four participants that appeared likely to provide a relatively rich set of data for answering the first research question. To answer my first research question, I chose a subset of four participants who engaged relatively consistently in the think-aloud process, readily responded to comments and questions posed by their peers and me, and openly displayed or expressed their responses to the composition processes and products.

When choosing a subset of four composers, I based my selections on two criteria: (a) participants who seemed undistracted by the camera, and (b) participants who seemed comfortable talking aloud during the composition process. After reviewing video of participants' activity during the first three weeks of the data collection phase with particular attention to the factors mentioned above, I identified four focus composers, Chelsea, Draco, Emily, and Ryan, for answering the first research question. Choosing four focus composers from the eight participants helped to winnow data for answering my first research question (Kosak, 2014; Wiggins, 1994). However, all eight composers participated in all composition activities even, if they were not one of the four focus composers.

Before answering the second research question, I winnowed the data to include that in which participants displayed or expressed their verbal and non-verbal responses (Erickson, 2006) to the composition process or their products. To encourage composers to reflect on their processes and products, I regularly initiated conversations with participants about their strategies and processes, engaged them in stimulated recall, and encouraged them to think aloud about their processes and products. Also, I conducted semi-structured interviews immediately after each composition session and encouraged participants to step back, reflect, and think deeply *about* the composition process and the compositions they had created within this constructionist-oriented environment.

Data for the third research question included webcam video, screen-captured activity, and researcher notes related to all eight participants and the various ways in which the concept dyads of affect-cognition, constructionism-instructionism, and concrete-abstract manifested themselves within the participants' activity. Because the volume of data was relatively large, I used frequency tables (Erickson, 2006; Maxwell, 2013) generated by NVivo to help decide which concept dyads manifested themselves to the greatest extent. I winnowed the data to include salient examples of the three concept dyads and the most vivid illustrations of participants actions and responses within this particular atmosphere.

Videoed observations. Because of my dual observer as participant role (Merriam, 2014), collecting video data was essential in my study. Although I took concurrent field notes during the process, I was concerned that I might often be unaware of something happening in another part of the room while interacting with individuals and collaborative pairs. Therefore, taking field notes while subsequently observing participants on video proved to be one of the most critical types of data collected. I found that, because of my dual role, impactful data that was impossible to observe otherwise, emanated from subsequent playback of videoed activity. My approach to video data collection and analysis was informed primarily by Erickson (2006) who asserted, "close investigation of learners' interaction with instructional materials and of details of their talk with one and other and with their teachers is necessary, and that video recording and analysis can facilitate this" (p. 8).

The layout of the particular computer lab in which the study took place would have made it challenging to place cameras facing toward participants because each computer abutted a wall. Therefore, I chose to collect videoed observation data using the webcam on each participant's computer. This turned out to provide a distinct advantage because using the webcam enabled me to analyze participants' verbalizations, gestures, and interpersonal activities simultaneously with screen-captured composition activities using the picture-in-picture option. I installed Screencast-O-Matic software (Version 2.0, 2015) on each computer, which included screen-capture and webcam recording functions and recorded both computer-generated audio as well as input from the built-in microphone.

Videoed think-alouds. Talk is a natural component of collaboration, and I hoped that conversation among participants and would yield rich think-aloud data (Burnard & Younker, 2002, 2004; Collins, 2007; Collins & Dunn, 2011; Parry-Jamieson, 2006; Younker, 1997; Younker & Smith, 1996). Ericsson and Simon (1993) reviewed numerous studies utilizing verbal protocol analysis (think-aloud data) and concluded, "…subjects can generate verbalizations, subordinated to task-driven cognitive processes (think aloud), without changing the sequence of their thoughts, and slowing down only moderately due to the additional verbalization" (p. xxxii). In my role as observer as participant (Merriam, 2014), I frequently questioned participants about and commented on their composition activities to capture as much think-aloud data as possible. I encouraged participants to ask questions of each other, answer my questions, and think aloud about the strategies they employed. I also encouraged students to engage in dialogue and solicit feedback from their peers and me, whether working on an individual or collaborative composition. I found that regularly prompting participants to stop, play back their composition, and talk yielded valuable think-aloud data.

Screen-captured composition activities. My role as observer as participant (Merriam, 2014) made it essential for me to rely on screen-captured data to achieve breadth and depth of data. Screen-captured composition activities yielded valuable data for making inferences. I utilized Screencast-O-Matic software to capture all composition activities throughout the 10-week data collection period. In addition to think-aloud data, screen-captured data provided high-resolution video of participants' composition activities, which I combined with webcam video of participants themselves to help me make inferences about their composition strategies and processes.

Videoed stimulated recalls. My research on the use of video-stimulated recalls revealed that this particular method has been employed extensively in studies about second language acquisition (Gass & Mackey, 2000) and, to a lesser extent, in other academic fields. However, this method has also been employed by several music education scholars (e.g., Burnard, 2006'; Tobias, 2010). Based on the application of this data collection method by scholars outside as well as inside the field of music education, I decided to include stimulated recall data. Time constraints sometimes made it difficult to engage students in stimulated recall. However, my analysis showed that this type of data was invaluable. When I noticed there was no verbal data present on video for inferring a particular composition strategy, process, or product of interest, I engaged participants in stimulated recall, when time allowed.

Erickson (2006) claimed that stimulated recall data "must be treated skeptically as evidence of participants' thoughts within the course of the original interaction" (p. 19). However, Erickson went on to say that such recall could provide valuable information "at a lower level of inference" (p. 19). Therefore, stimulated recall was primarily used as a triangulation method at lower inference levels for clarification about composition processes. In these instances, I replayed screen-captured activities in question and asked for clarification from appropriate participants. I made no claim that video-stimulated recall data were evidence of participants' thoughts.

Videoed semi-structured interviews. As a researcher who was quite familiar with 7th-grade music students and the use of composition in general music classrooms, I chose to follow Merriam (2014), who suggested conducting semi-structured interviews when the researcher is particularly familiar with the phenomenon of interest. Because I wanted to ensure that participants' interview responses allowed for flexibility, I chose a semi-structured interview process that allowed me to "use a personally congenial way of asking and sequencing the questions and to segment them appropriately for different respondents" (Miles, Huberman, and Saldaña, 2013, "Instrumentation," para. 10). However, I also aimed for question standardization to some extent so that interview questions could be compared more effectively. Therefore, the semi-structured interview format included predetermined questions that each participant answered, as well as emerging questions that reflected the unique experience of each participant. My list of predetermined questions, as well as questions that emerged throughout data collection, appear in Appendix C (link to Appendix C).

At the end of each 40-minute composition session, I conducted 10-minute semi-structured interviews with participants, who were asked to reflect on their processes and products. As suggested by Merriam, semi-structured interviews were "guided by a list of questions or issues to be explored" (p. 89) and were intended to prompt participants to reflect expressly on the composition process and their products. The semi-structured interview format was flexible enough to include predetermined questions that each participant answered, as well as emerging questions, the answers to which reflected the "worldview of the respondent" (Merriam, 2014, p. 90). I developed predetermined "experience and behavior questions" (p. 96) to ensure that I collected data related to participants' responses to the composition process and their products.

Because creating public entities is a significant component in a constructionist-oriented environment (Papert, 1999b; Papert and Harel, 1991), I was interested in what participants thought about their *products* as much as the composition *process*. Therefore, I utilized semi-structured interviews, along with the other data sources mentioned above, to encourage participants to share their thoughts with me about the compositions they created. These data helped me answer the product-oriented component of my second research question.

Researcher's field notes. In my role as observer as participant, I was moving about the classroom regularly during composition activities, which somewhat inhibited my ability to take notes during class time. However, I kept a mobile device or laptop with Microsoft OneNote software in the classroom at all times, which was available for taking notes when I was not interacting with participants. I also took extensive notes within the NVivo video transcript window for each of the approximately 125 videos generated. This particular data collection method, although typically associated with ethnography, was appropriate in this particular case study because of my observer as participant role.

Field notes helped me integrate my perspective of observer as participant with other forms of data collected. I aimed to balance my impressions while immersed in the process with those emanating from videoed observations. Comparing my impressions represented in field notes with those that emanated while observing videoed activity functioned as a type of 'self-member-checking' process because of my dual role as observer as participant.

Analysis Methods

I adopted an iterative analytic approach in which data collection, winnowing, condensation, and analysis were integrated. I conceived of the data coding process as *part of* analysis and not simply technical, preparatory work for *later* higher-level thinking (Miles, Huberman, and Saldaña, 2013). Therefore, I approached the coding process as the first stage of within-case analysis, during which I began winnowing data, identifying preliminary themes and categories, and condensing codes based on emerging themes and categories.

My first research question centered on inductively analyzing participants' composition processes and strategies; the second research question focused on inductively analyzing participants' displayed or expressed responses to the composition process and the products they create, and my third research question concentrated on deductively analyzing data through the lens of specific theoretical constructs. I utilized Erickson's (2006) Type I inductive strategy for analyzing video data to inductively identify emerging themes and related categories to answer my first two research questions. To answer my third research question, I employed Erickson's Type II deductive approach to analyzing video data. I also used Type II as an additional lens while answering my first two research questions to underscore connections between composers' strategies, processes, and perceptions and the theoretical framework.

The six sources of data collected for this study were: (a) videoed researcher observations, (b) videoed think-alouds, (c) screen-captured composition activity, (d) stimulated recalls, (e) semi-structured interviews, and (f) researcher's field notes. As a novice researcher previously unfamiliar with the process of video analysis, I relied on Erickson (2006), as well as other researchers who have used video data in music education studies to acquaint myself with analyzing video data. The following are descriptions of how I applied Erickson's Type I and Type II approaches to video analysis relative to my three research questions.

Research Questions #1 and #2

According to Erickson (2006), a reader should "come away from an analysis not only tree-wise but forest-wise" (p. 20). To this end, my first two research questions focused on participants in a tree-wise manner through in-depth, within-case analyses, each of which were followed by forest-wise cross-case analyses. For the first research question, I selected four focus composers by applying the constant comparison method (Harding, 2018; Merriam, 2014) while reviewing video data during the first three weeks of the study. I selected the four participants who, during the first three weeks of the data collection phase, seemed to engage regularly in the think-aloud process, readily responded orally or gesturally to peers' and my comments and questions, and articulated their strategies and processes to a greater extent than the other four participants. Choosing these four focus composers by the end of the third week enabled me to plan ahead and pair each one with another focus composer for the collaborative, latter part of the study. For answering the second and third research questions, I included all eight participants in my analysis.

Erickson (2006) suggested six steps for whole-to-part video analysis including: (a) viewing events holistically and take the equivalent of field notes, (b) reviewing again but stop and rewind as needed, (c) seeking out short, sustained powerful examples, and describing, charting or coding them, (d) continuing in this manner of identifying short segments until there is enough information to answer the research question, (e) engaging in stimulated recall with participants, and (f) return to the whole and verify typicality or a-typicality of instances. With the exception of engaging in stimulated recall earlier in the process as a practical matter (i.e., participants were not readily accessible for stimulated recall sessions after the 10-week data collection period), I used Erickson's whole-to part approach for within-case analyses. I also created crosstab and time-ordered matrices (Miles, Huberman, & Saldaña, 2013), which were helpful with synthesizing themes and categories during the cross-case analysis process.

In my presentation of data, I also included word tables (Harding, 2018; Yin, 2009) and network displays (Miles, Huberman, & Saldaña, 2013) that were integral to my constant comparison process. In my study, word tables, matrices, and network displays were invaluable tools for synthesizing data during cross-case analyses discussed later in this dissertation.

Numbers and counting. My research related to using numbers and counting in qualitative research elucidated varying opinions about the extent to which such methods are useful (Creswell and Poth, 2017; Erickson, 2006; Maxwell, 2013; Miles, Huberman, and Saldaña, 2013). Although the goal of qualitative research is not primarily to count things, I found that referring to frequencies of occurrence helped me "fracture the data and rearrange them into categories that facilitate comparison between things in the same category" (Maxwell, 2013, "Strategies for Qualitative Data Analysis," para. 9). Frequency tables and matrices were also helpful in unveiling larger patterns of variation (Erickson, 2006).

Coding. I used NVivo software throughout Erickson's six-step process described above to apply in vivo coding (Miles, Huberman, and Saldaña, 2013). Through this approach, I focused on phrases that were used repeatedly (or similarly paraphrased) by participants, or common threads in their accounts to establish patterns of strategies, processes, and perceptions. Additionally, I looked for patterns that illuminated differences among participants' composition strategies, processes, and perceptions. Considering the significance of relationships among people and theoretical constructs to the framework of this study, it seemed appropriate to use three 'summarizers' (Miles, Huberman, and Saldaña, 2013) during the coding process to initially group data into general categories. The summarizers I applied to my initial coding process were: (a) categories, (b) relationships among people, and (c) theoretical constructs.

Research Question #3

Analysis for the third research question included data related to all eight participants and the extent to which and how three concept dyads surfaced during my within- and cross-case analyses. These concept dyads were: (a) constructionism-instructionism, (b) affect-cognition, and (c) concrete-abstract. The specific theoretical concepts associated with these concept dyads and of interest to me were *bricolage, scaffolding, direct instruction, syntonic learning, hard fun, metacognition, cognitive complexity*, *socio-cognitive conflict,* and *epistemological pluralism*. Throughout this dissertation, I used the term *variables of interest* (Miles, Huberman, & Saldaña, 2013; Yin, 2009) to identify the specific theoretical constructs that I was particularly interested in examining. These variables of interest are explicitly tied to the theoretical framework and are compatible with Erickson's (2006) Type II, deductive approach to video analysis. Erickson used the term "communicative/pedagogical functions of research interest" (p. 21), which is similar to my use of the term *variables of interest*. It is important to note that, although I counted occurrences of my *variables of interest*, I counted primarily to help me determine the extent to which these particular theoretical constructs manifested themselves in this qualitative study. I did not perceive of these variables as metrics such as those used in a quantitative study.

In step two of Erickson's Type II deductive approach, Erickson suggested identifying "instances of interest exhaustively" (p. 21). I used this method combined with constant comparison (Harding, 2018; Merriam 2014) to identify action and talk that exemplified specific variables of interest. For step three, Erickson suggested tabulating frequencies of occurrence, which was helpful to me in moving from part to whole while answering the third research question.

Erickson's (2006) fourth step is to write detailed descriptions that illuminate "what a few of the various kinds of instances look like in actual performance" (Erickson, 2006, p. 22), an approach I utilized during the cross-case analysis process for the third research question. I used NVivo software throughout Erickson's four-step process described above to code data that reflected the concept dyads and related theoretical constructs discussed above, which I looked for deductively within each composition session.

Within- and Cross-Case Analyses

In multiple case studies, it is typical first to provide a detailed description of each case and identify themes *within* each case referred to as within-case analyses. This is followed by a thematic analysis *across* cases and an interpretation of what is found as a result of the cross-case analysis (Creswell, 2012; Yin, 2009). Within- and cross-case analyses allow researchers to attempt drawing “generalizable conclusions that *could* [emphasis added] apply to many other programs” (Yin, 2009, “Variations within Case Studies,” para. 5). I engaged in within- and cross-case analyses to deepen my understanding of participants’ composition strategies and processes, gain insight into participants’ responses to the composition process and the products they created, seek out negative cases or rival interpretations, and strengthen or question theory (Miles, Huberman, & Saldaña, 2013; Yin, 2009).

I applied a case-oriented approach to answer the first and second research questions because my objective was to first look for patterns within cases followed by comparing and contrasting those cases. I utilized a variable-oriented approach to answer the third research question because I was interested in applying a wide, theoretical lens to my observations of all eight participants. A variable-oriented approach casts a wide net over cases to examine variables of interest and their interrelationships. When applying a variable-oriented approach, the researcher homes in on the main trends across cases while “the details of any specific case recede behind broad patterns found across a wide variety of cases” (Miles, Huberman, and Saldaña, 2013, “A Key Distinction,” para. 2).

In addition to using NVivo software for the coding process, I used NVivo to create crosstab and time-ordered matrices (Miles, Huberman, and Saldaña, 2013) related to the first two research questions, and a hierarchy chart to represent data related to the third research question. The primary advantage of a time-ordered matrix is to examine “concurrent pathways of multiple variables and researcher evaluation notes” (“Ordering by Time,” para. 1) among multiple cases. Another advantage of matrices is that readers can see for themselves how conclusions were drawn, "rather than being handed summarized study results to be taken on faith" ("Making Inferences and Drawing Conclusions," para. 4).

While preparing for the cross-case analysis related to research question #2, it became apparent that creating word tables (Harding, 2018; Yin, 2009) and network displays (Miles, Huberman, & Saldaña, 2013) would help me identify cross-case patterns. I employed word tables to identify cross-case patterns that helped me focus on "argumentative interpretation, not numeric tallies" (Yin, 2009, "Cross-Case Synthesis," para. 6). Similarly, network displays were invaluable tools for identifying interrelationships among themes, theme-related categories (i.e., codes), and participants' actions and responses. I conceived of matrices, word tables, and network displays as snapshots that assisted with interpretation, making inferences, and drawing conclusions during the cross-case synthesis process. These visual displays were essential tools as I homed in on emergent themes, related categories and sub-categories, and discrepant cases.

Limitations of the Study

My study was an examination of the composition processes and products of eight 7^{th}-grade participants chosen through purposeful sampling from a population of 68 students in one particular suburban West Coast, college preparatory, independent school. Demographically speaking, the school is predominantly White, ranging from upper-middle to upper class. I am aware that similar studies within different contexts would likely produce different results and did not attempt to generalize results from this study to other populations. However, this does not preclude the possibility that results from this study may resonate with other similar situations, settings, or populations.

Due to the relatively small and homogeneous population of potential participants, I limited the purposeful sampling process to three particular demographic characteristics that I believed were feasible to diversify: (a) gender, (b) amount of private music lessons outside of school, and (c) previous experience creating original music. The purpose of this study was not to make contrasts or comparisons among participants based on demographic information. However, I believed it was important to create as diverse a group of participants as possible under the assumption that a diverse group of participants might result in a richer data set. It is possible that this study may have produced different results if the pool of potential participants had been more substantial and more diverse.

Participants were limited to using one particular software program chosen for its distinctly constructionist-oriented nature. Hyperscore is graphic music notation software developed at Massachusetts Institute of Technology (MIT) Media Lab and, in the Papertian sense, provides novice composers “objects to think with” (Papert, 1980a, p. 11). This particular software is designed primarily for users with limited or no musical training, enabling them to control pitch, rhythm, timbre, and melodic contour, and harmonic tension intuitively using graphic notation. One particularly notable limitation of Hyperscore is the relatively small number and relatively low quality of timbres available to users. The software incorporates 128 General MIDI timbres, which sound particularly synthetic and unrealistic. Despite the limitations associated with Hyperscore, I chose this particular software because of its inextricable link to the constructionism learning approach, and I do not claim that the results of this study would be similar if participants had used different graphic notation software or other mediating tools. The use of Hyperscore itself may have precipitated specific results.

The theoretical concept dyads on which the third research question focuses are solely a reflection of my relative level of curiosity about particular theoretical tenets as I reviewed the literature on constructionism, cognitive constructivism, and social constructivism. Many other constructionism-oriented concepts could have been examined, but those delineated in the third research question resonated with me strongly as I reflected on these learning approaches and their potential implications for music education. I do not assert that these particular concepts collectively epitomize Piagetian constructivism, Vygotskian social constructivism, or Papertian constructionism, respectively, or as a group.

Although embedded multiple case studies provide the opportunity to wholly examine several participants' processes and products within the same context, they typically produce extensive and diverse data that are challenging to winnow and manage. This study generated a large amount of data, including webcam video, screen-captured video, researcher field notes, and participant interviews. In multiple case studies, the researcher encounters many considerations when deciding which data to include for analysis. At best, the final report in this embedded multiple case study is a vivid snapshot extracted from a larger scenario, which was interpreted by me, a single observer.

Trustworthiness

Internal Validity

Multiple case studies inherently strengthen validity and add confidence to findings by examining extensive data from multiple units of analysis that are synthesized across cases (Miles, Huberman, and Saldaña, 2013). Because I aimed for including as many strategies as possible to bolster trustworthiness, I incorporated numerous validation procedures including: (a) clarifying researcher bias, (b) triangulation, (c) prolonged engagement and persistent observation, (d) member checking, (e) peer-review, and (f) negative case analysis or discrepant evidence (Creswell, 2012; Maxwell, 2013). I used the constant comparison method (Harding, 2018; Merriam, 2014) over a prolonged period of three months to analyze data and enhance validity.

Researcher bias. For my study, I took on the role as observer as participant during composition activities, which meant that I was the researcher who not only observed but guided and instructed participants as needed. A case study in which the researcher is also observer as participant is inherently limited because “the sensitivity and integrity of the investigator is the primary instrument of data collection and analysis” (Merriam, 2014, p. 52).

It is essential to disclose that I likely influenced participants’ processes and strategies in my role as observer as participant. I perceived of such influence as *reactivity*, and my goal was “not to eliminate this influence, but to understand it and use it productively” (Maxwell, 2013, “Reactivity,” para. 1). However, my role as observer as participant was consistent with a naturalistic (Lincoln & Guba, 1985; Papert, 1987, 1999;

Papert & Harel; 1991) setting. My decision to act as observer as participant in this study was partly a matter of convenience. I am the only general music teacher in this particular school, and although it may have been preferable to train the school's choir or band instructor to use Hyperscore and take on the observer as participant role, the school's daily schedule made this scenario infeasible. Also, I was significantly more experienced with music technology, and composition than the choir and band instructors, which influenced my decision to take on the role rather than asking the choir or band teacher to do so.

Another possible source of bias may have come from my particular experience and areas of interest as a music educator, which may have unintentionally influenced my interpretation of the data. I have a keen interest in using music technology and composition within the general music classroom, and regularly seek out various ways to engage students in composition and use of technology within the general music classroom. Therefore, as much as I aimed to maintain awareness of this particular interest throughout this study, my examination and analysis of 7th-grade novice composers' strategies and processes could have been influenced by my bias toward the use of technology and composition in the music curriculum.

Triangulation. Triangulation took place by analyzing multiple sources of data, including videoed observations, screencast captures of participants' compositions, videoed think-alouds, videoed stimulated recalls, videoed semi-structured interviews, and researcher field notes. Multiple semi-structured interviews enhanced triangulation by drawing on previous interviews to formulate follow-up questions for participants. Also, I drew on three perspectives to validate data: (a) the participants' perspectives articulated through composition activities, think-aloud data, and verbal responses to semi-structured interviews and stimulated recalls, (b) my perspective of observer as participant (Merriam, 2014) during composition activities, and (c) my perspective as an 'outsider' who observed participants' composition activities on video subsequent to each composition session.

Analyzing three types of verbal data (think-alouds, stimulated recalls, and semi-structured interviews) and screen-captured composition activity was helpful in triangulation. Rather than inferring participants' strategies or processes from screen-captured data alone, I was able to use videoed verbal data for corroboration. As an additional triangulation component, I examined frequencies of occurrence (Erickson, 2006) tabulated for questions one and two, and word tables and network displays related to question two. Crosstab and time-ordered matrices (Miles, Huberman, and Saldaña, 2013) and word tables (Harding, 2018; Yin, 2009) were invaluable tools for drawing inferences by providing visual and summary representations of data that could be compared and verified within and across cases.

Concerns surrounding verbal reports as data. While considering using verbal reports (i.e., think-alouds) as data, I wondered if questions might exist about their efficacy reports for accurately reflecting research participants' thought processes. Therefore, I reviewed the protocol analysis model set forth by Ericsson and Simon (1993), who asserted that subjects can verbalize cognitive processes "without changing the sequence of their thoughts and slowing down only moderately" (p. xxxii). I also investigated how previous researchers have made use of verbal reports as data and determined that think-aloud data was important for helping me understand participants' strategies and processes. However, I do not claim that think-aloud data can be interpreted as insight into the human mind (Perkins, 1981; Wilson, 1996).

While discussing concerns about asking people to think aloud concurrently or report something right after their actions, Perkins (1981) asserted, "the risks of disruption are largely a cultural myth, something so plausible-seeming and so often repeated that people take it as fact even though there is hardly any evidence for it" ("A Voice for the Mind," para. 10). Perkins argued that if thinking about something "just means observing, that need not be disruptive at all" (para. 14). Also, Perkins claimed that simply asking subjects to express their thoughts and not asking them to "think about their thinking" (para. 14) is unlikely to prevent accurate reporting, and further asserted that various experiments have shown "disruption is not a serious problem" (para. 17).

The validity of think-aloud data as the sole data source has been questioned because cognitive load may increase during problem-solving activities, making accurate *concurrent* verbal reporting difficult for participants (Collins, 2007). However, previous researchers have found that participants who are asked to engage in *immediately retrospective reporting* is effective because respondents "should still retain in their short-term memory the necessary retrieval cues to report everything they can remember about their thoughts from the immediately preceding problem-solving situation" (Collins, 2007, p. 241). Ericsson and Simon found that participants who are asked to engage in *immediately retrospective reporting* can retrieve valid information when a general instruction is given “to report everything you can remember about your thoughts during the last problem” (p. 19). In addition, Ericsson and Simon concluded that research participants can accurately and concurrently talk aloud about low cognitive load problem-solving activities that do not involve sophisticated perceptual-motor skills.

Based on the conclusions of previous researchers cited above, and the use of verbal reports as data by previous music educators, I felt comfortable including think-aloud data as one of the multiple sources of data in my study. In the context of this study, think-alouds refer to participants’ concurrent or immediately retrospective reports during their composition activities. I reserved explicitly prompting participants to think about their thinking during later stimulated recall moments and semi-structured interviews.

Prolonged engagement and persistent observation. In my effort to build trust with participants and allow time for the constructionist-oriented environment to thrive, I interacted with participants over a relatively long 10-week period. This prolonged period reflected helped to support internal validity (Creswell, 2012; Maxwell, 2013). Prolonged engagement also allowed me to learn the culture and check for misinformation (Creswell, 2012; Maxwell, 2013). Repeated observations and interviews, such as those included in the present study, helped to “rule out spurious associations and premature theories” (Maxwell, 2013, “Validity Tests,” para. 4). Multiple viewing of video data facilitated persistent observation well beyond the 10-week collection period and enabled me to continually revisit and recheck my observer perspective (Derry, 2007).

Member checking. I utilized member checking (Creswell, 2013) or *respondent validation* (Maxwell, 2013) regularly to verify my interpretation of participants’ strategies and processes. Participants' responses to my questions during the think-aloud process, daily semi-structured interviews, and occasional video stimulated recalls allowed me to employ member checking regularly during the 10-week data collection period. Also, a great deal of member checking occurred when I asked participants to describe their composition strategies and experience orally. I included participant responses to their actions while viewing themselves on video as a method to increase validity, a strategy known to be especially effective when participants watch themselves as soon as possible after their activity (Derry, 2007). Except for certain occasional video stimulated recalls, participants' verbal reports were captured within relatively close proximity to their composition activities through think-alouds, videoed observations, and semi-structured interviews.

I anticipated the effect of member checking coinciding with data collection and its potential for influencing participants' perspectives or actions (Miles, Huberman, and Saldaña, 2013). As the researcher who observed, but also participated by assisting and instructing as needed, I may have influenced participants' perspectives or actions when applying *respondent validation* immediately rather than relying on participants' longer-term memory at a later time or date. When this happened, I aimed not to influence participants' perspectives or actions when asking clarifying questions. In the interest of maintaining a naturalistic setting (Lincoln & Guba, 1985), I strived to maintain a balance between observing and participating (i.e., assisting and guiding) during composition activities.

Peer-Review. The data set for my study underwent a brief peer-review (Creswell, 2012) with a professor emeritus who holds a Ph.D. in the field of music education and is a well-known qualitative music education researcher. The peer-review focused on examining data related to the first two research questions and reviewing the various themes and categories I identified during the coding process. Considering that a priori codes had already been developed for answering the third research question, and the reviewer was not familiar with the concept-dyads referenced in the third research question, the peer-review did not include examining data related to the third research question.

Negative cases and discrepant evidence. To be as open-minded as possible to contrary findings (Yin, 2009, 2015), I used the constant comparison approach to look purposefully for contrasting cases and avoid "the proclivity to find confirming rather than disconfirming evidence" (Creswell & Miller, 2000, p. 127). The constant comparison approach helped me identify inconsistent or conflicting findings and "outliers in the phenomena…that merit[ed] closer examination" (Miles, Huberman, & Saldaña. 2013, "Triangulation," para. 5), as much as consistent, recurring themes and patterns that emerged from the data. I intentionally sought to find data that refuted emerging themes and aimed to balance my search for confirming and disconfirming evidence while answering my three research questions. Such balance was essential for establishing verisimilitude (Barrett, 2014; Creswell, 2013; Miles et al., 2013), and I was continuously aware of balancing my search for recurring themes with seeking discrepant evidence.

Constant comparison method. I applied the constant comparison method while analyzing various types of video data and my field notes to characterize particular events or states into more abstractly defined categories (Miles et al., 2013). In addition to the constant comparison of video data sources, my field notes underwent constant comparison with the various sources of video data (i.e., composition sessions, screen-captures, think-alouds, interviews, and stimulated recalls) to confirm or disconfirm my impressions and inferences. The constant comparison method was instrumental in developing the cross-case analyses presented in this dissertation.

Reliability

My goal was not to ensure that circumstances of my study could happen twice, "but whether the results are consistent and dependable within the data collected" (Merriam, 2014, p. 221). It is vital to distinguish reliability in qualitative research from that of quantitative research. Reliability in qualitative research stems from consistency and dependability, rather than the ability to replicate findings in future studies. If the findings of a study are consistent with the data presented, the study can be considered dependable. Certain strategies for establishing internal validity also help to make data consistent and dependable. For example, using multiple methods of collecting data and triangulation, both of which took place in my study, helps to ensure data analysis consistency and dependability. Throughout the present chapter, I aimed to identify my "biases, dispositions, and assumptions regarding the research to be undertaken" (Merriam, 2014, p. 219) in my effort to make data interpretation more dependable.

I took a number of steps to improve reliability including: (a) describing methods and procedures in detail, (b) detailing how data were collected and processed so an outsider could easily audit the process, (c) explicitly stating personal assumptions and biases, (d) retaining data for potential re-analysis by others, (e) ensuring that the study design is congruent with research questions, (f) explicitly describing my role, (g) ensuring connectedness to the theoretical framework, and (h) collecting data across the full range of appropriate settings, times, and participants (Miles, Huberman, and Saldaña, 2013).

I aimed to document procedures to such an extent that a subsequent researcher could follow the same procedures in the *same setting* with the *same participants* and arrive at the same findings and conclusions (Yin, 2009). To this end, I maintained a detailed account of all research decisions and procedures, which described how data were collected and analyzed. I integrated this chain of evidence with video data and researcher notes using NVivo software. This allowed me to create what Yin referred to as a case study protocol, which includes case study notes, documents, and narratives collected during the study and organized so that later investigators may retrieve this protocol if requested. The audit trail I created increased reliability by enhancing confirmability and dependability (Creswell, 2013; Merriam, 2014; Yin, 2009).

Generalizability

As stated earlier, I was aware that similar studies within different contexts would likely produce different results and did not attempt to generalize results from this study to other populations. Studying multiple cases can increase potential generalizability;

furthermore, “it is the reader, not the researcher, who determines what can apply to his or her context” (Merriam, 2014, p. 51). I strived to enhance *transferability* (Lincoln & Guba, 1985) rather than generalizability. Although I could not know the sites to which transferability might be sought, I provided sufficient descriptive data to make establishing transferability possible. Therefore, conclusions drawn from my study may resonate with other similar situations in the field of music education.

I applied maximum variation sampling to potentially enhance transferability. I purposefully chose participants with varied musical backgrounds and different genders, which “allowed for the possibility of a greater range of application by readers or consumers of the research” (Merriam, 2014, p. 227). Although variations in participants’ characteristics in my study were not wide-ranging due to the relatively small pool of 68 potential participants, purposeful sampling allowed me to establish a somewhat diverse group of participants. This diversity, limited as it was, was intended to increase the possibility of this study’s transferability to other situations.

The research questions for the present study were underpinned by a robust theoretical framework and were meant to facilitate theoretical inference, not wide generalization. My goal was not to prove but to present claims soundly and logically so that other music educators may determine for themselves if the findings from this study may transfer to situations familiar to them. The relatively small number of cases in the present study cannot and were not intended to generalize to a larger population. However, *analytic generalization* (Yin, 2012) can be valuable due to its emphasis on “using a study’s theoretical framework to establish a logic that might be applicable to other situations" ("Generalizing from Case Studies," para. 3). In my study, I aimed to elucidate constructionism as a theoretical framework that may or may not be transferrable to other music educators' situations.

Various qualitative researcher experts have emphasized the significance of internal generalization, and I aimed for strong internal generalization by utilizing tenets of constructionism as the underlying framework for answering research question three, only the most salient themes and categories that emerged for answering research questions one and two, and word tables and network displays as additional instruments for answering question two. Also, examining frequencies of occurrence functioned as one way of checking the internal generalizability of my conclusions (Maxwell, 2013), which I did by creating crosstab and time-ordered frequencies of occurrence (Erickson, 2006) matrices for the first two research questions and a hierarchy chart for the third research question.

CHAPTER 4: PARTICIPANTS' COMPOSITION STRATEGIES AND PROCESSES

The previous chapter described the design and methodology for the present study examining the composition strategies and processes of 7th-grade composers in a constructionist-oriented setting. For this chapter, I focused on four participants to answer my first research question: What composition strategies and processes do participants display or express while composing music within this constructionist-oriented environment? Also, in this chapter, I underscored how the theoretically-oriented variables of interest that I identified in Chapter 1 revealed themselves as I analyzed participants' composition strategies and processes. In Chapter 6, I will elaborate on these variables of interest by filtering the data through the theoretical framework and presenting a cross-case analysis framed by the concept dyads I identified in Chapter 1.

The focus composers, who chose their own pseudonyms, were two females and two males. I chose the focus composers based on my observations during the first three weeks of the data collection phase. The focus composers engaged regularly in the think-aloud process, readily responded orally or gesturally to my and peers' comments and questions, and explicitly articulated or displayed their strategies and processes to a greater extent than the other four participants. I selected the participants by applying the constant comparison method while I reviewed video data of participants in action during the first three weeks of the study.

The focus composers participants presented in this chapter engaged in five weeks of individual composition followed by five weeks of collaborative composition with a partner while using Hyperscore music composition software. I used Screencast-O-Matic and its picture-in-picture function to record participants' simultaneous on-screen composition activities, voices, and physical activity. Similar to Bamberger (2003) and Hickey (1995), I imposed no time limits or specific guidelines during the 10-week data collection period. Also, I assured participants that I would neither adjudicate the quality of their compositions nor grade their final products.

The within-cases analyses of the participants' strategies and processes presented in this chapter focus on the most prevalent in themes and related categories that surfaced as I observed the participants composing individually and in pairs. I combined examining crosstab and time-ordered matrices with constant comparison and seeking out exceptions, variants, and contrary findings among the most prevalent processes and strategies displayed or expressed by the four focus composers. My within-case analysis process comprised nine months of coding, transcribing, note-taking, counting, comparing and contrasting, and disassembling and reassembling data while "being especially alert to negative instances, developing rival explanations, and continually posing questions" (Yin, 2011, p. 177) about the data.

As I proceeded through the coding process and toward identifying themes and related categories, I continued to employ Erickson's (2006) Type I inductive approach to video analysis (p. 17) and the constant comparison method for inductive analysis. In a manner described by Creswell (2007), I built patterns from the bottom up "by organizing the data into increasingly more abstract units of information…working back and forth between the themes and the database" (p. 38). I ultimately identified four overarching themes, each with multiple related categories that guided my within- and cross-case analyses. Figure 2 represents the emergent themes and related categories pertinent to my first research question, which I answer in this chapter. To underscore the full range of strategies and processes used by the participants in the present study, I enumerated the related categories for each primary theme comprehensively and included all theme-related categories observed in Figure 2. However, as a practical matter, within this chapter, I discussed only the most prevalent strategies and processes.

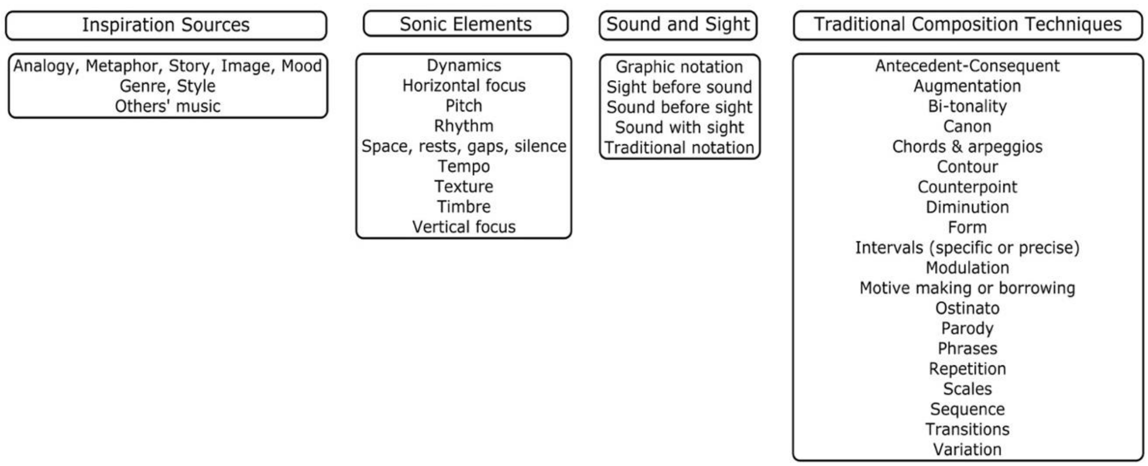


Figure 2. Themes and related categories pertinent to research question #1.

The within- and cross-case analyses presented in this chapter aim to show the metaphorical trees and forest, respectively, while attempting to employ a manuscript style intended to be visually varied and engaging (Yin, 2009, 2011). This chapter includes selected situations, quotations, transcriptions, screenshots, tables, and figures intended to illuminate the participants' most salient strategies and processes as they composed individually for five weeks and then collaboratively in pairs for five weeks.

Emily Composing Individually

Emily stated that she had no previous experience composing music before taking part in this study. She indicated that she had taken private lessons on piano and electric bass for more than one year. I chose Emily as one of the focus composers because she consistently and clearly articulated her strategies and processes when I asked her to elaborate or engage in stimulated recall:

> SD: Does it matter if you have a strategy?
> Emily: I think both strategy and experimentation would be really good. Just needed to get something out there, so I experimented. Definitely easier to have some kind of idea of what you want the piece to be and what you want it to start out as.
> (stimulated recall, October 2, 2017)

While observing Emily's and all other participants' strategies and processes, I used NVivo software to code both verbal and non-verbal (i.e., body language and screen captured Hyperscore activities) data. Erickson (2006) and Maxwell (2013) recommended creating frequency tables to help identify codes (categories) and important themes. Considering the extensive amount of video data produced during the 10-week course of this study, and the large number of categories that emanated from the analysis process, frequency tables became an invaluable tool for me as I searched for the predominant strategies and processes displayed or expressed by each participant.

Sonic Elements in Emily's Process

Emily integrated various sonic elements into her compositions in multiple ways and to varying degrees. Table 2 delineates the sonic elements and frequencies of occurrence, reflecting Emily's individual composition process during Weeks 1–5 (link to Table 2, Appendix D). In Emily's case, I determined that tempo, rhythm, and timbre were the predominant sonic elements that emerged from her individual composition process.

Tempo. Tempo as a sonic element was regularly evident in Emily's think-aloud data with comments such as, "I wanted it to start slow and slowly pick up" (individual composition, September 20, 2017). Emily appeared to think of making tempo changes as a specific composition strategy. At one point, Emily wanted the tempo of her composition to increase; however, creating internal tempo changes is not an option in Hyperscore. After encouraging Emily to think critically about how to solve this problem, she eventually determined that she could create the effect of an accelerando by decreasing note values and the space between notes.

Rhythm. Emily often hummed or sang the specific rhythm that she wanted while simultaneously notating the rhythm with the droplets tool, an example of *body-syntonic* (Papert 1980a) behavior that occurred regularly throughout Emily's process. As illustrated in Figure 3, she usually created evenly-spaced rhythms using the same note duration several times in succession and demonstrated the intentional and consistent use of rests (<u>link to Figure 3, Appendix D</u>). Emily usually took time to align her rhythms vertically and carefully and appeared to use the on-screen grid to intentionally place notes (<u>link to Figure 4, Appendix D</u>). Emily tended to focus on beat-making over other sonic elements in her compositions. Creating a steady beat was a high priority for Emily and often came first in her process. For example, as she began her second individual composition, Emily dedicated several minutes to perfectly aligning the 'boom-chick' kick and snare drum notes on her basic drumbeat. Emily diligently alternated between listening and adjusting note spacing until she was satisfied with the steadiness of her beat (link to Figure 5, Appendix D).

Timbre. Emily spent a great deal of time exploring the timbres (instruments) available in Hyperscore. Emily's think-aloud data often indicated her concern about finding satisfactory instruments. She made comments such as, "I need a new instrument to kind of soften it up…I need a quieter instrument" (individual composition, September 8, 2017). Emily seemed to have a strong sense of what different instruments sounded like and what she preferred, which resonated with Papert's (1980a) idea of *ego syntonicity* Papert defined as "that which is coherent with children's sense of themselves" (p. 63).

Emily usually took time to compose melodies using the default Hyperscore piano sound and drum sounds before exploring different timbres available in the software. However, after composing melodies, she often spent considerable time focused on assigning instruments (timbres). Emily was particular about which timbres she thought sounded best for her melodies, and I sometimes noted that Emily seemed to have a wide-ranging palette of instrumental colors in mind and a solid sense of what various instruments should sound like: "Why is it so high? That's not what bass is" (individual composition, September 26, 2017). Emily appeared to be thinking abstractly in sound before concretely applying her desired timbres using the software. This type of thinking exemplified abstract thinking being "on tap," as described by Turkle and Papert (1990, p. 133).

Traditional Composition Techniques in Emily's Process

Despite the lack of formal composition instruction, Emily intuitively applied various traditional composition techniques, although she usually did not know the musical term for the technique she was applying. Emily's overall unfamiliarity with traditional composition techniques prompted me to take on a participant role rather than merely observing. Table 3 displays frequencies of occurrence that helped me determine which traditional composition techniques were prevalent in Emily's process during the first five weeks (link to Table 3, Appendix D). I determined that contour was the predominant traditional composition technique emanating from Emily's individual composition process. Emily's motive-making strategy and use of chords and arpeggios were also relatively prevalent.

Contour. Contour emerged as a significant aspect of Emily's composition process. Early in the process, Emily's most common approach to contour was to draw highly organized, aligned sequences of droplets when creating melodies, and relatively straight lines for drawing phrases in the Hyperscore sketch window (link to Figure 6, Appendix D). By the time Emily completed her final composition, her approach to contour on the sketchpad (i.e., conductor's score) was more exploratory in nature and contrasted somewhat with her previous, predominantly linear approach to contour. Although Emily's *melodies* in her final composition remained somewhat linear and organized, she took a drastically different, more random and curvilinear approach to drawing *phrases* in the sketch window as, seen in Figure 7 (link to Figure 7, Appendix D).

Motive-making. Emily was inclined to create relatively short, highly-organized motives of relatively few notes. Her longer motives tended to be scalar, at times creating diatonic scales and at others drawing chromatic scales. It appeared that the concept of a scale as a strategy for creating motives was foremost in Emily's mind based on her first think-aloud moment during her first individual composition session:

> So right now, I am gonna try to make a song that kind of goes up like a scale, kind of. But not a scale, like um, from like, starts quiet and soft and then goes loud and then all over the place. (individual composition, September 1, 2017)

Emily's motives were linear overall, and usually comprised straight lines of repeated notes or highly structured patterns of repetitive intervals, as demonstrated by the purple, light blue, and orange motives in her final composition (see Figure 7). During her final individual composition session, I observed Emily creating a more disjunct melody (link to Figure 8, Appendix D), which she immediately deleted after listening to it saying, "Okay, this is really not working for me" (individual composition, October 2, 2017). In one of Emily's first compositions, which bore a preponderance of linear, highly structured motives and predominantly straight lines on the sketchpad, as shown in Figure 9 (link to Figure 9, Appendix D), Emily was thinking aloud about a title for her piece, saying, "Now I want to name it, but not sure what to name it. Linear, linear, linear, linear. Linear movement. Linear track. Linear, linear, linear, linear" (individual composition, September 8, 2017).

Chords and arpeggios. Early in her individual composition process, Emily did not create chords, but it was clear that she had prior knowledge of chords:

> SD: Do you know much about chords?
> Emily: There are three notes in a chord. C-E-G is a major chord, with the black note it's minor.
> SD: Can you figure out a major chord with the software? (Emily arranges the droplets to create a major chord by ear. She eventually succeeds with a little

help.)
(individual composition, September 26, 2017)

I noted that after this brief interaction, Emily began regularly incorporating chords into her compositions, carefully listening as she placed notes in the melody window and creating a tertiary pattern (field notes, September 26, 2017). Emily also discovered that using the droplet tool in the sketch window created chords, a finding that was apparently exciting to her considering the countless number of chords she inserted in her final composition (see Figure 7). During one particular stimulated recall session, Emily described how a series of chords she created reminded her of a piano piece she knew, *Arabesque* by Burgmüller. Emily seemed particularly excited about the possibility of being able to use the *Arabesque* chords in her individual composition.

Sound and Sight in Emily's Process

The interplay between sound (e.g., humming, singing, listening) and sight (i.e., notation) manifested itself in various ways as I observed Emily's individual composition process. At times, I observed Emily interacting with sound and sight dynamically; however, most of the time, she focused discretely on either the aural or visual aspect of the composition process. Participants each used the Hyperscore graphic notation tools in their unique manner, and some participants strived to reconcile what they knew about traditional notation with Hyperscore's graphic approach to notation. In Emily's case, graphic notation emerged as the most prevalent Sound and Sight category, as indicated in Table 4 (link to Table 4, Appendix D).

Graphic notation. While using the graphic notation tools provided by Hyperscore, I observed that Emily's use of droplets was a prevalent part of her process. I also noted that Emily applied two geometrically-oriented strategies, reflection and translation, which are referred to as inversion and transposition, respectively, in music.

As displayed in Figure 10 (see Appendix D), one of Emily's graphic notation strategies was to draw random droplets on the sketch pad, which causes Hyperscore to insert chords rather than single pitches. Emily was initially not pleased with the dissonant quality of her droplets, saying, "That reminds me of chaos, and that something needs to be done to control it all" (individual composition, September 14, 2017). Eventually, Emily discovered Hyperscore includes a 'classical' algorithm that converts dissonant droplet clusters to consonant, tertiary chords. After this discovery, Emily used droplets extensively on the sketch pad to include numerous chords in her final composition (see Figure 7). At one point, after adding many 'classical' droplets (chords) to her composition, Emily remarked, "This piece makes me think of a concerto, one that a composer would write, not me" (individual composition, September 14, 2017). Here again, Papert's (1980a) concept of *ego syntonicity* surfaced in Emily's opinion of herself as *not* a composer.

In her final composition, Emily applied reflection (i.e., inversion in music) to create extended phrases of contrary motion. As shown in Figure 10 (link to Figure 10, Appendix D), Emily drew her blue and yellow melodies to sound simultaneously yet rise and fall in opposite directions throughout the composition. Emily also experimented with translation (i.e., transposition in music) as part of her process. For example, before determining the final location for her red melody in Figure 10, she transposed it up and down until she found her preferred pitch level. The droplets in Figure 10 were reminiscent of a geometric scatter-plot and appeared to decorate her red melody and her blue and yellow melodies moving in contrary motion. I often observed Emily copying, pasting, and transposing her melodies or motives to new pitch levels, as shown in Figure 11 (link to Figure 11, Appendix D).

Inspiration Sources in Emily's Process

Each of the participants drew on inspiration to different extents and from various sources to help them in the composition process. When Emily demonstrated a need for inspiration, she referred to others' music for ideas. Occasionally, Emily inadvertently came across one of the sample compositions included with Hyperscore and listened to it for inspiration: "I think I wanted to listen to hear, like, some sort of inspiration" (stimulated recall, October 26, 2017). Occasionally, Emily listened to Chelsea's music for inspiration. This might have been a matter of convenience because Chelsea sat nearby, but Emily mostly listened to Chelsea's music and rarely ventured to the other side of the room to hear Bri's or Brittany's compositions.

At one point, I asked Emily about her strategy as she worked intently to build a major arpeggio. Emily responded, saying, "I think I listened to this piece of music before, and I kinda got like inspired by that" (stimulated recall, October 12, 2017). Emily's words, and her attempt on another occasion to emulate *Arabesque* by Burgmüller, indicated that she was connecting the composition process with her previous experience, at least to some extent. On another day, when asked if she had intentionally incorporated a chromatic scale in one of her compositions, Emily shared, "I had just learned how to play *Phantom of the Opera*" (stimulated recall, November 7, 2017), and expressed her desire to include a chromatic scale in her composition. Emily's reflection on familiar music followed by applying her previous knowledge to her compositions was an example of a *reflexive* process, as described by Ackermann (1996) and Duffy & Cunningham (1996).

Chelsea Composing Individually

Chelsea stated that she previously created music on her own to a minimal extent by improvising on the drums. She had taken private lessons on the drums for less than one year. Early in the process of observing Chelsea, it became clear that she was generally comfortable thinking aloud and expressing herself orally, which is why I selected her as one of the focus composers.

Sonic Elements in Chelsea's Process

As indicated in Table 5, several sonic elements played a role in Chelsea's individual composition process during the first five weeks of the study (link to Table 5, Appendix D). What follows is a discussion of the five sonic elements that provided the richest data in Chelsea's case: dynamics, tempo, pitch, rhythm, and timbre.

Dynamics. Chelsea seemed to prioritize incorporating dynamics into her compositions and would spend considerable time creating dynamic effects: "Stacking notes makes them louder. You can't make them louder, only longer" (stimulated recall, October 6, 2017). This comment was Chelsea's explanation for creating dense clusters of notes on top of each other. She aimed to increase the intensity of her notes, and this was her creative solution to the lack of a velocity function in Hyperscore.

Similar to the cluster approach to dynamics described above, Chelsea sometimes copied and pasted fragments of phrases on top of each other to vary the intensity of her phrases and create a quasi-Baroque terraced dynamics effect, as shown in Figure 12 (link to Figure 12, Appendix D). Later, as shown in Figure 13, Chelsea discovered that adjusting the thickness of lines on the sketchpad allowed her to build crescendos and decrescendos instead of sudden dynamic changes (link to Figure 13, Appendix D). In one of our semi-structured interviews, Chelsea expressed her interest in dynamics, saying, "I kind of like the whole concept of getting louder and quieter" (interview, October 2, 2017).

Tempo. Starting with her first individual composition session, Chelsea experimented with the metronome settings. Although Chelsea did not seem to realize that adjusting the tempo of each discrete melody, motive, or rhythm outside of the sketchpad did not affect the overall tempo of her composition, she consistently used the metronome to test out the effect of tempo on her melodies, motives, and rhythms before combining them on the Hyperscore sketchpad. Her routine experimentation with metronome settings suggested that she was cognizant of tempo as a sonic element in her process.

Eventually, Chelsea realized that adjusting spaces between notes would change the rate of speed without the need to adjust the metronome to create the same effect. Figures 14 and 15 illustrate how Chelsea decreased the space between notes in one of her percussion patterns to create the effect of a faster tempo (link to Figures 14 and 15, Appendix D).

Pitch. Chelsea's think-aloud data and comments regularly included references to the contrast between high- and low-pitched sounds. She appeared to have a dichotomous concept of pitch and often used contrasting high and low sounds as a composition strategy: “Let’s make it all high notes right now. I kind of like that, so that I have it high in some spots and low in other spots” (individual composition, September 14. 2017).

One of Chelsea’s particularly intriguing and common strategies was to drag various notes of her motive individually to a relatively lower or higher pitch level without regard for trying to maintain the integrity of the original motive. She seemed primarily concerned with quickly moving all notes to a lower or higher pitch level and not at all concerned about preserving the quality of her original melody. Figures 16 and 17 are examples of the before and after effect of this strategy (<u>link to Figures 16 and 17, Appendix D</u>).

Rhythm. Because Chelsea played the drums, she might have been particularly interested in the rhythmic aspect of her compositions and often experimented considerably with droplet sizes (note durations). As shown in Figure 18, I regularly observed Chelsea deliberately adjusting note durations as demonstrated in her first composition session, during which she applied a variety of droplet sizes to her melodies and short motives (<u>link to Figure 18, Appendix D</u>).

Creating vocal percussion sounds while she composed rhythmic patterns was a regular part of Chelsea’s process, and she occasionally verbalized a drummer’s sticking patterns as well (e.g., “left, right, left, left”). Chelsea’s use of vocal percussion during the composition process resonated with Papert’s (1980a) concept of *body-syntonic* reasoning, which he observed in children’s processes as they programmed a robotic turtle to draw various geometric shapes. In Papert’s constructionist laboratory, students used their bodies to test out the action they intended to program for the robotic turtle: “I think of a drumbeat and try to impersonate it” (individual composition, October 2, 2017).

Timbre. During one particular interview, as Chelsea discussed her composition strategies, she indicated that she liked to "use different instruments, so it's not too overwhelming on one" (interview, September 14, 2017). Chelsea seemed to think of instrumentation and timbre as an integral part of the composition process and experimented considerably with different timbres for her melodies.

At one point, Chelsea stated that she was "all out of colors" (individual composition, September 20, 2017), commenting on the fact that Hyperscore limits the composer to a maximum of eight colors. Although Chelsea had used the same color (blue) for composing two different motives, as shown in Figure 19 (<u>link to Figure 19, Appendix D</u>), her comment above indicated she was not *aware* of the option to use the same color (timbre) more than once. Instead, Chelsea seemed to equate the number of available colors with the number of possible musical ideas, and her composition process suddenly came to a standstill. Chelsea's strategy for moving beyond this obstacle and improving her composition was to become solely focused on finding new timbres rather than creating additional sonic elements: "I'm kind of desperate right now.…I don't have anything that sounds good.…Finding cool sounds and trying to put them in because I'm not that good (individual composition, September 26, 2017.) Chelsea was regularly self-deprecating about her process and products, which reflects Papert's (1980a) observation that learning was an *ego-syntonic* experience for the children he observed in his Logo programming lab.)

Traditional Composition Techniques in Chelsea's Process

Although I observed Chelsea employing a variety of traditional composition techniques, the most frequently noted was Chelsea's attention to contour. Chelsea's focus on motive-making was also a relatively frequent strategy, as exhibited in Table 6 (link to Table 6, Appendix D).

Contour. Chelsea initially created melodies and phrases of varying contours and was apparently unconcerned with how various contours may or may not complement one another. She explored many shapes for her discrete melodies, sometimes drawing random droplets and other times creating distinct rising and falling patterns. As shown in Figure 20, when drawing musical phrases on the sketchpad, Chelsea often incorporated multiple contours simultaneously by combining relatively straight lines with somewhat curvilinear lines (link to Figure 20, Appendix D). Dissatisfied with the resulting dissonance, Chelsea began modifying her approach, first by drawing a wide variety of phrase contours but sketching fewer of them to sound simultaneously on the sketchpad, thereby creating a less dense texture, as shown in Figure 21 (link to Figure 21, Appendix D). Eventually, as shown in Figure 22, Chelsea adopted a more methodical approach that sounded better to her, one in which she abandoned dense textures, randomly drawn droplets, and concurrent contrasting phrase contours in favor of more linear melodies, fewer concurrent phrases, and minimal contour variations (link to Figure 22, Appendix D).

Motive-making. Chelsea's motive-making strategy evolved from randomly drawing densely stacked droplets to a more horizontal and organized melodic approach. During the first two composition sessions, Chelsea seemed to approach the melody windows as palettes for painting interesting images. She did not seem to think of a melody as something that unfolded over time because she typically inserted droplets haphazardly on the melody window. For example, as shown in Figure 23, Chelsea drew droplets (notes) in the order indicated (link to Figure 23, Appendix D).

Possibly because she was a drummer, Chelsea spent more time strategically building percussion motives than she did developing melodic material. When creating percussion motives, Chelsea often created vocal percussion sounds while composing. Composing percussion motives appeared to be a *body-syntonic* experience (Papert, 1980a) for Chelsea as she often thought aloud about specific instruments and regularly produced vocal percussion sounds.

Sound and Sight in Chelsea's Process

For Chelsea, graphic notation was the only Sound and Sight category I observed during her composition process within Weeks 1–5, except for one brief allusion to traditional notation. I made this determination partially based on frequencies of occurrence shown in Table 7 (link to Table 7, Appendix D).

Graphic notation. Chelsea's use of the graphic notation tools in Hyperscore evolved from a scattershot collection of lines and dots in her first two individual compositions to a more structured approach in the latter part of her process. At first, Chelsea was more interested in drawing random dots and lines on the sketchpad before developing any melodic or rhythmic elements. Figure 24 illustrates how Chelsea created one melodic motive (red melody window) and subsequently impulsively drew several lines and dots on the sketchpad representing sonic elements she had not yet formulated (link to Figure 24, Appendix D).

By the time Chelsea completed her individual composition in Week 5, she seemed to give more consideration to Hyperscore's graphic notation tools as devices to help express her unique musical ideas, rather than merely as tools for drawing and painting interesting designs. During a particular stimulated recall moment as she reflected on her composition, Chelsea exemplified how her thinking evolved from not being sure what to do with the sketchpad to developing a piece with structure, dynamic changes, and a variety of timbres and textures, as shown in Figure 25 (link to Figure 25, Appendix D):

> I just put lines, and then I put the dots over it 'cuz I thought it would sound cool and maybe louder. And then I thought that I wanted to add something onto it, so I thought it could get…quieter and then get louder again with a new sound. So, I made it quieter, and then I made it getting eventually louder, and then into a different beat, and then into my last couple of beats before the end. (stimulated recall, October 2, 2017)

Inspiration Sources in Chelsea's Process

Although Chelsea rarely asked for advice or help, she appeared to enjoy listening to Emily's music at least a few times during Weeks 1-5, ostensibly for inspiration. At one point during the second individual composition session and before Chelsea began creating more structured compositions, Chelsea spent a few minutes listening to one of Emily's compositions. Chelsea listened closely to Emily's entire composition, intentionally played back each melodic motive separately, and asked Emily a few questions about her composition. This exchange was one of the few moments I observed during the five-week individual composition period when a participant explicitly asked questions about another's composition process or product with the result of the other student functioning functioned as a Vygotskian "more capable peer" (1978, p. 86). In general, when one participant listened to another's, they would make general comments of approval such as, "that's cool" or "that's really good," but rarely provided insight or advice unless I prompted them to do so.

Starting with the third composition session, besides listening to Emily's compositions, Chelsea also spent some of her time listening to sample compositions included with Hyperscore. From that point forward, Chelsea practically abandoned the strategy of drawing impulsively on the sketchpad. Overall, besides her experience as a drummer as discussed above, Chelsea's primary sources of inspiration appeared to come from listening to Emily's compositions and the sample pieces provided in Hyperscore.

Draco Composing Individually

Draco stated that he had had previous experience making original music and had taken private trumpet lessons for less than one year. Of all participants in the present study, Draco was the most verbal and articulate, and more likely to think aloud than the others. Draco seemed to enjoy explaining his strategies and processes in detail and often commented on his preference for working on the mechanics of music:

> I'm good at mechanics, but not great at composing tunes in my head. It (composing) requires the mechanical 'how does this work, how does *this* work' and then also requires the really creative abstract thinking, which I, I'm a really mechanical kind of guy. I have big, grand ideas about mechanisms to make, and 99% of them I can't even make— at least not yet. (interview, October 30, 2017)

Draco was inclined to talk about his compositions using traditional musical terminology more than other participants and seemed to enjoy talking about music abstractly when thinking aloud, engaging in stimulated recall, or answering interview questions.

Sonic Elements in Draco's Process

The most prevalent sonic elements I noted while observing Draco's composition process and strategies were horizontal focus, timbre, rhythm, and vertical focus, as displayed in Table 8 (link to Table 8, Appendix D). I noted that Draco focused discretely and intently on building his compositions both horizontally or vertically and seemed *almost* equally concerned about both aspects of his compositions. Ultimately, horizontal composition prevailed.

Horizontal focus. A horizontal process in the present study was one in which the composer worked in a monophonic or 'mono-rhythmic' (i.e., one rhythmic pattern) mode, focusing on a single melody or percussion pattern unfolding over time. Conversely, a vertical process focused on pitches, melodies, rhythms, and percussion patterns combined vertically to create harmony, counterpoint, or polyrhythms. Draco spent considerable time working in a horizontal, monophonic mode developing the melodic aspect of his composition. Draco often stated his intention to develop good melodies and orally expressed his thoughts about composing melodic material. Draco's self-assessment as a mechanical guy was apparent throughout my observation of his process as he spent substantial time refining his melodies.

At the outset, Draco composed short melodic motives. However, as the individual composition process progressed, Draco conceived of melodies as phrases rather than short motives. This preference for longer phrases appeared to be why Draco ultimately composed using a single larger melody window and spent time developing one extended melody rather than working with short motives in smaller windows. Draco became increasingly interested in developing fewer, lengthier melodies with minimal repetition. During one particular stimulated recall session, I asked Draco to elaborate on his thoughts about his concept of melody. He responded by saying, “Personally, in my mind, a melody, it doesn’t just repeat, repeat, repeat, repeat” (stimulated recall, October 18, 2017).

Draco’s interview comments and think-aloud data often indicated how important it was to him that his melodies were interesting and not repetitive. After listening to his composition shown in Figure 26, in which the main melody is stated four times, Draco commented, "I don’t like that the melody repeats itself. I really don’t like that" (stimulated recall, October 18, 2017) (link to Figure 26, Appendix D). It was clear from Draco’s comments above and the analysis shown in Figure 27 that he perceived of melody as a fully developed, non-repetitive phrase rather than a short, looping motive (link to Figure 27, Appendix D).

As I observed Draco regularly creating melodies by simultaneously humming or singing and transcribing with graphic notation, it appeared that his strategy resonated with Turkle and Papert’s (1990, 1991) concept of *epistemological pluralism*. Turkle and Papert’s idea of epistemological pluralism centers on the complementary relationship between abstract and concrete thinking, and the equal valuation of both modalities. Draco’s concurrent use of Hyperscore’s graphic notation tools to transcribe melodies he hummed or sang exemplified epistemological pluralism by merging abstract thinking (musical ideas) with concrete thinking (humming, singing, and manipulation of graphic notation icons).

Timbre. When asked to talk about his composition process, Draco often spoke of composing for specific instruments. Think-aloud data such as, "So, I'm just trying to still create the guitar" (individual composition, September 18, 2017) suggested that Draco composed with specific instruments in mind, and possibly specific functions for each instrument. At one point, during his first composition session, I noticed that Draco was singing a melody aloud, "Dun-din-duh-dun-din-dun." He explained, "I am just trying to figure out the guitar" (individual composition, September 6, 2017). Although he had only drawn two notes on the screen, Draco was thinking in sound with a complete guitar phrase in mind.

At one point, Draco figured out a way to 'hack' the Hyperscore software and force it to play both percussion and bass timbres within a percussion window, as shown in Figure 28 (link to Figure 28, Appendix D). Draco's 'hacking' strategy is the only way a Hyperscore composer can hear more than one simultaneous timbre before combining melodies or percussive patterns on the sketchpad.

During one particular interview, Draco discussed how essential it is for a composer to imagine a wide range of instrument timbres, which implied that thinking in sound is something that Draco thought was essential:

> They (composers) have to know what all the instruments sound like, so they can be like, yeah, I think it will be this note for this instrument to get the sound that I

> want. If the composers don't have that (timbral memory), they can't get the sounds. (interview, September 12, 2017)

In a later interview, Draco described how he was usually "thinking the instrument first, not thinking of a melody and then saying, it would sound good on this" (interview, November 3, 2017), which confirmed my finding that his value of timbre as a sonic element in the composition process.

Rhythm. Beginning on the first day, Draco regularly vocalized (hummed and sang) his rhythmic and melodic ideas, which resonated with Turkle and Papert's description of b*ody-syntonic* learning (Papert, 1980a; Turkle & Papert, 1990):

> I'm always, like, thinking something like humming it, kind of have it in the back of my head, but then I need to hum it out loud to build on it. I can't just think of it in my head and then put it down; I need to hum it out loud. (interview, September 18, 2017)

Draco would often vocalize specific rhythms and take the time to fine-tune his rhythms while drawing with Hyperscore. On the first individual composition day, while others worked as bricoleurs (Lévi-Strauss, 1962), exhibiting "a desire to play with the elements of the program, to move them around almost as though they were material elements" (Turkle & Papert, 1990, p. 136), Draco devoted considerable time to single ideas, carefully lengthening and shortening note values and incorporating rests to emulate the rhythm he was vocalizing. For example, while composing one particular melody, Draco spent almost five minutes adjusting note size and spacing to refine this rhythm, as shown in Figure 29 (<u>link to Figure 29, Appendix D</u>).

Draco would often vocalize complex rhythmic patterns but could not notate the rhythm, presumably because his ability to transcribe his sonic ideas was limited or the graphic notation tools were a limitation for him. Draco expressed that he preferred the interactive function on the GarageBand iPad app, and his description resonated with the type of *body-syntonic* experience Papert observed in children ‘playing turtle’ while programming a robotic turtle (Papert, 1980a; Turkle & Papert, 1990). For Draco, being able to tap the rhythm physically on a virtual instrument to transcribe his desired rhythms would have been preferable to drawing rhythms with graphic notation, which seemed to be an obstacle for him.

After discovering that he could import pre-existing drum loops into his compositions, Draco devoted considerable time to experimenting with pre-existing drum loops to customize them, more than he did to creating original drumbeats. Throughout the five-week individual composition period, Draco embraced his interest in the mechanics of music by focusing a great deal on editing drum patterns. Draco’s self-ascribed nature as "a mechanical kind of guy" (interview, October 30, 2017), which led to considerable time spent editing drum loops, resonated with Papert’s description of *ego-syntonic* learning, or "that which is coherent with children’s sense of themselves" (Papert, 1980a, p. 63). Draco’s determination to represent his desired rhythms accurately was impressive. The complex set of specific and various note values and rests illustrated in Figure 30 represent Draco’s determination as a mechanic and a music editor (link to Figure 30, Appendix D).

Vertical focus. Consistent with his self-ascribed mechanical tendency, Draco was particular about aligning musical elements vertically, primarily to perfect the rhythmic aspect of his composition and not out of concern for creating harmony. The before and after screenshots in Figure 31 illustrate how Draco adjusted a melody (light blue line) and a drum pattern (dark blue line) by appending rests to each iteration until the two motives aligned perfectly with the same number of iterations (link to Figure 31, Appendix D).

While composing the main melody of his final individual composition shown in Figure 32, Draco 'hacked' the percussion window by assigning each of the 10 percussion lines to a guitar timbre and definite pitches, which was not the intended function of this window (link to Figure 32, Appendix D). Draco pointed out that using the percussion window for melodies provided the option of assigning multiple timbres to various melody notes, allowing him to vertically "synchronize instruments with one another" (individual composition, September 22, 2017). Draco's keen attention to vertical alignment was consistent with his stated interest in mechanics and resonated with Papert's (1980a) concept of *ego syntonicity.* Draco articulated his sense of himself as "a mechanical guy," and the extensive time he spent editing his musical ideas with attention to vertical alignment was consistent with his self-ascribed mechanical nature.

Traditional Composition Techniques in Draco's Process.

The four traditional composition techniques I noted as I observed Draco's composition process were his application of contour, motive-making, his concern for form, and his use of repetition (link to Table 9, Appendix D).

Contour. When Draco composed melodies, he often used his voice to guide the contour of his melody. I often observed him concurrently adjusting droplet pitches to simulate the contour of the melody he was humming. Conversely, I also noticed that he sometimes adjusted his humming or singing to match the pitches of the tune he had already notated in the melody window. As Draco drew and adjusted the contour of his melody using Hyperscore, his humming also adjusted as needed to match the software playback of his notation. It was as if his musical ideas and the software were engaged in a dynamic mediated experience similar to that described by Ackermann (1993). To Ackermann, a dynamic mediated experience requires three elements, hands-on, heads-in, and playback. As I observed Draco's process of creating melodies, these three components were obviously at work as Draco drew droplets in the melody window (hands-on), sang or hummed (heads-in), and used the software to playback and adjust his musical ideas.

Similarly, when Draco composed bass lines, he used his voice to guide the rhythm. However, his bass lines often comprised just one pitch but with varied rhythm such as the one shown in Figure 33 (link to Figure 33, Appendix D). Near the end of his individual composition process, the final bass line Draco composed included some variations in pitch. The few shifts in pitch at the end of this bass line were the most varied of all the bass lines Draco composed, as shown in Figure 34 (link to Figure 34, Appendix D).

Hyperscore's drawing tools enable the composer to shape phrases by drawing straight or unencumbered curved lines anywhere on the sketchpad. Algorithms built into the software interpret the contour and position of each line and alter the pitch level (tonal center) at which notes are played back. After experimenting with one wavy line on one occasion, as shown in Figure 35, Draco expressed dissatisfaction with the results and only applied straight lines to his sketchpad thereafter (link to Figure 35, Appendix D). Because he disliked the changes of tonal center caused by curved lines, Draco subsequently drew nothing other than straight lines to represent his musical ideas.

Motive-making. Although Draco ultimately focused on composing complete melodic phrases, at the outset of the individual composition process, he composed several short motives. Draco's motive-making process was intentional and labor-intensive and often included several minutes at one time focused on one motive. Unlike the other participants, each of whom initially worked like bricoleurs who have goals "but set out to realize them in the spirit of a collaborative venture with the machine" (Turkle & Papert, p. 136), Draco was more like a planner who was "saying one's piece" (Turkle & Papert, 1990, p. 136) via Hyperscore rather than engaging in a metaphorical conversation with the software.

Draco usually chose his desired instrument (timbre) before creating a motive, rather than starting with the default piano sound. During the second individual composition session, Draco's process included singing his original seven-note motive a few times, singing the motive again but transposing the last two notes lower, copying and pasting the original seven-note motive, and adjusting the final two notes to create the transposition he sang. This meticulous, planner-oriented process was the beginning of his pattern of developing more extended melodies with antecedent-consequent phrase members (link to Figure 36, Appendix D).

Form. As exemplified by the antecedent-consequent phrase illustrated in Figure

36, Draco appeared predisposed to consider form in his composition process. For example, Draco spent considerable time creating an ending for his piece. As displayed in Figure 37, he first used the sketchpad to draw the desired length of his final idea before creating the musical idea itself, which indicated he was thinking about creating a coda or other type of distinct ending (link to Figure 37, Appendix D). After inserting space for his coda, Draco spent several minutes perfecting the two-note ending to his final individual composition, as shown in Figure 38 (link to Figure 38, Appendix D). For his final composition, Draco developed seven phrase members into his main theme that incorporated unity and variety by using three antecedent-consequent relationships, a unifying rhythmic motive, and a contrasting final phrase member. Figure 39 is a screenshot of the final result (link to Figure 39, Appendix D).

Repetition. Despite Draco's assertion that a melody should not repeat itself, he appeared to have an intuitive sense of how to incorporate limited repetition along with variety into his composition. Draco's initial concept of repetition appeared to be a notion of exact duplication of both pitch and rhythm. However, after he and I engaged in a brief collaborative analysis, Draco seemed to understand how his process actually included repeating short motives to create unity and changing a few pitches in a repeated phrase member to create variety. Draco's innate sense of balance between repetition and variety contributed to the success in developing a coherent musical phrase for his main theme.

Sound and Sight in Draco's Process

Regarding sound and sight, the two most frequently noted aspects of Draco's process were his emphasis on sound (i.e., humming, singing, or vocal percussion) *before* sight (i.e., notation), and his use of Hyperscore as a graphic notation tool to incorporate transposition into his composition process (link to Table 10, Appendix D).

Graphic notation. Draco's primary application of Hyperscore as a graphic notation tool was to incorporate translation (the geometric equivalent to transposition in music) into his composition process. Draco's process resembled the process of translation in geometry as he purposefully shifted musical material up or down the melody window or sketchpad. For example, during his first individual composition session, Draco drew a bass line on the sketchpad and dragged this line to various pitch levels on the grid until it was satisfactory to him, as shown in Figure 40 (link to Figure 40, Appendix D). In a subsequent individual composition session shown in Figure 41, Draco transposed the final two notes of his second phrase member to create an antecedent-consequent effect with the first phrase member (link to Figure 41, Appendix D).

Sound before sight. Overall, Draco was more of a planner than a bricoleur (Lévi-Strauss, 1962) and often displayed a methodical *sound before sight* (Azzara, 1993). approach. Rather than drawing something first and playing it back second as most other participants sometimes did, Draco usually focused on developing one melody for extended periods. Draco seemed to believe that it was important to compose a melody by thinking abstractly in sound first and notating it concretely second, as demonstrated by the frequent humming, singing, and vocal percussion sounds that preceded his notation. Here again, evidence of *epistemological pluralism* (Turkle & Papert, 1990, 1991) surfaced as Draco demonstrated effective negotiation of the abstract and concrete. One particular stimulated recall session provided further evidence of Draco successfully negotiation the abstract and concrete:

> SD: Did your singing strategy work here?
> Draco (watching himself on video): Here, I *did* create the melody I was looking for.
> SD: Let's keep playing it.
> Draco (singing on playback video): Dee, dee, dee duh dee.
> SD: Is your voice matching what you notated?
> Draco (watching himself on video): Not yet, but it will, I think, eventually. Took me a little bit, but I am sure I eventually got it.
>
> (stimulated recall, October 18, 2017)

During one of my interviews with Draco, I asked him about his concept of a composer. Once again, he demonstrated a bias toward sound before sight by saying, "They (composers) kind of sit there with like an idea of what they want in their head, and then they try out different sounds" (interview, September 12, 2017). Also, Draco's sound before sight proclivity combined with his body-syntonic behavior (i.e., humming, singing, vocal percussion) led me to conclude that of all the participants, Draco exhibited the type of balanced concrete-abstract process described by Turkle and Papert (1990, 1991) to the greatest extent.

Relatedly, Draco often commented on how he and composers, in general, need to *fi*rst imagine their music, *before* notating it. In his case, Draco also needed to hear his music out loud during the process. Draco spent considerable time applying an iterative, think-sing-notate-playback cycle, which indicated that he intuitively incorporated metacognition into his composition process in a reflexive manner (Ackermann, 1996; Duffy & Cunningham, 1996). Draco not only reflected regularly on his process, but he also acted on his composition as a result.

Inspiration Sources in Draco's Process

Initially, Draco's inspiration for his composition process appeared to emanate strictly from ideas he hummed and sang. Over time, Draco occasionally listened to other participants' compositions and complimented others on their work. However, listening to other participants' compositions did not seem to influence Draco's process directly.

Conversely, beginning with the third week of the individual composition phase, Draco began listening to and borrowing excerpts from the Hyperscore library. Rather than merely copying and pasting pre-existing Hyperscore motives into his composition, Draco preferred to use them as springboards for developing new ideas. Consistent with his self-described mechanical nature, Draco would tinker with pre-existing Hyperscore motives to transform them into something new. It was during the process of reconstructing motives that Draco appeared to be less of a planner than usual, resembling a bricoleur (Lévi-Strauss, 1962) working with the materials at hand rather than developing something wholly original. Although Draco seemed inspired by borrowing and recreating material from the Hyperscore library, when I asked him about this aspect of his process, he expressed that borrowing pre-existing material compromised originality, or was possibly not being authentic.

Ryan Composing Individually

Ryan stated that he had never created original music before participating in this study and had taken private piano lessons for over one year. I chose Ryan and three other participants as focus composers because he and others were more forthcoming with their thoughts when I asked them to describe their composition processes and strategies. Also, I chose Ryan as a focus composer partly because his think-aloud comments were relatively frequent, and his interview answers seemed particularly thoughtful, providing me with useful data for interpretive purposes.

Sonic Elements in Ryan's Process

Table 11 displays frequencies of occurrence related to the various sonic elements Ryan focused on during the five-week individual composition phase (link to Table 11, Appendix D). Ryan's attention to rhythm and timbre was prevalent during my observation of his composition process. Also, Ryan's relatively consistent attention to tempo and his application of discrete horizontal and vertical strategies over the five-week individual composition process were of particular note.

Rhythm. Ryan spent much of the five-week individual composition time focusing on drums, making beats, and experimenting with rhythm. Most of his think-aloud data related to creating beats and comprised comments such as, "Let's make some beats" (individual composition, September 12, 2017) and, "Trying to make long, repetitive drumbeats. Just keep that repeating like that" (individual composition, September 6, 2017).

Ryan's process of creating percussion patterns was minimalistic, deliberate, and careful. Figure 42 illustrates the results of Ryan's lengthy and persistent attempt to create an evenly ascending timbale rhythm (link to Figure 42, Appendix D). After dedicating several minutes to this challenge, Ryan ultimately expressed that he "can't really get it…completely straight" (individual composition, September 22, 2017) and deleted the pattern. Ryan often spent several minutes creating one drum pattern, only to delete it out of dissatisfaction with the result. By the time Ryan completed his final composition, he had practically abandoned making percussion patterns altogether and only included one brief drum pattern in his final piece.

Occasionally, Ryan expressed frustration with his lack of productivity, making comments such as, “Honestly, not feeling that great right now” (interview, September 12, 2017). Ryan sometimes seemed overwhelmed by the composition experience, a disposition related to the concept of *cognitive complexity* (Perkins, 1992), and the affect-cognition dyad I discussed in Chapter 1 as aspects of the theoretical framework. Ryan often appeared stifled by the task at hand and occasionally disappointed in his results, indicating that the affective aspect of individual composition experience was not particularly positive. However, Ryan seemed to become slightly more optimistic and productive when he focused on creating beats and drop beats. To Ryan, ‘the beat’ seemed to be the essential sonic element.

During his fourth individual composition session, Ryan “came up with a new idea, that was playing this sound right here (pointing) and then doing a drop beat” (individual composition, September 22, 2017). After working on his drop beat idea for a few minutes, Ryan ultimately composed a one-note kick drum motive, as shown in Figure 43. The length of this motive was consistent with his overall minimalist approach to composition (link to Figure 43, Appendix D). Consistent with his previous pattern of deleting rhythmic material, Ryan eventually removed the drop beat from the final version of his composition.

Ryan’s interest and focus on rhythm also manifested itself in his attention to droplet length (note duration). He regularly engaged in a persistent, iterative listening-adjusting process until he achieved the desired rhythm. For example, Figure 44 illustrates Ryan's transformation of the last two notes of his melody after listening and adjusting their length several times over a few minutes. From my perspective as observer as participant, Ryan's iterative listening-adjusting process resonated with Ackermann's (2001) metaphor of knowledge construction as a cognitive dance, during which the learner dives in and steps out of the process to reach a more in-depth understanding. The transformation illustrated in Figure 44 is a typical example of how Ryan dove in and stepped out of the process (link to Figure 44, Appendix D).

Timbre. Some of Ryan's think-aloud comments suggested that he conflated instrumentation and the concept of timbre with the concept of melody. Statements such as, "Now I am gonna start a different instrument" (individual composition, September 12) and, "We'll put in some guitar here" (individual composition, September 22), which preceded composing the melody itself, indicated that Ryan was either thinking about timbre as a pre-cursor to melody or equating timbre *with* melody. Figure 45 illustrates how Ryan sometimes opened a blank melody window, previewed several timbres, and *then* composed a melody (link to Figure 45, Appendix D).

Ryan was primarily interested in guitar and drum timbres, as suggested by the approximately 30 references he made to searching for a guitar sound and approximately 75 references he made to drums during the individual composition process. Except for referring to a "horn" approximately 10 times, Ryan referred only to drums and guitar when talking about timbres, which was consistent with his minimalist approach to rhythm discussed earlier in this chapter. Although I showed him how to explore various timbres within the software a few times, Ryan demonstrated little interest in going beyond using drums and guitar sounds. I encouraged Ryan to listen to the sample compositions in Hyperscore because they demonstrated a variety of instrumental timbres and musical genres. However, Ryan explored this option minimally and continued to focus on guitar and drum timbres for most of the five-week individual composition phase.

Tempo. Ryan demonstrated an interest in using tempo adjustments to develop his composition. He would regularly and deliberately drag the metronome slider to change the tempo and make comments such as, “I’ve gotta speed it up a little bit more” (individual composition, September 18, 2017). At times, Ryan would use the metronome to adjust the tempo while discretely listening to one of his melodies or drum patterns. However, he did not seem to realize that adjusting the metronome affected the tempo of the entire composition, not only for the particular melody or drum pattern to which he was listening. At one point, as illustrated in Figure 46, Ryan seemed to discover the temporal effect of composing relatively short note values close to one another when he created a melody of multiple small, compressed droplets (notes) (link to Figure 46, Appendix D).

Vertical and horizontal strategies. Ryan applied vertical and horizontal composition strategies in two discrete ways. First, Ryan occasionally considered the vertical, rhythmic relationships between various melodic or percussion motives before drawing them on the sketchpad. Second, when transferring his musical elements to the sketchpad, Ryan composed with almost exclusive attention to unfolding musical ideas horizontally over time without layering elements vertically. The one exception to Ryan's lack of layering musical ideas vertically was in his first composition, during which he experimented with a geometric approach to composition. However, rather than working as a bricoleur (Lévi-Strauss, 1962; Papert, 1980a, 1993) by manipulating the material at hand, Ryan exhibited planner tendencies (Stager, 2001; Turkle & Papert, 1990) by quickly abandoning the geometric strategy, a tendency I discuss further later in this chapter.

Ryan's vertical musical thinking emanated from the strategy illustrated in Figure 47 (<u>link to Figure 47, Appendix D</u>). In this instance, Ryan created three motives and rearranged their respective melody windows on the screen to align them vertically. Aligning these windows allowed Ryan to examine the rhythmic relationship among the motives. However, almost invariably, after Ryan combined one or more melodies, he deleted one or both of them immediately, expressing dissatisfaction with the result. The dissonant harmony that usually occurred seemed unacceptable to him. Figure 48 illustrates two melodies that Ryan listened to and deleted immediately (<u>link to Figure 48, Appendix D</u>). After several attempts at vertically layering melodic material, listening to the resulting harmony, and discarding the result, Ryan ultimately created the monophonic composition shown in Figure 49 (<u>link to Figure 49, Appendix D</u>).

Traditional Composition Techniques in Ryan's Process

Table 12 summarizes the various traditional composition techniques I noticed and the extent to which they appeared over Ryan's five-week individual composition process (<u>link to Table 12, Appendix D</u>). Ryan's application of contour was the predominant traditional composition technique emanating from his individual process during the first five weeks. Ryan's motive-making strategy and attention to repetition were also relatively prevalent.

Contour. Although Hyperscore's graphical user interface allows the composer to draw on the sketchpad in a completely unrestricted manner, Ryan's drawing approach and the resulting phrase contours were predominantly linear. Ryan's primarily linear approach to drawing on the sketchpad was consistent with his minimalist approach to composition. Although he could have drawn unbounded contours on the sketchpad, Ryan rarely ventured outside of drawing straight lines. Figures 48 and 49 above provided evidence of Ryan's overall preference for drawing straight lines on the sketchpad.

Later on, Ryan's planner tendency (Stager, 2001; Turkle & Papert, 1990) surfaced again. As shown in Figure 50, Ryan began by drawing a curvilinear motive that caused the melody to modulate gradually to a lower tonality. After adding a second melody and listening to the result, Ryan deleted one motive and listened to the other motive by itself. Ryan subsequently deleted the remaining motive as well (link to Figure 50, Appendix D). On another occasion, Ryan drew on the sketchpad somewhat randomly, which caused the melody to modulate higher and lower several times according to the shape of the line, as shown in Figure 51 (link to Figure 51, Appendix D). After listening to this version two times, Ryan deleted it and replaced it with a perfectly straight line that did not modulate.

Ryan used predominantly straight lines on the sketchpad, ostensibly, to avoid changes in the tonal center. Conversely, Ryan's melodies examined discretely indicated that he explored contour more freely when composing a melody in isolation before transferring it to the sketchpad. Figure 52 illustrates the contrasting contour among three of Ryan's selected melodies (link to Figure 52, Appendix D). I concluded that the variations in tonal center caused by drawing curved lines on the sketchpad yielded unfavorable results to Ryan. The screenshot of Ryan's final composition in Figure 53 revealed his preference for linear, non-modulating phrases on the sketchpad contrasted with the use of multiple contours within his discrete melodies (link to Figure 53, Appendix D).

Motive-making. Because I provided no explicit instruction on creating melodies or percussion patterns (drumbeats), Ryan's evolving motive-making progress throughout the five-week individual composition period was particularly noteworthy. While creating his first composition, Ryan's motive-making process comprised placing relatively few notes in straight lines of repetitive pitches. As depicted in Figure 54, Ryan often took time to adjust the spacing between notes carefully, and sometimes checked to see how his motives aligned vertically (link to Figure 54, Appendix D).

While composing his second piece shown in Figure 55, Ryan integrated a scalar approach, wider intervals, and lateral spacing into one of his motives. Conversely, I noted that Ryan's other three motives remained sparse and comprised repetitive pitches similar to the motives he created for his first composition (link to Figure 55, Appendix D).

As Ryan composed his third and final piece shown in Figure 56, he seemed to experience a breakthrough with his dark blue melody, which contained three distinct phrase members and a balance between unity and variety by following an A, A, A′ form. Conversely, the light blue melody displayed at the bottom of the screenshot is reminiscent of Ryan's strategy in his first composition with repetitive pitches and only two variations in duration (link to Figure 56, Appendix D).

As Ryan developed his final composition shown in Figure 57, one of his melodies resembled his earlier, sparse and rudimentary motives. Another melody was Ryan's earnest attempt at creating a strict sequence, which he ultimately abandoned and deleted (link to Figure 57, Appendix D). As Ryan continued developing his final piece, he composed a chromatic scale with exact semitones, a wildly exploratory motive, and a melody that employed diminution as note values gradually decreased and ultimately dissipated (link to Figure 58, Appendix D).

Repetition. Ryan displayed an interest in using repetition as a composition technique, particularly during the first three weeks of the individual composition phase. For example, as shown in Figure 59, Ryan compressed his motive so it would loop more often over time after he drew it on the sketchpad, making it seem more repetitive (link to Figure 59, Appendix D). Conversely, Ryan decompressed the notes of his second motive by increasing the spacing between the notes to "make it repeat each other note" (individual composition, September 6, 2017), as displayed in Figure 60 (link to Figure 60, Appendix D).

At one point, I asked Ryan to reflect on his repetition strategy, which he seemed to think of as a development strategy by repeating something familiar and extending it with new material. The most telling interaction I had with Ryan about his use of repetition is when he and I analyzed the main I of his final composition, which contained the three distinct phrase members shown in Figure 61 (link to Figure 61, Appendix D).

This interaction illuminated Ryan's intentional use of repetition as a composition strategy:

> SD: Do you have any repetition in here?
> Ryan: Yeah, right here, the first two, uh…(pointing to the first two phrase members)
> SD: Did you copy and paste?
> Ryan: No.
> SD: Did you know you could do that?
> Ryan: I can?
> SD: That would have saved you some time. So, you *meant* to do a repeat?
> Ryan: Yeah.
> SD: And is this third part (pointing to the third phrase member), is that anything like these two (pointing to the first two phrase members) or is it different?
> Ryan: It's the same until the end where it goes dun, dun, dun, dun—except it goes dun-dun-dun (pointing to the end of the third phrase member) and then higher.
> SD: Okay.
> (stimulated recall, September 18, 2017)

Sound and Sight in Ryan's Process

Table 13 summarizes the Sound and Sight categories I noted while observing Ryan's process in Weeks 1–5. Ryan's particular use of Hyperscore as a graphic notation tool was something I noted multiple times as I observed his process (<u>link to Table 13, Appendix D</u>). There were also a few occasions when Ryan expressed or displayed cognizance of the relationship between sound and sight for a composer.

Graphic notation. Ryan's use of the graphic notation tools in Hyperscore was unique among the four focus composers whose individual processes I analyzed. At times, I noticed that Ryan appeared to be focused on the drawing experience more than the auditory aspect of his composition as he used the graphic notation tools to draw interesting geometric patterns on the sketchpad. Figure 62 illustrates how Ryan incorporated parallel and oblique motion into four-part counterpoint for his first composition (link to Figure 62, Appendix D).

Ryan occasionally experimented with transposition by copying and pasting or drawing the second iteration of a motive at a higher or lower pitch level. Consistent with his tendency to delete most of his ideas, Ryan usually removed transpositions after trying them out and noticing dissonance. However, probably because of their lack of dissonance, Ryan incorporated two monophonic melodies and their transpositions, as shown in Figure 63 (link to Figure 63, Appendix D).

While observing Ryan as he developed his second and third compositions, I noticed that he often created predictable, sequential patterns moving in one direction, such as those illustrated in Figure 64 (link to Figure 64, Appendix D). Ryan was adept at quickly drawing relatively precise patterns such as those in Figure 64, and watching him draw was sometimes akin to observing a visual artist-mathematician at work. Ryan's visual artist-mathematician identity appeared regularly throughout his composition process.

Sound and sight. Ryan's interview and stimulated recall comments displayed a modicum of awareness about the dynamic relationship between sound and sight and their connection to the composition process. A few times during the five-week process, Ryan displayed or expressed a general awareness of how aural and visual modalities might manifest themselves in the composition process. During our first interview, Ryan expressed appreciation for notation but preference for playing by ear. Also, Ryan initially seemed to perceive Hyperscore as a sight *before* sound tool when he said, "With this (Hyperscore), you can compose something before you actually do something [with it].

So, you can listen to it, see if it sounds good, and then play it on a real instrument" (interview, September 6, 2017). During a later interview, Ryan commented on feeling more successful the day he relied on his aural skills for inspiration, saying, "[This time] I had a beat or melody in my mind, and I tried to put it on here, and [now] I can add on to it. (interview, September 18, 2017).

During a particular stimulated recall session, I asked Ryan to describe the challenge he seemed to experience. Ryan explained that he was frustrated when he could not accurately transfer the musical idea he had in mind. Ryan was attempting to transfer sound (his musical idea) to sight (graphic notation) but was unsuccessful and abandoned the process:

> Ryan (on playback video): That does not sound good.
> SD: You immediately said, "It doesn't sound good." I am wondering if you remember why you didn't like what you heard.
> Ryan: I think that I didn't really like the way they (the two rhythms) went with each other. I was trying to do something different, and that was not what I was thinking of. I wanted it to be like dun, dun, dun, dun (singing even eighth notes), and not like uneven.
>
> (stimulated recall, October 10, 2017)

Chelsea and Emily Collaborating

During Weeks 6–10 of the study, the four focus composers collaborated in pairs. The present study did not focus on gendered differences in participants' strategies and processes, and my decision to pair students according to their stated gender on the pre-study survey was based on findings from previous studies (Colley, Comber, & Hargreaves, 1997; Webb, 1984) and thirty years of personal experience in music education. I have observed that students collaborating in same-gender pairs often work more enthusiastically and productively with one another than in mixed-gender pairs.

Sonic Elements in Chelsea and Emily's Process

Chelsea and Emily's attention to sonic elements provided a relatively large amount of rich data, which I summarized in Table 14 (link to Table 14, Appendix D). Timbre was the sonic element with which they engaged most during the collaborative composition phase. I also noted their particular attention to tempo, rhythm, dynamics, and pitch.

Timbre. Finding 'creepy' sounds consumed much of Chelsea and Emily's attention and time and often dominated their conversations. Chelsea and Emily rarely created motives, melodies, or percussion patterns before discussing the timbre or effect they were looking for first. During the following interview, Chelsea expressed the challenge associated with developing their composition, which underscored the importance she placed on timbre:

> Chelsea: It's easy to come up with ideas but hard to execute them.
> SD: Is it because the software is awkward to use?
> Chelsea: It's just because it doesn't have every instrument that there is. So, like if you're thinking of something, it might not have the right sound.
> (interview, October 20, 2017)

During another particular interview, Chelsea and Emily expressed excitement and a sense of challenge about their composition process. This sentiment resonated with *hard fun*, which is one of Papert's (1996, 1999b) eight big ideas associated with a constructionist environment. Although Chelsea and Emily expressed it was sometimes difficult to find their ideal timbres, their lively affect displayed that they enjoyed the process regardless of their unsuccessful moments. Occasionally, Chelsea and Emily focused on melody and harmony rather than sound effects. However, their conversation often gravitated toward the timbre associated with their melody or harmony:

> Chelsea: Now, we really need to add some harmony music.
> Emily: Like, you know the doo, doo, doo, doo (humming a quasi-*Twilight Zone* motive).
> Chelsea: I don't think we're ever gonna find that [instrument], though.
> Emily: I know, [we need] the right instrument for it.
> (collaborative composition, October 20, 2017)

Chelsea and Emily transcribed their quasi-*Twilight Zone* theme into Hyperscore. However, consistent with their tendency to focus on timbre, they first listened to several possibilities for an instrument before beginning the transcription process. The transcription task took them several minutes to complete and comprised a persistent, iterative process of singing and transcribing, as illustrated in Figure 65 (<u>link to Figure 65, Appendix D</u>). Chelsea and Emily's persistent and iterative process provided evidence of the kind of cognitive dance described by Ackermann (2001), during which the learner dives in and steps out of the process.

Chelsea and Emily's use of Hyperscore's graphical user interface combined with their persistent singing to transcribe their quasi-*Twilight Zone* theme epitomized Turkle and Papert's (1990, 1991) concept of *epistemological pluralism.* Turkle and Papert's idea of epistemological pluralism holds that abstract thinking should be "on tap, not on top" (p. 133) and complementary to concrete thinking. Chelsea and Emily combined their abstract musical thinking and their concrete use of graphic notation tools in Hyperscore to create their quasi-*Twilight Zone* theme. Chelsea and Emily seemed to enjoy the challenge of replicating this well-known motive, which exemplified Papert's (1996, 1999b) concept of *hard fun.*

Tempo. Chelsea and Emily's strategy of adjusting the spacing between notes to affect the rate of speed was their intuitive way of incorporating tempo changes into their composition. Because Hyperscore does not provide a tool for making internal tempo changes, Chelsea and Emily circumvented this limitation instinctively by adjusting the spacing between notes. At one point, Chelsea wanted the footsteps sound effect to accelerate at an even faster rate, and she attempted to 'hack' the software by overlapping notes. However, Hyperscore does not allow the composer to overlap repeated notes of the same pitch. In their concerted effort to create the effect of accelerating footsteps, as shown in Figure 66, Chelsea and Emily started again and composed their footsteps motive while carefully considering the impact of the distance between sonic events (link to Figure 66, Appendix D). At another point, Emily suggested, "Maybe slow it down" (collaborative composition, October 6, 2017) and points to the metronome. As illustrated in Figure 67, Chelsea dragged the metronome to its lowest setting and, apparently dissatisfied with the result, increased the spacing between notes to create the effect of an even slower tempo (link to Figure 67, Appendix D).

Rhythm. Chelsea and Emily explored a relatively wide range of note values, sometimes resulting in more sophisticated rhythms. At other times, Chelsea and Emily used exaggerated note values seemingly for a stark contrast rather than for creating complex rhythms. Figure 68 contains a screenshot of Chelsea and Emily's collaborative composition, which revealed the relatively wide range of note values used (link to Figure 68, Appendix D).

Dynamics. Chelsea and Emily's various comments throughout their process occasionally indicated that they appreciated dynamics as a sonic element: "It needs to be loud and painful" (Chelsea, collaborating with Emily, November 7, 2017). "Oh, yeah, each time we could, like make it louder…each time it gets louder as if the person is coming closer to you" (Emily, collaborating with Chelsea, October 6, 2017).

Chelsea and Emily expressed how much they valued dynamics by their attention to detail and the amount of time they dedicated to working with dynamics. For example, because Hyperscore does not provide a tool to create gradual or automated dynamic changes, Chelsea and Emily spent several minutes dividing one particular phrase into smaller parts and adjusting the relative line thickness of each part to create a decrescendo, as shown in Figures 69 and 70. The effect they created was more akin to Baroque style terraced dynamics rather than a gradual crescendo. However, Chelsea and Emily's determination to incorporate a decrescendo into their composition was impressive to observe and evidenced Papert's (1996, 1999b) idea *of hard fun* (link to Figure 69, Appendix D; link to Figure 70, Appendix D)

Pitch. The time-lapse depiction of Chelsea and Emily's quasi-*Twilight Zone* transcription displayed earlier (see Figure 65) is a compelling example of Chelsea and Emily's awareness of and sensitivity to pitch. By applying *body-syntonic* reasoning (Papert, 1980a) and engaging in *epistemological pluralism* (Turkle & Papert, 1990. 1991), Chelsea and Emily persistently sang the four-note motive and used the graphic notation tools until they accurately transcribed the pitches for their desired melody.

Another instance of Chelsea and Emily's strategy of singing and transcribing pitches occurred when their impromptu singing led them to the well-known motive for Beethoven's *Fifth Symphony* finale. After slightly more than twenty minutes of continuous singing and transcribing, Chelsea and Emily ultimately created a chordal version of the Beethoven motive shown in Figure 71 (link to Figure 71, Appendix D). Their persistent, elongated process combined with bursts of laughter each time they played back the theme on Hyperscore, resonated strongly with Papert's (1996, 1999b) concept of *hard fun*. Chelsea and Emily discovered a challenge that took over twenty minutes to complete, and it appeared their enjoyment of the challenge made it easy to dedicate a relatively large amount of time to it.

Traditional Composition Techniques in Chelsea and Emily's Process

Table 15 provides a summary of the various conventional techniques I observed during Chelsea and Emily's collaborative process (link to Table 15, Appendix D). Other than their motive-making or borrowing approach and their attention to contour, my analysis of Chelsea and Emily's collaborative process did not result in numerous references to other particular traditional composition techniques. However, my analysis of their motive-making and borrowing strategy highlighted a noteworthy dynamic between the two composers. Also, Chelsea's *body-syntonic* (Papert, 1980a) tendency to hum and sing aloud at times appeared to have an influence on the contour of the melodies she and Emily created.

Motive-making and borrowing. Chelsea and Emily disagreed on whether to consider using motives (loops) available in the Hyperscore library in their composition. Chelsea once commented during her individual composition process, "I used motives as ideas, but didn't use any motives directly in my piece because I didn't really feel like that was my work if I used a motive" (interview, November 9, 2017). Although Emily regularly suggested using motives, Chelsea continually disagreed with the idea. Chelsea and Emily's disagreement about using motives from the Hyperscore music library, and their ultimate resolution, was one of the rare instances of *socio-cognitive conflict* that I observed among participants during the five-week collaborative composition phase. Chelsea exhibited disinterest in using motives and a preference for doing original work while Emily continually suggested the idea of borrowing preexisting motives from the Hyperscore library. Overall, the collaborative pairs I observed in this study appeared to engage in relatively little "discussion between peers who bring different perspectives to the task" (Tudge & Winterhoff, 1993, p. 72).

At one point, when Emily had control of the mouse and was exploring the Hyperscore library, she found a motive she thought would complement their composition, saying, "sounds like a spy movie" (collaborative composition, October 26, 2017). Although Chelsea expressed a number of times her desire to avoid using Hyperscore motives, the 'spy' motive, Emily found inspired a change of heart. A few minutes later, Chelsea took over the mouse and continued tinkering with the motive's ending. Chelsea and Emily continued singing, collaborating, and adjusting the motive until they agreed on an ending.

Contour. Chelsea's tendency, and to a lesser extent, Emily's, to hum and sing while composing influenced the contours of the various motives they composed. Overall, most participants usually drew motives quickly and spent little time adjusting the contour of their motives, which was not the case with Chelsea and Emily. They dedicated over twenty minutes to modifying the contour of their Beethoven transcription and several minutes to perfecting the contour of their quasi-*Twilight Zone* motive. In another instance of contour development at work depicted in Figure 72, Chelsea drew a distinctly curvilinear motive, and she and Emily listened to it one time. Subsequently, in bricoleur mode, they ventured into several minutes of singing variations of the motive until they agreed on a final version (link to Figure 72, Appendix D).

In another instance, I encouraged Chelsea and Emily to consider how their motives might harmonize with one another as they composed. I suggested that aligning them vertically on the screen might help them consider how the two motives interact with one another. The similarity of the two contours shown in Figure 73 was immediately apparent to Chelsea, who hummed and then commented, "I feel like it will sound too [much] the same. They have almost the exact same pattern (contour)" (collaborative composition, October 6, 2017) (link to Figure 73, Appendix D).

Sound and Sight in Chelsea and Emily's Process

As I observed Chelsea and Emily's process through a sound and sight lens, their use of the graphic notation tools in Hyperscore to create patterns and incorporate translation (the geometric equivalent to transposition in music) was noteworthy. Almost as prevalent were instances of sound before sight activity in Chelsea and Emily's process. Table 16 represents the various sound and sight categories I noted as I observed Chelsea and Emily's process (link to Table 16, Appendix D).

Patterns. As I observed Chelsea and Emily using the graphic notation tools in

Hyperscore, I noted that Emily typically used the tools to draw structured patterns and chords in contrast to Chelsea's typically monophonic, unstructured motives drawn rather freely and without attention to pattern. Chelsea controlled the mouse most of the time and preferred to draw motives impulsively. When Emily controlled the mouse, she was partial to meticulously drawing formal and chordal patterns, as illustrated in Figure 74 (link to Figure 74, Appendix D). Later, Chelsea incorporated chords and a structured pattern for the first and only time while in control of the mouse as she and Emily transcribed Beethoven's *Fifth Symphony* finale motive. As illustrated in Figure 75, Chelsea was likely influenced by Emily's use of pattern and chords, which preceded Chelsea's mouse control (link to Figure 75, Appendix D). In one other instance, Chelsea attempted to create a steady 'footstep pattern' but was unsuccessful. Emily took over the mouse and drew a pattern fairly quickly and intuitively, as shown in Figure 76. For Emily, pattern-making seemed to be more intuitive than for Chelsea (link to Figure 76, Appendix D).

Translation. The graphic notation tools in Hyperscore facilitated quick translation (the geometric equivalent to transposition in music) of sonic elements. For example, as they ventured to find a major third and a perfect fourth (although Beethoven's motive used a major third and a minor third), Chelsea and Emily incorporated geometric translation by moving icons up and down the grid until they were satisfied with the intervals. Figure 77 traces Chelsea and Emily's transposition process from top to bottom (link to Figure 77, Appendix D).

In another instance of Chelsea and Emily applying translation, they discovered that the blue line in the center of the screen (the harmony line) provided them with a valuable pitch reference point (middle C). As they debated about the effect of translating their motive lower and higher, Hyperscore's graphical user interface allowed Chelsea and Emily to quickly and easily translate (transpose) their motive to different pitch levels. As illustrated in Figure 78, Chelsea and Emily translated (transposed) their melody up and down several times relative to the harmony line (blue line) until they ultimately agreed on a pitch level that sounded "spooky" and not "too happy" (link to Figure 78, Appendix D).

Sound before sight. Sound before sight was a common strategy in Chelsea and Emily's process. For example, Chelsea, Emily, and I, as observer as participant (Merriam, 2014), engaged in several minutes of *hard fun* (Papert, 1996, 1999b) to transcribe their quasi-*Twilight Zone* motive. This process comprised all three of us working together diligently to transcribe Chelsea and Emily's quasi-*Twilight Zone* motive. Similarly, Chelsea and Emily worked tirelessly to transcribe both accurate pitch and rhythm for Beethoven's *Fifth Symphony* finale motive, a challenging process that seemed to bring them much satisfaction (i.e., *hard fun*). Chelsea and Emily's sound before sight approach consumed much of their composition time; however, it seemed organic and enjoyable to them.

Various comments from Chelsea and Emily indicated that sound before sight might have been an innate part of the composition process to them: "Once you find them (the instruments) you have to make (notate) the sound that you're thinking of, which doesn't always come out how you're thinking [of it]" (Chelsea, interview, October 6, 2017); "Sometimes, I hum a tune, and I forget to record myself or write it down" (Emily, interview, October 6, 2017); "I've never written anything down. I just remember it"

(Chelsea, interview, October 6, 2017).

Inspiration Sources in Chelsea and Emily's Process

In one particular interview, Emily talked about her concept of story as inspiration for music:

> SD: Can you talk about what you think makes a good composition?
> Emily: A good composition has a meaning or a story, kind of behind it. When you are writing a piece of music, you always have something in your mind of like what is this symbolizing? Does it tell a story about what has happened in my life, what has happened in other people's lives?
> (interview, October 12, 2017)

As I observed Chelsea and Emily's collaborative process, I identified a relatively large number of moments related to finding inspiration, as shown in Table 17 (link to Table 17, Appendix D). These emanated from Chelsea and Emily's brief exploration of genre, the extensive application of imagery, and a certain amount of borrowing of ideas from others' music. Chelsea and Emily's initial source of inspiration came from considering various genres and timbres (instruments):

> Chelsea: Let's start with thinking [about] what we want it to sound like. Any ideas?
> Emily: Nope.
> Chelsea: We could make it sound more like a classical, like opera thing.
> Emily. Yeah.
> Chelsea: Or we could make it sound more like hip hop.
> Emily: Modernized.
> Chelsea: Or maybe some electrical something. We could start trying to make cool sounds.
> Emily: Yeah.
> Chelsea: Let's do the thing of electrical.
> Emily: Yeah, like techno.
> (collaborative composition, October 6, 2017)

After composing and listening to their first motive, they decided that it sounded "like opera, like classical" (Chelsea, collaborating with Emily, October 6, 2017).

Subsequently, Chelsea and Emily continued looking for more techno instruments: “We could try some other synth instruments” (Emily, collaborating with Chelsea, October 6, 2017). After exploring the Hyperscore instrument library for a few more minutes, Chelsea and Emily discovered the sci-fi category of instruments in Hyperscore and created a disjunct four-note motive using an eerie timbre called ‘echoes.’ The combination of this eerie timbre with their disjunct four-note motive shown in Figure 79 provided Chelsea and Emily with the initial inspiration for creating a horror movie soundtrack and motivation that permeated their collaboration process for five weeks (link to Figure 79, Appendix D).

Chelsea and Emily’s inspiration for their horror movie soundscape emanated from exploring various timbres, and from serendipitously drawing a disjunct motive that sounded somewhat sinister when combined with the ‘echoes’ timbre in Hyperscore. This serendipitous moment "opened the floodgates to all the ideas" (Emily composing with Chelsea, October 6, 2017). From that point forward, their initial inspiration source remained essentially that of a horror film but became more specific as they aimed to evoke more specific “creepy” images.

Chelsea and Emily’s use of imagery for inspiration combined with borrowing ideas from others’ music helped to sustain their energy throughout the five-week collaborative composition process and resonated with Papert’s (1980a) concept of *affective computing*. Although Chelsea and Emily only created one short composition during the five weeks, they were consistently enthusiastic, joyful, and motivated, ostensibly inspired by their excitement about creating “creepy” music. As they strived to perfect their quasi-*Twilight Zone* motive, transcribe their variation on Beethoven's *Fifth Symphony* finale motive, or adapt the spy movie motive from the Hyperscore library to work with their own composition, Chelsea and Emily exhibited enthusiasm and perseverance as they created their horror movie soundscape.

Draco and Ryan Collaborating

Although Draco and Ryan spent a great deal of time discussing, listening, and planning, Draco made many of the decisions and controlled the mouse most of the time despite my regular reminders to share the mouse. Ryan appeared to regard Draco as a "more capable peer" (Vygotsky, 1978, p. 86) and readily deferred to Draco. Draco would occasionally solicit ideas from Ryan, and Ryan sometimes assertively offered input. Despite the relative imbalance in ownership of the process, Ryan made some significant contributions to the process, and Draco and Ryan successfully completed a highly structured and cohesive jazz style composition that provided insight into their composition strategies and processes.

Sonic Elements in Draco and Ryan's Process

Table 18 summarizes the various sonic elements I coded as I observed Draco and Ryan collaborating. Draco and Ryan's collaborative composition process and their engagement with melody and rhythm were the sonic elements that provided the richest process-related data (link to Table, 18, Appendix D). To a lesser extent, but still yielding relatively rich data was Draco and Ryan's attention to the vertical structure of their compositions.

Melody. Draco and Ryan's initial strategy was to listen to different styles of motives in the Hyperscore library, which included jazz, hip-hop, Latin, funk, rhythm and blues, rock ‘n roll, and classical. Listening to several melodies in the library evidently inspired Ryan when he shared what he was thinking with me: “We were thinking about the jazz-blues [melodies], jazz-blues can go with a lot of different things. We could have a whole bunch of different solos” (Ryan, collaborating with Draco, October 10, 2017). Ryan’s reference to a “bunch” of solos indicated that he was thinking of including many melodies in their composition.

Maintaining their focus on the melody, Draco and Ryan’s next step was to think of how to vary or improve some of the Hyperscore melodies. This was the genesis of Draco and Ryan’s melodic strategy for the next five weeks, which focused predominantly on finding ways to vary the main theme of their composition. Figure 80 illustrates how Draco and Ryan developed their main theme from a Hyperscore library motive (link to Figure 80, Appendix D).

Melody continued to dominate Draco and Ryan’s process for the vast majority of their five-week collaboration period. During their third collaborative session, after completing their main theme and adding a drumbeat, Draco and Ryan consider their next step, which was to focus on creating another melody. Their conversation led Draco and Ryan to decide on composing a completely original melody. However, a lengthy discussion about form diverted their attention. Draco and Ryan debated ideas such as whether there should be an introduction, how many times the listener should hear each melody, and whether the drums should start immediately at the beginning. When Draco and Ryan eventually returned to creating an original melody, Ryan asserted himself and suggested, “Maybe we do the exact opposite” (i.e., an inversion) of the Hyperscore motive they used already. This led to them creating a variation on the first melody rather than an original melody.

Ultimately, Draco and Ryan imported one melody from the Hyperscore library, to which they devoted considerable time editing and varying, and they jointly composed one original melody for the solo break in their composition. Their original melody for the solo break sounded much like an improvisatory jazz solo and harked back to Ryan’s first-day idea of having “a whole bunch of solos” (Ryan, collaborating with Draco, October 10, 2017). Draco embarked on a painstakingly slow process of singing and transcribing each note of the short melody he hummed. Although the written transcription of his hummed melody was not wholly accurate in pitch, Draco’s transcription of the contour he hummed was very precise. Eventually, Draco and Ryan capitalized on their mechanical and visual-mathematical identities, respectively, to expand and complete the melody for the solo break.

Rhythm. Draco and Ryan’s attention to rhythmic accuracy was impressive and consistent with Draco’s earlier self-proclaimed bias toward the mechanics of music and my earlier impression of Ryan as a visual artist-mathematician. Draco and Ryan spent much of their time meticulously adjusting note sizes (values) for rhythmic precision and aligning material vertically. Two examples of these mechanic and visual artist-mathematician’s attention to rhythm appear among Figures 81, 82, and 83, which included rhythmic variations via diminution and augmentation, respectively (link to Figures 81, 82 and 83, Appendix D).

Vertical rhythmic focus. Possibly because of the design of the Hyperscore software, most participants created discrete musical motives (melodies or percussion patterns) in separate melody and percussion windows without considering the rhythmic and harmonic implications of vertically combining various motives. Consequently, this often resulted in compositions comprising incongruous melodic and rhythmic material. However, Draco and Ryan spent considerable time adjusting their musical ideas to align vertically and create rhythmic synchronicity, and their composition bore a sense of cohesiveness that otherwise would have been lacking.

For example, after listening to how their melody and drum pattern sounded in combination, Draco and Ryan spent several minutes adjusting the melody to synchronize better with the drum pattern. Their arduous editing and alignment process resonated with Draco's previously stated interest in the mechanics of music, and with my previous description of Ryan as a visual artist-mathematician. These two modes of operation complemented each other in their effort to synchronize two motives rhythmically. Figure 84 illustrates part of the process, during which Draco and Ryan edited one particular melodic motive until it synced better with their drum pattern (link to Figure 84, Appendix D).

Traditional Composition Techniques in Draco and Ryan's Process

Draco and Ryan employed a wide range of traditional composition techniques, as represented in Table 19 (link to Table 19, Appendix D). Whenever these strategies emerged, I attempted to interject direct instruction explaining the musical terms for these techniques. However, I often did not notice the specific strategy until viewing it on video, and there was often no opportunity to follow up with direct instruction without interrupting the flow of the participants' composition process. My challenge with skillfully interjecting direct instruction within this constructionist environment reflected the dialectical *constructionism-instructionism* (Papert, 1980, 1993, 1996) dyad I discussed in Chapter 1 as part of the theoretical framework for this study.

Draco and Ryan's attention to form was the predominant traditional composition technique I observed. Also, their use of sequence, fragmentation, and repetition to compose was impressive and particularly noteworthy. Finally, Ryan and Draco's application of contour generated some relatively compelling data that I present in this section.

Form. Draco and Ryan were planners (Stager, 2001; Turkle & Papert, 1990) more than bricoleurs (Lévi-Strauss, 1962; Papert, 1980a, 1993). Draco and Ryan rarely experimented with form by using the graphic notation tools to draw on the sketchpad extemporaneously. Instead, they usually discussed their plan in advance to a great extent before drawing it on the sketchpad, and rarely changed something once they drew it. Draco and Ryan's desire to plan and organize their composition in advance also resonated with Papert's (1980a) concept of *ego syntonicity,* which Papert described as that which "is coherent with children's sense of themselves as people with intentions, goals, desires, likes, and dislikes" (p. 63). Draco and Ryan were self-aware composers.

Although Draco and Ryan's regular listening, discussing, and planning sessions resulted in a composition of minimal content, their composition (shown in Figure 85) was impressively cohesive in structure (A, A′, A″, B, A″, A′, A) and possibly influenced by their reflexive process (Ackermann, 1996; Duffy & Cunningham, 1996) (link to Figure 85, Appendix D). Draco and Ryan embraced a metacognitive approach that involved extensive self-directed listening, discussing, reflecting, and subsequently *acting* on their reflection. Also, Draco and Ryan's respective mechanic and visual artist-mathematician identities I described earlier in this chapter seemed to complement one another during the collaborative composition process.

Sequence, fragmentation, and repetition. Consistent with their respective mechanic and visual artist-mathematician identities, Draco and Ryan spent several minutes crafting the solo section of their composition by sequencing two short musical ideas. Draco and Ryan's process while creating their sequence was imbued with concentration balanced with lighthearted conversation. This scenario was an impactful example of *hard fun* (Papert, 1996, 1999b). Draco and Ryan exhibited cheerful diligence during this process, which is illustrated in Figures 86 and 87 (link to Figure 86, Appendix D; link to Figure 87, Appendix D).

Draco and Ryan's strategy of using a fragment of their main theme to expand their solo section was tantamount to a technique classical composers sometimes used in the development section of a symphonic movement in Sonata-Allegro form. The analysis in Figure 88 of Draco and Ryan's solo section illuminates a rather sophisticated use of fragmentation, sequence, inversion, and transition (link to Figure 88, Appendix D). An outline of the form for their composition shown in Table 20 revealed how Draco and Ryan used repetition while concurrently infusing variety (link to Table 20, Appendix D).

Contour. Contour emerged as a relatively common elemental component in

Draco and Ryan's process. Although they were not extraordinarily prolific composers, a variety of contour emanated from their process at various times. For example, the solo section of their composition (see Figure 88) begins with a somewhat linear sequence and then transitions to a distinctly curvilinear sequence, which resulted in this section of the piece sounding particularly well-balanced.

Draco and Ryan's *body-syntonic* (Papert, 1980a) singing and humming as they attempted to generate and draw musical ideas for their solo section did not result in particularly pitch- accurate transcriptions; however, the contour of what they notated was often very similar to the contour of their humming or singing. Draco and Ryan's choice to draw only straight lines on the sketchpad to combine their musical material was noteworthy. Drawing a motive using a straight line on the sketchpad maintained one tonal center for that motive, whereas drawing a curved line resulted in a fluctuating tonal center. During the entire five-week collaborative composition phase, Draco and Ryan never explored curvilinear drawing on the sketchpad. It is possible that the contour of their motives (see Figure 85) alone provided extensive variation in pitch, and Draco and Ryan did not want to introduce further tonal shifts. Figure 89 illustrates Draco and Ryan's 'straight line' approach to their composition (link to Figure 89, Appendix D).

Sound and Sight in Draco and Ryan's Process

As I observed Draco and Ryan's process, it quickly became clear that they used the Hyperscore graphic notation tools masterfully and in a manner consistent with my previous descriptions of them as 'mechanic' and 'visual-artist-mathematician,' respectively. Also, beginning in Week 7, a sound before sight approach permeated and benefited their process, particularly in Week 9. Table 21 represents the sound and sight categories I noted as I observed Draco and Ryan's process (link to Table 21, Appendix D).

Graphic notation. Draco and Ryan excelled in using the graphic notation tools to facilitate reflection, the geometric counterpart to musical inversion. Figure 90 illustrates this strategy. Although it took time for Draco and Ryan to create an accurate tonal inversion, it is noteworthy that they committed to such a lengthy, somewhat tedious process. This process was consistent with the mechanical and visual-mathematical characteristics associated with much of their other work (link to Figure 90, Appendix D). Regular appearances of Draco and Ryan's respective mechanic and visual mathematician identities resonated with Papert's (1980a) observation that *ego syntonicity* sometimes permeated children's processes in the Logo computer programming lab.

Draco and Ryan's persistent and reflexive process (Ackermann, 1996; Duffy & Cunningham, 1996) ultimately led to a structurally defined composition that sounded rather musically sophisticated (see Table 20). Also, although they did not speak in terms such as reflection, inversion, translation, transposition, tonal centers, or bi-tonality, Draco and Ryan intuitively applied these sophisticated musical processes by using Hyperscore as a geometrically-oriented tool to realize their musical ideas. Their work with Hyperscore as a tool underscored the Vygotskian notion of two meditational means: technical tools and semiotic tools, with the computer bearing aspects of both tools and sign (Duffy & Cunningham, 1996). Although other participants in the present study frequently capitalized on Hyperscore's graphical user interface to integrate technical tools and semiotic tools, Draco and Ryan probably did so most expertly.

Sound before sight. “When I hum it, I try and get it just right.” (Draco, interview, October 30, 2017). Sound before sight (humming or singing then notating) permeated Draco and Ryan’s process and exemplified Papert’s (1980a) constructionist concept of *body syntonicity*. Even after completing a section of a composition, Draco and Ryan would often hum or sing along, move to the music, or play air drums with it on subsequent playbacks. At times, Ryan would provide the sound, and Draco would transcribe to the best of his ability. The resulting graphic notation would usually resemble the contour of what Ryan was singing or a new, yet similar idea sung by Draco.

Most of Draco and Ryan’s orally or physically expressed melodies or rhythms were too complex for them to transcribe exactly, which usually led to minimal, precise transcription. However, it is noteworthy that they spent much of their time imagining possibilities by making vocal sounds, playing air drums or trumpet, or drumming on the desk. Even when sound ultimately led to sight (notation), Draco and Ryan often spent much more time orally or physically expressing their music than they did notating it in Hyperscore.

At times, Ryan would allow Draco to take over as the “more capable peer” (Vygotsky, 1978, p. 86), during which Draco would often adopt a sound *with* sight process to confirm that what he notated was accurate. As illustrated in Figure 91, Draco would sing or hum a melody, transcribe his idea, and then go into slow-motion, note-by-note check of his idea by pointing to each note with the mouse and singing along (link to Figure 91, Appendix D).

Inspiration Sources in Draco and Ryan’s Process

Much of Draco and Ryan’s inspiration came from each other as they discussed, listened, and planned regularly. Although Draco usually controlled the mouse and made many of the musical decisions, he would occasionally ask for input from Ryan, and Ryan gradually contributed more of his own suggestions to the process throughout the five weeks. During one particular interview, Draco shared his sense of their teamwork, saying, "I am much better at the mechanical thinking, and Ryan is much better at the abstract thinking" (interview, October 30, 2017). Draco seemed to see himself more a *technician* than a *musician* and viewed Ryan as an 'ideas person' with whom he collaborated effectively.

I noted that Draco and Ryan drew inspiration for their composition in a few more specific ways beyond collaborative dialogue, which are delineated in Table 22 (<u>link to Table 22, Appendix D</u>). Draco and Ryan expressed gaining inspiration through analogy, by considering genre or style, and from others' music. In this section, I provide a few examples that "show what a few of the various kinds of instances look[ed] like in actual performance" (Erickson, 2006, p. 22).

Analogy. Draco and Ryan once expressed that a good composition was similar to a good essay with structural elements such as a thesis, topic sentence, and evidence. Also, during the collaborative process phase, Draco underscored his mechanical proclivity in one particular interview using a science analogy to describe his process:

> SD: I noticed that in your current composition, you are adjusting things on a very detailed level. What are you trying to do?
>
> Draco: I am trying to make it better. (Pause.) I just actually had the idea of a microscope. Like, in science, there's two adjustment knobs. There's the coarse adjustment knob; it goes like rant-rant. Then there's the little tiny fine adjustment knob that goes like eet-eet-eet. It's the fine adjustment knob that makes it look really good, super sharp and clear and nice. It's the same kind of

> thing here, if you adjust it in broad strokes, yeah, it will still sound good. But if you also take that fine adjustment knob and, like reet-reet-reet it will sound *really* nice.
> (stimulated recall, October 30, 2017)

Although Draco and Ryan's use of analogy was limited, their connection between music and other academic disciplines was unique in this study and noteworthy.

Genre or style. At the beginning of their process, Draco and Ryan spent considerable time listening to Hyperscore library samples of various styles, including jazz, hip-hop, Latin, funk, rhythm and blues, rock 'n roll, and classical. As mentioned earlier, after listening to sample compositions in the Hyperscore library for several minutes, Ryan was clearly drawn to jazz as a style to emulate. Ultimately, the Hyperscore library motive Draco and Ryan chose for their main theme was based on a blues scale, and the accompanying drum pattern they selected from the Hyperscore library emulated a be-bop style, as shown in Figure 92 (link to Figure 92, Appendix D).

At first, Ryan seemed to be open to a variety of genres: "We haven't even tried pop or rock" (collaborative composition, October 10, 2017). However, once they chose their blues-oriented main theme from the Hyperscore library, Ryan seemed to become slightly more concerned about staying in the jazz vein, interjecting occasional reminders about their chosen jazz genre, such as, "That's dance music, not jazz" (collaborative composition, October 10, 2017)

Others' music. Draco and Ryan's final composition was almost wholly comprised of others' music (i.e., Hyperscore library motives), which Draco and Ryan edited, varied, and developed to their liking. The Hyperscore library motives were a significant source of inspiration for Draco and Ryan. The one original element of Draco and Ryan's final product was a short motive composed by Draco, which was part of the solo section of their composition (see Figure 88, Sequence #1). Consistent with his tendency to defer to Draco as the "more capable peer" (Vygotsky, 1978, p. 86), Ryan agreed to remove the one short motive he had created for the solo section shown in Figure 93 (link to Figure 93, Appendix D).

Draco and Ryan seemed to gain more satisfaction from developing others' material than from creating original motives. For example, when they were working on the mechanics of developing inversions and sequences of pre-existing music, they often became absorbed in the process. However, when trying to come up with their own ideas, creating original musical material often seemed out of reach. When this happened, their session would often evolve into antics and unproductive activity. On one particular day, while struggling to get started on composing the solo section of their piece, instead of getting off track as would often happen, Draco and Ryan experimented with using the contour of a *Mr. Sandman* for inspiration. Although this strategy did not ultimately lead to creating any original material, it appeared to have inspired Draco and Ryan to regain focus.

Cross-Case Analysis

In the previous section, I presented the composition strategies and processes of the four focus composers and the two collaborative pairs discretely. In the next section of this chapter, I examine the data globally through the theme- and category-related lenses, as summarized in Figure 94 (link to Figure 94, Appendix D). I discuss the most impactful strategies and processes that revealed themselves across the four individual cases and two collaborative cases and within each of the four overarching themes. At times, the most impactful data within a particular category or sub-category coincided with data presented earlier during the within-case analysis, which functioned as a type of internal validation and called for additional emphasis in the cross-case analysis. At other times, new data emerged as the most compelling examples of resemblance or contrast between or among cases. I also noted how the theoretically-oriented variables of interest that I identified in Chapter 1 revealed themselves during my cross-case analysis of participants' composition strategies and processes.

Inspiration Sources in the Composers' Processes.

In the present study, there were no deadlines or time constraints, which might have allowed participants more time to seek inspiration. Table 23 summarizes the three inspiration sources I identified and the extent to which they surfaced as I observed the four focus participants composing individually and collaboratively over ten weeks (link to Table 23, Appendix D). In the following section of the chapter, I discuss sources of inspiration displayed or expressed by the four participants: (a) analogy, metaphor, story, imagery, mood, (b) genre or style, and (c) others' music.

Analogy, metaphor, story, imagery, mood. During their individual composition phase, neither Chelsea nor Emily explicitly displayed or expressed an interest in using imagery or story to inspire their compositions. However, story and image played a major role during their collaborative composition phase. While Chelsea and Emily initially struggled to get started, they began by discussing genres. For several minutes thereafter, Chelsea and Emily explored the Hyperscore instrument menus as they aimed to create “electric sounding stuff” (Chelsea, collaborating with Emily, October 6, 2017). After expressing dissatisfaction with their initial results, Chelsea and Emily started over and eventually came across the sci-fi option in the list of instruments. Discovering the sci-fi list of instruments marked a turning point in Chelsea and Emily’s collaborative process. Chelsea suggested, “What if we do an echoing kind of dark sound?” (collaborative composition, October 6, 2017). Emily agreed to Chelsea’s suggestion, which precipitated their goal of creating “creepy” music.

Over the next few weeks, Chelsea and Emily spent the rest of their time focusing on creating sound effects and setting a mood. The inspiration for their music also seemed to inspire positive interaction between Chelsea and Emily. They shared ideas, laughed regularly, and often seemed excited about their progress, which was an indication of composition being a positive *affective* experience (Papert, 1980a) for them.

For Draco and Ryan, the inspiration-related category of analogy, metaphor, story, imagery, mood played a less prevalent role than for Chelsea and Emily. While composing individually, Draco once drew an analogy between fine-tuning a microscope and fine-tuning his music like a mechanic. However, he used this analogy more to explain his process than to cite a source of inspiration. During one particular stimulated recall session, Ryan briefly mentioned trying to create a suspenseful mood in his first composition when he described the oblique motion in his first composition, saying, “I think I was trying to create something more suspense[ful]” (stimulated recall, October 10, 2017). Figure 95 illustrates Ryan’s use of oblique motion (link to Figure 95, Appendix D). While composing collaboratively, Draco and Ryan briefly drew an analogy between a musical composition and a written essay when they described their introduction as the "topic sentence," the drums as "the evidence," and the guitar solo as "the analysis" (stimulated recall, October 18, 2017). However, there were no subsequent parallels drawn between a musical composition and an essay in Draco and Ryan's process.

Genre and style. While Chelsea and Emily composed individually, I noted no explicit references to genre or style as sources of inspiration. When Chelsea and Emily collaborated, there was an initial desire to create something "electric," and they also briefly discussed creating classical and opera. However, once they discovered Hyperscore's 'eerie' timbre and were inspired to create 'creepy' music, emulating a specific genre or style never emerged as important to Chelsea and Emily.

During his second composition session, Ryan appeared to be at a standstill at one point when I asked him about his musical preferences. I suggested that Ryan listen to some sample compositions in Hyperscore, which are categorized by genre. Ryan listened to a few examples, began anew, and never explicitly referenced a particular genre or style again during his individual composition process. Similarly, Draco made one reference to genre during one particular stimulated recall moment, saying, "I like how it (his composition) sounds less future techno now" (stimulated recall, October 18, 2017). Draco made no other references to genre or style as a source of inspiration during his individual composition phase.

Conversely, as described during the within-case analysis above, Draco and Ryan adopted 'jazz-blues' as their desired style for their collaborative composition early in the process and devoted a considerable amount of time listening to various existing motives in Hyperscore until they found a primary theme that sounded like “jazz-blues” to them. To summarize, genre or style was important to Ryan and Draco, while composing collaboratively but not individually, and genre or style was not apparently an important consideration for Chelsea and Emily, whether composing individually or collaboratively.

Others’ music. While composing individually, Chelsea asked Emily several times if she could listen to her music. However, Chelsea did not express or display the direct influence of Emily’s music on her composition process. Similarly, Chelsea occasionally listened to sample compositions in Hyperscore:

> Chelsea: (Listening to a Hyperscore arrangement of Beethoven’s *Fifth Symphony* finale)
> SD: So, what did you think about it?
> Chelsea: That was somebody else’s, obviously.
> SD: Yeah, but what did you think about it?
> Chelsea: I was just trying to get ideas.
> (individual composition, September 14, 2017)

This brief exchange between Chelsea and me exemplified the type of *scaffolding* (Duffy & Cunningham, 1996; Wood, Bruner, & Ross, 1976) that occurred throughout the 10-week data collection phase. I noted my tendency as observer as participant (Merriam, 2014) to ask questions to promote deeper thinking, and if a participant did not respond favorably, I often moved on rather than probing further.

Although Chelsea did not overtly display or express how other participants’ music influenced her strategies or processes, her occasional interest in listening to others’ music and the few favorable comments she made while listening indicated that others’ music was possibly influential. Conversely, Chelsea expressed that listening to Hyperscore motives provided inspiration for her compositions to some extent but felt like directly borrowing pre-existing motives was not an authentic approach to composition.

Emily spent some of her time listening to other participants' music and, similar to the other participants in this study, did not display or express any specific influence on her composition from listening to other participants' pieces. However, Emily's inspiration from other sources was sometimes apparent. For example, "I had just learned how to play *Phantom of the Opera"* (stimulated recall, November 7, 2017) explained Emily's inspiration for using a chromatic scale in one of her compositions, and, "I just wanted to listen to it to get some sort of inspiration" (stimulated recall, October 26, 2017) was an overt expression of why Emily was listening to a sample composition in Hyperscore at one point. Emily also articulated how a previous piano piece she had learned inspired part of one of her compositions. After drawing four A minor chords and noticing that they reminded her of the first measure of *Arabesque* by Burgmüller, Emily spent the rest of her composition session, attempting to emulate the melody of *Arabesque*.

While composing collaboratively, Chelsea and Emily occasionally expressed gaining inspiration from others' music. Although Chelsea and Emily did not listen to specific 'creepy' music to gain inspiration, it was clear by their timbral choices (e.g., the eerie voices timbre), comments while listening to Hyperscore sample compositions such as, "That sounds like a spy movie" (Emily, collaborating with Chelsea, October 2017), and their commitment to creating a quasi-*Twilight Zone* theme showed that they were inspired by music they had heard previously in films or on television.

At one point, while collaborating with Emily, Chelsea began humming

Beethoven’s *Fifth Symphony* final motive, probably recalling it from listening to a Hyperscore arrangement of this theme a couple of weeks earlier. Chelsea’s humming led to collaborating with Emily for several minutes and creating a variation on Beethoven’s motive. Beethoven’s motive inspired several minutes of intensive collaboration or *hard fun* (Papert, 1996, 1999b) that resulted in a re-harmonized version of Beethoven’s *Fifth Symphony* motive (see Figure 71).

Contrastingly, Draco and Ryan individually displayed less influence by others’ music on their composition processes. At one point, Draco promoted the benefit of using the pre-existing Hyperscore motives for inspiration. However, similar to Chelsea, Draco questioned the validity of using Hyperscore motives as part of an original composition, saying, “It’s really good to take inspiration and maybe steal a few notes from other things…but when you’re going for that original sound like it’s yours, you shouldn’t use the motives” (interview, October 4, 2017). Chelsea and Draco’s adamant position about originality underscored composition as an *ego-syntonic* (Papert, 1980a) process for them.

I did not observe noticeable influence from others’ music during Draco’s composition process, and he never articulated that others’ music influenced his process. During his final interview, Draco offered advice to future Hyperscore composers, during which he indicated that trying to simulate others’ music might not be a useful strategy.

Similar to Draco, Ryan listened to others’ compositions a few times but displayed no particular influence by others’ music on his composition process. Although I suggested listening to some Hyperscore sample compositions and motives, Ryan only did so briefly during his individual composition process. Listening to others’ music during his individual composition process apparently did not appeal to Ryan.

During the collaboration phase, Draco and Ryan exhibited more interest in gaining inspiration from others' music than when they composed individually. Contrary to Draco's earlier suggestion that "you shouldn't use the motives" (interview, October 4, 2017) when attempting to be original, he worked with Ryan and devoted much collaboration time to creating an inversion of a pre-existing Hyperscore melody to use in their composition. It is possible that Ryan's interest in listening to Hyperscore motives and sample compositions influenced Draco to be more open about using pre-existing melodies and drum patterns. For one brief moment, Draco and Ryan experimented with creating an original melody by emulating the contour of *Mr. Sandman.* This was the only manifestation of others' music influencing their composition process I noticed beyond their listening to Hyperscore sample motives and compositions and the one Hyperscore motive they used for their composition.

Sonic Elements in the Composers' Processes.

The manner in which the four focus composers in the present study interacted with various sonic elements emerged as a primary theme along with three prevalent, related categories: timbre, rhythm, and tempo. Table 24 elucidates the extent to which various sonic elements manifested themselves as I observed the four focus composers' individual and collaborative processes (<u>link to Table 24, see Appendix D</u>). Also, the directional manner in which the focus composers focused when combining particular sonic elements emerged as a prominent related category. Certain composers focused more on the horizontal (i.e., temporal and melodic) aspects of their pieces while others considered the vertical (i.e., harmonic and polyrhythmic) implications of their compositions besides applying a horizontal lens. At times, composers explored a curvilinear process without regard to traditional horizontal and vertical constructs related to music composition (e.g., measures, beats, staff lines).

Timbre. The four focus composers in the present study devoted much of their composition time to exploring timbre. Such exploration often consisted of previewing sounds available in Hyperscore before creating thematic material. My cross-case analysis revealed variations in the type of interactions with timbre among the four focus composers.

As an individual composer, Chelsea's interest in timbre focused primarily on using specific percussion instruments, probably because she was a drummer and seemed to have specific instruments in mind for her drum patterns. Other than specific percussion instruments, Chelsea did not express an interest in using particular instrumental timbres while composing individually. However, as shown in Figure 96, Chelsea used all eight drawing colors provided by Hyperscore for her first composition (link to Figure 96, Appendix D). Soon after expressing dissatisfaction with the sonic results of her first composition, Chelsea discontinued the strategy of erratically superimposing all eight colors and started using them more discretely and sparingly. Chelsea seemed to perceive of creating a composition as combining colors, possibly because the Hyperscore user interface resembled an artist's palette.

During her individual composition process, Emily expressed a modicum of interest in exploring timbre while also displaying specific preferences and preconceived notions about timbre. Comments such as, "The French horn doesn't add anything, so I am just gonna get rid of it," (individual composition, September 14, 2017) suggested that Emily considered timbre an integral aspect of her composition process. Probably because she is a bass player, Emily was especially discerning about the timbre of the bass instrument she chose for her compositions: "Why is it so high? That's not what bass is!" (individual composition, September 26, 2017). Although other participants spent more time than Emily exploring a variety of instrumental sounds, Emily was the most specific of all the composers about the quality and effect of particular timbres on her compositions.

Timbre played a major role in Emily and Chelsea's process when they composed collaboratively. One-hundred of the 232 references to timbre I noted among the focus composers emanated from observing Emily and Chelsea's collaborative process. Chelsea and Emily spent a great deal of time looking for 'creepy' sounds in Hyperscore and seemed to enjoy exploring timbre more than any other aspect of the composition process. Although Chelsea and Emily's composition included only two short melodic motives, much of their composition ultimately consisted of sound effects. Chelsea and Emily's process also included a great deal of discussion about the images they wanted to portray with their music and experimenting with sound effects to support their intended storyline. Timbre, integrated with analogy, story, mood, and imagery as inspirational devices, was the sonic element that dominated Chelsea and Emily's process.

During his individual composition sessions, Draco committed a great deal of time auditioning various timbres for his composition. However, he distinguished himself from the other focus composers by usually focusing on timbre *while* creating musical material.

Whereas other participants often sought out timbres first and subsequently created melodic and rhythmic material using their desired timbre, Draco typically created motives, rhythms, or melodies while simultaneously considering timbre. None of the other focus composers displayed or expressed that they equated an instrument's timbre with its *function*.

Ryan sometimes displayed that he integrated considerations of timbre with planning the form of his compositions. Think-aloud comments such as, "Then [I will] start a drum beat and then get into the real thing with a different instrument…and hopefully, try to put some electric guitar in there later," (individual composition, September 12, 2017) suggested that Ryan sometimes determined in advance which instruments he planned to use in a particular order. Likewise, when collaborating with Draco, Ryan integrated form and timbre when he suggested alternation between drums and guitar timbres as part of their composition's structure.

Timbre was less prominent as a sonic element when Draco and Ryan composed collaboratively than when they composed individually. Not surprisingly, Draco and Ryan used only guitar and drum timbres, while composing collaboratively, which was consistent with their preferred timbres while composing individually. One unique manifestation of timbre surfaced a few times during Draco and Ryan's collaborative process as they were previewing various pre-existing Hyperscore motives. Comments such as, "That would be good with a different instrument" (Ryan, collaborating with Draco, October 10, 2017) suggested that Draco and Ryan had a clear idea of what timbres would be appropriate for their 'jazz-blues' composition.

Rhythm. Similar to the various ways in which timbre manifested itself, rhythm presented itself in various ways within the four composers' processes. All four composers used Hyperscore graphic notation tools regularly to experiment with rhythm. Probably because it was easy to resize notes quickly and affect rhythm with little effort, the focus composers gravitated toward changing and editing rhythms fairly consistently and achieved some sophisticated results. Examples of tinkering with the rhythm in this manner abounded. At one point, I observed Chelsea and Emily attempting to emulate Beethoven's famed four-note motive from his *Fifth Symphony* finale. As Chelsea and Emily hummed the short-short-short-long motive several times, they adjusted note lengths to quickly achieve the desired result (see Figure 71).

Two other situations, Draco and Ryan's use of the note resize function to incorporate augmentation (see Figure 84) and Ryan's use of diminution (see Figure 58), exemplified the intuitive application of rhythmic variation exhibited by the focus composers in the present study. All four participants appeared to use the graphic notation tools easily in Hyperscore to experiment with rhythm through a simple process of elongating and shortening notes as if painting on the screen.

Tempo. The focus composers in the present study demonstrated an interest in experimenting with tempo to see how it affected their compositions. For example, while composing collaboratively Draco and Ryan discussed the effect of slowing down the tempo:

> Ryan: Try a different speed. I feel like if you do it slower, it allows you to do more stuff with it.
> Draco: The tempo depends on how long it (the composition) is. If it's a slow

tempo, then less things will be longer.
(collaborative composition, October 18, 2017)

Similarly, Chelsea and Emily regularly discussed the effect of tempo and made many metronome adjustments during their process. At one point, they tried out a few possibilities by adjusting the metronome, realized that a faster tempo did not complement their imagery, and ultimately agreed on a slower tempo that would sound ‘creepy:’

> Emily: What happens if you speed things up? Speed it up, so it’s funny.
> Chelsea: How cool is that?
> Emily: Sounds like a ringtone.
> Chelsea: No, it has to be slow like it was before.
> (collaborative composition, October 26, 2017)

While composing individually, Emily expressed a desire to integrate tempo changes into her composition before she realized that internal tempo changes were not an option in Hyperscore. After realizing she did not have the option of creating internal tempo changes, Emily decided to "see how this works fast-paced" and determined that the fast tempo sounded "a little all over the place" (individual composition, September 20, 2017). Emily’s persistence in trying a variety of tempos until finding one that complemented her music exemplified her sense of tempo as an integral element in her composition process.

Despite the lack of internal tempo changes being an option in Hyperscore, the two pairs of focus composers each devised creative solutions that allowed them to incorporate tempo changes into their compositions. As shown in Figure 66, Chelsea and Emily created an acceleration effect by gradually decreasing note lengths. Similarly, as illustrated in Figure 84, Draco and Ryan created a ritardano at the end of a phrase by increasing note lengths. As an individual composer, Draco applied a similar strategy to one of his bass lines, as demonstrated in Figure 97 (link to Figure 97, Appendix D).

Curvilinear, horizontal, vertical processes. Hyperscore requires composers to draw their sonic elements (i.e., motives, melodies, chords, and drum patterns) in discrete windows, and combine these elements through a separate drawing process on the sketchpad (i.e., the conductor's score). Figure 98 highlights the three types of windows used for composing in Hyperscore: the melody window, the percussion window, and the sketchpad (link to Figure 98, Appendix D).

As I observed the focus composers in this study, the manner in which they used Hyperscore as a graphic notation tool to combine sonic elements on their sketchpads emerged as a distinct category. At times, composers focused mostly on the horizontal aspect of their pieces as they drew on the sketchpad resulting in a predominantly or sometimes entirely monophonic composition. 'Horizontal composers' focused on sound unfolding over time and creating successive unison melodies or discrete drumbeats, usually without layering sounds vertically. Even when a predominantly horizontal composer layered sounds vertically, they often expressed or displayed little concern about the resulting harmonies or polyrhythms. At other times, composers worked with sonic elements bi-directionally, displaying an interest in how their music unfolded over time and how their sonic elements complemented one another vertically (i.e., harmonically or poly-rhythmically).

Sometimes, composers worked in a curvilinear, exploratory manner by drawing freely on the sketchpad, which I interpreted as the antithesis of horizontal and vertical approaches. Composing in a curvilinear fashion on the sketchpad allows the composer to explore countless points on the sketchpad, and bypass the confines of traditional measures, beats, or staff lines. The algorithms in Hyperscore analyze the composers' curvilinear shapes to derive a pattern of tension-release, simplicity-complexity, and variable harmonization (MIT Media Lab, n.d.).

The screenshots and narratives referenced in the following section exemplify the composers' curvilinear and linear (horizontal and vertical) processes and elucidate the range of directional approaches taken by the focus composers as they created their sonic elements and combined them on the sketchpad. At times, the screenshots and narratives also function as discrepant evidence to highlight apparent circumvention of a particular directional strategy by one or more of the focus composers or to draw comparisons among their processes.

The composers' curvilinear processes. Chelsea and Emily both used curvilinear strategies to a significant extent while Draco and Ryan only dabbled in curvilinear processes briefly. Chelsea initially created most of her melodic material in a curvilinear manner, drawing droplets in her melody windows randomly, as if creating an abstract painting, without consideration for how the droplets would sound as they unfolded over time. In Chelsea's first composition shown in Figure 99, it was evident from the haphazard and rapid manner in which she created eight melodies that she did not consider the quality of what she created from either a horizontal or vertical perspective (<u>link to Figure 99, Appendix D</u>).

Immediately after listening to the results, Chelsea commented, "That sounds horrible" (individual composition, September 1, 2017) and subsequently strived to modify her eight motives and improve her composition. Chelsea continued to express dissatisfaction with the results of her process, and eventually abandoned her first composition and started a new piece. Throughout the individual composition phase, Chelsea gradually moved away from a predominantly curvilinear approach to a more linear, horizontal and vertical approach, which I discuss later in this section of the chapter.

Unlike Chelsea's expressed discontentment with the results of her first highly curvilinear piece, Emily expressed satisfaction with the results of her curvilinear approach to her final individual composition and included this piece in our performance at the end of the study. Figure 100 depicts four milestones during Emily's final individual composition process. Emily's intentional weaving of the yellow and blue melodies in contrary motion and her intertwining of the less-curvy red melody appeared to be part of her strategy for making the curvilinear approach successful. Emily carefully drew the three curved melodic lines to complement one another and avoid conflicting. Finally, Emily 'splattered' the green dots (chords) in a haphazard, circular manner on the screen (link to Figure 100, Appendix D). Emily's splattered chords could have easily led to unfavorable results; however, Emily applied the 'classical' setting in Hyperscore, which launched an algorithm that converted her chords to consonances and complemented her weaving melodies.

Although Emily had success with the curvilinear approach, the four focus composers in the present study overall displayed and expressed dissatisfaction with the results of drawing curved lines on the sketchpad. Often, a composer would experiment with drawing curved lines on the sketchpad, listen to the results, and either delete the curved iterations altogether or redraw them as straight lines. Presumably, the variations in tonal center caused by drawing curved lines were undesirable to the focus composers in this study, as suggested by the overwhelming number of straight lines appearing on their sketchpads compared with curved lines. Screenshots excerpted from Emily's (Figure 101), Ryan's (Figure 102), and Draco's (Figure 103) processes illustrate how they converted curved lines to straight lines or deleted the curved lines altogether, a process I noted numerous times while observing the four focus composers (link to Figure 101; link to Figure 102; link to Figure 103, Appendix D).

The following exchange and screenshot illustrated in Figure 103 depict why and how Draco deleted a curved line that he identified as "the problem" with his composition (link to Figure 103, Appendix D):

> SD: Let's hear that.
> Draco: It's gonna sound really terrible. I'm gonna tell you right now. (Listens.) Nope!
> SD: Don't like it?
> Draco: This is the line that's the problem. (Pointing to the curved line.) It's going too up and down. (Deletes the curved line). That's better!
> (individual composition, September 28, 2017)

Draco and Ryan's linear processes. As an individual composer, Draco devoted most of his time to composing horizontally and was a decidedly melody-oriented composer. Draco orally expressed his ideas about melody more often than other participants through comments such as, "Let's think about the melody we want [and] come up with the melody before we actually start writing it down" (Draco, collaborating with Ryan, October 18, 2017). Possibly because of his expressed special interest in melody, Draco's melodies were longer and more rhythmically complex and developed than those composed by the other focus composers (see Figure 27).

Draco's primary vertical strategy first surfaced when he combined three iterations of the same melody at different pitch levels to create polytonality, as shown in Figure 104. At that time, Draco also experimented with the 'classical' setting in Hyperscore, which launched an algorithm converting highly dissonant harmonies to more consonant sonorities. Draco also reshaped the Hyperscore harmony line (the solid blue line in the center of the screen) to launch an algorithm that re-harmonized his music (link to Figure 104, Appendix D). After listening to the Hyperscore re-harmonization of his music, Draco commented, "I actually like that better" (individual composition, September 28, 2017). Ultimately, Draco removed one line from his polytonal passage to make it a bitonal passage, added a short percussion pattern to accompany the bi-tonal melody, and inserted a two-note coda in the last few minutes of his process. The screenshot of Draco's individual composition in Figure 105 epitomizes Draco's apparent bias toward melody, which is the most prominent sonic element in his composition (link to Figure 105, Appendix D).

Similar to Draco, Ryan's process also displayed particular attention to melody and a tendency to focus on the horizontal aspect of his compositions. While working on his first composition, Ryan experimented with a few curvilinear shapes and overlapped melodies to create harmony (see Figure 62). However, after the first day, Ryan's focus became almost entirely horizontal, and everything he composed was monophonic.

Ryan's process usually focused on creating a series of short phrases over time and drawing perfectly straight lines on the sketchpad. Ryan showed little interest in layering ideas vertically to create harmony or polyrhythms, which is apparent in his second and third compositions shown in Figure 106. These screenshots in Figure 106 exemplify Ryan's careful, minimalistic approach to the composition process (link to Figure 106, Appendix D).

While composing collaboratively, Draco and Ryan continued their tendency to focus on horizontal processes. They spent much of their time creating an inversion of their main melody borrowed from the Hyperscore library and composing an original melody for the solo break. However, Draco and Ryan briefly left their horizontally-oriented process to become 'vertical composers' when they combined a pre-existing Hyperscore drum loop with their melody, and when they combined their original melody and its inversion (see Figure 90). Other than these two ventures into the vertical aspect of composition, Draco and Ryan exhibited a predominantly horizontal approach during their collaborative activities.

Although they explored the vertical aspects of their compositions to some extent, their individual and collaborative compositions rarely included more than two or three sonic elements happening simultaneously, and usually one or two. A close examination of Draco and Ryan's collaborative composition revealed their emphasis on melody (link to Figure 107, Appendix D).

Chelsea and Emily's linear processes. Chelsea appeared to go through a gradual transition from being a predominantly curvilinear composer for her first composition (see Figure 99) to a predominantly horizontally-oriented composer for her third and final composition (see Figure 110). For her second composition shown in Figure 108, Chelsea's approach became somewhat more linear when she drew on the sketchpad. Chelsea seemed to create a visually interesting artwork on the sketchpad and made no connection between her sonic elements and the lines and dots she drew on the sketchpad. However, compared with the wildly curvilinear approach in her first composition, Chelsea appeared to be more concerned about creating form while drawing on the sketchpad for her second composition (link to Figure 108, Appendix D).

Ultimately, and similar to Ryan, Chelsea composed mostly by sequencing a series of unrelated monophonic ideas without attention to creating something that developed over time, and with no apparent concern for the vertical implications of her music. One exception occurred at the beginning of her final composition when Chelsea created a quasi-stretto effect by having subsequent themes enter before each previous theme finished. Despite the stretto effect, Chelsea's approach was distinctly horizontal, with one unrelated musical event after another appearing in succession. Figure 109 illustrates the beginning of Chelsea's final composition (link to Figure 109, Appendix D).

Chelsea's complete final composition illustrated in Figure 110 included a preponderance of straight lines that avoided variations in pitch level. The only pronounced curved lines represented unpitched percussion instruments, and these curved lines had no effect on the pitch or timbre of the instruments. It is possible Chelsea might not have considered the pitch effect of the curved lines when she drew them, or she might have been aware that the curved lines represented unpitched percussion, the pitch of which would be unaffected (link to Figure 110, Appendix D).

In contrast to Chelsea, who gradually evolved from a predominantly curvilinear composer to a more linear composer over the first five weeks, Emily gradually moved in the opposite direction, from linear to curvilinear. While composing her first piece, Emily gravitated toward a curvilinear process by adding curved lines to her composition. The following think-aloud data and screenshots in Figure 111 exemplify Emily's early interest in both linear and curvilinear processes (link to Figure 111, Appendix D):

> I just want to toss this [curved line] in to see if it makes it any better. Just giving it the swervy thing. I mean it *is* (emphasis in her voice) about the piece, but also, I just kind of want it *looking* (emphasis in her voice) good, ya know (individual composition, September 8, 2017).

After experimenting with adding curved lines to her predominantly linear composition and listening to the result, Emily ultimately deleted the curved lines, saying, "That just makes it a little busy" (individual composition, September 8, 2017). Emily entitled the final version of her first composition *Lines* (see Figure 7), solidifying her initial reputation as a linear composer. However, as described earlier, Emily eventually moved into a 'curvilinear period' for her second composition.

As collaborative composers, Chelsea and Emily never explored the curvilinear approach. Their approach was distinctly linear and mostly horizontal, probably because of their emphasis on creating a programmatic piece of music that told a story more than experimenting with Hyperscore's drawing tools. Chelsea and Emily's exploration of vertical depth was minimal, with two layers of sonic elements at the most occurring at one time. Chelsea and Emily's composition process strongly reflected their linear, storyboard-style conversations, with five discrete events in succession shown in Figure 112 (link to Figure 112, Appendix D).

To summarize, Chelsea and Emily's linear processes were a mix of horizontal and vertical strategies. Chelsea and Emily explored the vertical aspect of composition to a greater extent than Draco and Ryan. However, similar to Draco and Ryan, Chelsea and Emily's individual and collaborative compositions usually included only two or three sonic elements happening simultaneously (vertically), and often just one or two. Figure 113 summarizes the various directional approaches that the four focus composers displayed or expressed while graphically notating their individual and collaborative compositions (link to Figure 113, Appendix D).

Sound and Sight in the Composers' Processes

For this study, I envisioned an environment in which participants composed music without the need to manipulate abstract musical symbols associated with traditional notation and where sound (i.e., creating aural elements) and sight (i.e., creating visual elements) were equally accessible to the participants. Relatedly, Kendall (1986) cautioned that, antithetical to Pestalozzi's concept of education emphasizing sound before symbol, music educators sometimes overemphasize traditional notation at the risk of placing children under "the tragic delusion that notation is music" (p. 40). Reimer (2003) included considerations of both sound and sight, saying, "Composers think and do creatively by imagining possibilities of sounds coming into being and by capturing them in some way (notation, computer memory, their own memory) so they can be worked on and made something of (p. 123)." Reimer's concept of composition closely aligned with the design of the present study in which I expected participants to think in sound and capture it with the graphic notation tools provided in Hyperscore.

However, the Hyperscore design makes it possible for students with an understanding of basic traditional notation principles to draw on this previous knowledge while they notate graphically. This particular aspect of the design was ideal for students with an understanding of abstract musical notation who might want to integrate their understanding with the more concrete, graphic notation approach. For these students, Hyperscore facilitated a dynamic relationship between the abstract and the concrete and reflected Turkle and Papert's (1990, 1991) concept of *epistemological pluralism*. For example, it is possible within Hyperscore to create droplets emulating the length of traditional note values and place these droplets within the bounds of gridlines emulating traditional measures, if so desired.

Although Hyperscore places composition in a notational environment, it does so to facilitate intuitive written composition unfettered by the challenges of using abstract traditional notation. By design, the novice composers in the present study created music in an environment that required notation, and it was through this lens that the Sound and Sight theme and its related categories emerged. I summarized these categories in Table 25 and discuss them in this section of the cross-case analysis (link to Table 25, Appendix D).

A few times, I observed participants who drew sonic elements hastily, and subsequently listened to their music and assessed the results, which I deemed a 'sight before sound' process. Many times, I observed composers who hummed or sang ideas or listened to sample melodies and compositions before notating their own, which I referred to as ‘sound before sight.’ A few times, I noted a ‘sound with sight’ process, during which the composer engaged with sound (usually humming or singing) and the graphic notation tools practically simultaneously.

The purpose of the following section is to elucidate some of the most impactful verbal and non-verbal episodes of interest (Erickson, 2006) that emerged from my cross-case analysis of the four focus composers’ sight before sound, sound before sight, and sound with sight processes. I also discuss how and to what extent traditional notation and graphic notation revealed themselves among the four focus composers’ processes within the context of the dynamic relationship between sound and sight.

Sight before sound. My expectation when designing this study was that participants’ processes would comprise thinking in sound first and capturing it with graphic notation second. However, I noted instances while observing Chelsea and Emily’s processes when sight (notation) came first with a noticeable lack of concern for its sonic implications. Also, in my conversations with Draco, sight before sound and its role in the composition process surfaced twice, revealing his insightfulness about notation and its relation to the composition process. The concept of sight before sound did not emerge while I observed and interacted with Ryan.

Chelsea’s initial strategy was a distinct sight before sound process that none of the other focus composers exhibited to such a drastic extent. Figure 114 is a screenshot of Chelsea’s results after composing for just over 10 minutes on her first day of composition, which elucidates her initial impulsivity (link to Figure 114, Appendix D).

Chelsea persisted with the sight before sound strategy for two composition sessions. After working on editing and striving to improve her sight-oriented composition for the first two composition sessions, Chelsea, ostensibly dissatisfied with the results, moved away from sight to sound as her primary strategy.

Emily briefly applied a similarly erratic approach at one point in her individual process by splattering droplets randomly (see Figure 100), which created a constant chordal accompaniment supporting her three contrapuntal melodies. Unlike Chelsea's dissatisfaction with her sight before sound approach, Emily was pleased with the result. A side-by-side comparison of Chelsea and Emily's compositions shown in Figure 115 revealed that Emily's composition was more structured, which may have accounted for different sonic results and Chelsea and Emily's contrasting opinions of their own pieces (link to Figure 115, Appendix D).

During one particular stimulated recall session, Emily described her individual composition process as sometimes dependent on trial and error and expressed that drawing before she knew what she wanted her music to sound like sometimes helped her:

> For some things, it was more trial and error, and the times I couldn't [think of something], I would start doing it (draws in the air). And then I'm like, wait, this is another good idea, and then that doesn't work, and it just goes everywhere. (Emily, stimulated recall, November 1, 2019)

In one of our semi-structured interviews, my conversation with Draco evolved into a discussion about the usefulness of drawing music graphically. After expressing his preference for GarageBand over Hyperscore because it incorporated more musically satisfying timbres, our conversation turned toward the drawing function in Hyperscore, and whether drawing music before hearing it was helpful. Draco expressed that the drawing aspect of Hyperscore was not beneficial to him. My exchange with Draco demonstrated that thinking about the sound of an instrument was more useful to Draco than drawing music with graphic notation tools. Draco also implied that traditional sheet music *is* notation while graphic notation is *not*.

In a subsequent interview, Draco expressed that notating music is important for recall purposes *later* in the process. Draco commented that without notation, “I wouldn’t know what to hum when the time came to hum it” (interview, November 3, 2017). Draco seemed to say notation was essential for a composer who wants to recall his music later, asserting that sight (notation) is essential for recalling sound (aural memory). Draco was the only one of the four focus composers who expressed the importance of preservation during my observations and interviews.

Sound before sight. Sound before sight was a relatively prevalent theme among the four focus composers in the present study. When participants displayed or expressed emphasis on the aural aspect of their composition or orally articulated their sonic intentions before drawing, I deemed this a manifestation of sound before sight. Sound before sight revealed itself in two specific manners elucidated in this section of the cross-case analysis. When participants hummed or sang as a precursor to notation or planned or described their intended sonic elements before notating, I considered these sound before sight instances. The humming and singing in which participants engaged resonated with Papert and Turkle’s description of *body-syntonic* learning (Papert, 1980a; Turkle &

Papert, 1990), and the manner in which certain participants planned or described their intended elements prior to notating aligned with Papert's (1980a) idea of *ego syntonicity* and how it is complementary with constructionism. In the following section, I present some of the more compelling sound before sight examples I observed among the four focus composers, some of which also resonated with Papert's concept of *body*- and *ego-syntonicity*.

Chelsea often created vocal percussion sounds before drawing her drum patterns: "I always have a song in my head and can kind of put [it] on there and make it into something (interview, November 1, 2017)." Usually, Chelsea did not accurately transfer her vocal percussion patterns to graphic notation, and the result was a drum pattern somewhat different from the sound she made with her voice. Chelsea did not seem to notice or be concerned that the drum patterns she made with her voice and those she drew were ultimately not that similar. However, it was clear from observing Chelsea's process that she often planned her desired percussion sounds before notating them. Making percussion sounds before drawing permeated Chelsea's process, possibly because she was a drummer and took advantage of her previous experience.

In contrast with Chelsea, who usually worked quickly and seemingly without concern for whether notation accurately reflected her vocal percussion sounds, Emily often exhibited a process of refining notation over several minutes as she reflected on her intentions and results. Emily often persisted with developing a single sonic element as she composed, adjusting the pitch and rhythm for several minutes. Emily's reflexive process (Ackermann, 1996; Duffy & Cunningham, 1996) that included reflection and subsequent action inspired by her reflection was an indication of the inherent value of reflection she demonstrated throughout the composition process. During one of our stimulated recall sessions, as Emily and I observed her process on video, we homed in on a particular melody on which she spent several minutes adjusting pitches:

> Emily: I think I was saying something in my head, and I wanted it to play out like that.
> SD: I would encourage you to work with that 'saying something in your head' thing. There is a process…
> Emily: Yeah. [Back] then there was a process.
> SD: I think it's a good strategy if you've got something in your mind. It takes longer…
> Emily: A long time, yeah.
> (stimulated recall, October 6, 2017)

Occasionally, the sound before sight theme surfaced during Chelsea and Emily's collaborative process and in our interviews. The following dialogue emanated from Emily and Chelsea's stated perception that it was sometimes difficult to find the timbres about which they were thinking:

> Emily: It was fun coming up with all these creepy sounds. It was hard finding the right instruments.
> Chelsea: And then, once you found them, you have to make up the sound that you are thinking of and it doesn't always come out how you are thinking.
> SD: Do you ever make up songs on an instrument?
> Emily: Sometimes, I just play random stuff on the piano sometimes.
> SD: Do you ever remember it and save it in your mind?
> Chelsea: I have never written any down; I just remember them. There's this one natural beat that comes straight to mind whenever I'm asked to play drums.
> Emily: I have written a couple down, but I have never revisited them. Sometimes, I just start humming a tune, and I'm like, oh yeah, I need to remember this, and I never do. I forget to either record myself or write it down.
> SD: Have you been successful at all with getting an idea in your mind and trying to put it in Hyperscore?
> Emily: Yes, I think with the echoing (timbre) when we first heard it we were like, yeah, this needs to go (into our composition). Then with the footsteps, we wanted something slow, gradually getting into fast and high pitch.

Chelsea: And then a big, loud bang.
(interview, October 6, 2017)

The above exchange with Chelsea and Emily displayed how they held preconceived ideas of particular timbres for their scary story and explored Hyperscore until they identified something similar to the timbre they imagined. For Chelsea and Emily, their predetermined ideas of appropriate timbres for their intended story drove much of their collaborative composition process.

Chelsea and Emily engaged in occasional exchanges expressing how they wanted their music to sound before notating it either by describing the texture or by singing a melody. Their subsequent notation sometimes reflected the general contour of what they sang, but the melodic intervals they notated were usually considerably different from their sung melody. Chelsea and Emily did not seem to notice or be concerned that their notated ideas did not resemble the ideas they discussed or sang. However, their verbal expression of musical ideas before notating was a clear indication they were "imagining possibilities of sounds coming into being" (Reimer, 2003, p. 123).

One of the semi-structured interview questions I used in this study was, "What aspects of composing have been difficult for you?" Draco's first and immediate response explicitly connected to sound before sight. His assumption was that a composer should have a tune in their head before notating it. Definitely coming up with a tune in my head (is difficult). Like, trying to find what I actually want to put on the paper is like, no, no, no (Draco, interview, October 30, 2017)

Although Ryan did not use his singing voice to display sound before sight processes, as did Chelsea, Draco, and Emily, he sometimes expressed that he had intentions and expectations for how he would like his music to sound before notating it. Ryan expressed feeling more successful later in the process when he made plans in advance:

> SD: Is this (composition) something new?
> Ryan: Yes, this is something new because my other ones haven't been working out.
> SD: Why not?
> Ryan: Because, um, I didn't really have a plan in the beginning. I think that would have helped me a lot. This one I had a thing in my head thinking of what I should do. What I did was I used the same, um, melody, and just made it a couple octaves higher. (I) took the ending note off and placed it down here. I wanted to make it lower. And then I was going to start with piano.
> (individual composition, September 18, 2017)

From this point forward, Ryan became more of a planner (Stager, 2001; Turkle & Papert, 1990) than a tinkerer or bricoleur (Lévi-Strauss, 1962; Papert, 1980a, 1993). As I observed his later individual composition sessions, I noted that Ryan became less prolific and more careful and intentional. Ryan's tendency to think aloud diminished during his later individual composition sessions, pausing only occasionally to express what he was planning. His think-aloud moments, albeit infrequent, showed that he had ideas for how he wanted his music to sound in advance and valued the planning process.

I used part of my final interview with Ryan to delve more into his interest in carefully planning out the sound of his compositions in advance more than experimenting with drawing and Hyperscore tools. During this interview, he expressed that his ability to think Ryan: I think my ability to compose has definitely improved:

> SD: Can you think of anything specific as an example?
> Ryan: I think I'm better at, like, before I go to class, I think of a melody that would go with my composition. And then I try to put that into notes and see how it sounds…Sometimes it doesn't work, and I don't like the way it sounds, and I have a couple of ideas in my head.

(interview, November 9, 2017)

Although I rarely observed Ryan humming or singing as part of a sound to sight process while composing individually, I noticed he hummed and sang while collaborating with Draco. At one point, several minutes passed while Draco controlled the mouse and notated a melody while Ryan became visibly disinterested. Suddenly, after listening to Hyperscore playback of a phrase Draco had just composed, Ryan burst into an extended scat solo inspired by the sound of Draco's melody. Draco accompanied Ryan's scat singing by repeatedly chanting, "melody, melody, melody, melody, melody." After a moment of laughter, Ryan became more involved in notating their melody and contributed more intentionally. Ryan's reconnection with the process in this situation appeared to be inspired by his scat singing and the sound of Draco's melody.

In another impactful sound before sight instance, Draco and Ryan discussed their intentions for the next part of their composition and considered the sound of their pre-existing melody before engaging with notation tools. Draco's idea to "come up with" the melody before writing it down and Ryan's desire to listen to their pre-existing material before composing new material displayed these two composers' priority of sound before sight at this moment. Several minutes passed with Draco and Ryan listening to what they already composed and discussing options. Ultimately, Draco and Ryan agreed to combine Draco's idea of stating the same melody at two different pitch levels (i.e., bitonality) with Ryan's idea to "do the exact opposite," which was his way of suggesting using inversion. Their verbal planning process presented illustrated an explicit sound before sight process in which they imagined sound before notating.

In this instance, a metacognitive dynamic arose organically between Draco and Ryan. This scenario reflected Ackermann's (1996) description of metacognition as a metaphorical dance of diving in and stepping out, and Papert's well-known comment, "You can't think about thinking with thinking about thinking about something" (Papert, 2005, p. 367). Draco and Ryan's conversation, during which they improved "their understanding of their own thinking, learning and playing" (p. 367), was a somewhat regular occurrence for these two composers.

Draco and Ryan subsequently created an inversion of their main theme and harmonized it with their original theme (see Figure 90). This situation exemplified how Draco and Ryan often focused on discussing their ideas and expressed their intentions more than focusing on notation. This situation also illustrated ego-syntonic behavior, which Papert (1980a, 2005) claimed as complementary with constructionism, "that which is coherent with children's sense of themselves as people with intentions" (Papert, 1980a, p. 63).

Sound with sight. Occasionally, three of the four focus composers (Chelsea, Draco, and Emily) expressed or displayed thoughts or processes where sound and sight worked in tandem with one another, which I deemed a sound *with* sight process. In these instances, Hyperscore's graphic notation icons and drawing tools functioned as "objects to think with" (Stager, 2005; Turkle and Papert, 1990, 1991) rather than objects used solely to create visual representations of sonic elements. The following situations epitomized Turkle and Papert's (1990, 1991) concept of *epistemological pluralism*, which emphasizes using computers to help learners bridge concrete physical objects with abstract ideas and creating environments "where logic is on tap not on top" (p. 133) and "the mind can think with objects rather than the rules of logic" (p. 143). The following are three of the more impactful descriptions of how sound with sight processes among three of the four focus composers reflected the concept of epistemological pluralism.

Draco likened the tools in Hyperscore to a microscope that has both fine and coarse tuning functions. The sketchpad facilitated coarse tuning, while the melody and percussion windows enabled fine-tuning. Draco's individual composition process frequently exhibited fine and coarse tuning of rhythm and pitch. In terms of rhythm, Draco would often simultaneously sing and adjust the rhythm of a motive to match his voice by lengthening or shortening droplets or increasing or decreasing spaces between droplets. Draco's ability to transcribe rhythm was usually relatively accurate.

In terms of melody, Draco would often sing or hum while simultaneously drawing the individual notes of his melody, usually taking much more time than the other focus composers to refine his melodies. Although it often appeared that Draco was attempting to meticulously transcribe a specific melody he had in mind, the process usually evolved into Draco adapting his singing or humming to match the melody being played back by Hyperscore after he notated it. However, Draco's simultaneous use of his singing voice while transcribing and adjusting note values and pitches, and the adaptation of his voice to the melody Hyperscore played back epitomized the sound *with* sight concept. Draco believed he was transcribing what was in his mind, and my impression was that Draco was possibly memorizing the tune that he was notating in Hyperscore as he was creating it. It is also possible that a quasi-partnership developed between Draco and Hyperscore that made this a reciprocal experience as if Hyperscore was *scaffolding* (Duffy & Cunningham, 1996; Wood, Bruner, & Ross, 1976) Draco's process.

On one notable occasion, Emily engaged in a quasi-dialogue with Hyperscore when she transcribed a musical idea while humming. Emily immersed herself in an iterative sing-notate-playback (SNP) cycle until she accurately notated the first five notes of *Arabesque* by Burgmüller, as illustrated in Figure 116 (<u>link to Figure 116, Appendix D</u>). Emily's merging of abstract thinking (her musical idea) with the concrete (graphic notation) resonated with Turkle and Papert's (1990, 1991) assertion that a constructionist environment nurtures "the revaluation of concrete approaches in the domain of formal systems" (p. 132). Also, the immediate feedback provided by Hyperscore provided *scaffolding* as described by Wood, Bruner, and Ross (1976) and Duffy and Cunningham (1996), that which *guides* a learner toward a personal objective rather than directly *instructs* a learner toward a well-defined end.

As Chelsea and Emily collaborated on one particular melody, they used both of their singing voices and simultaneously transcribed in Hyperscore to look for the perfect ending note. After almost four minutes of multiple sing-notate-playback iterations depicted in Figure 117, singing their desired phrase ending to each other several times, and much discussion about where to notate place the final note, Chelsea and Emily decided that the phrase should end with two longer notes (<u>link to Figure 117, Appendix D</u>).

Sound before sight, sound with sight, and thinking in sound. There were two primary ways in which the composers in the present study exhibited thinking in sound, which I described as sound *before* sight and sound *with* sight. Sometimes, the four focus composers exhibited thinking in sound by humming or vocalizing a melody or rhythm before notating or describing their intended sonic elements before notating; that is, sound *before* sight. At times, participants exhibited thinking in sound while trying to transcribe a melody they had in mind, sometimes while simultaneously humming the tune or vocalizing the rhythm; that is, sound *with* sight.

In the present study, singing and humming often preceded notation for Chelsea, Draco, and Emily, although it played a minimal role in Ryan's process. When Draco and Ryan composed together, they hummed and sang ideas frequently before notating, and also spent considerable time planning the order of their sonic elements (form) in advance. Thinking in terms of timbre before notating was evident in Chelsea and Emily's process via their discussions, probably because their goal was to compose a soundscape comprised of scary music. Draco and Ryan also spent time at the outset of their collaborative process listening to sample compositions and motives in Hyperscore for inspiration or to borrow for their composition, respectively, and discussing how they might make their composition sound like a 'jazz-blues' piece.

Ryan expressed that he thought his ability to think in sound improved during the ten weeks. Draco stated that thinking in sound was difficult for him yet important for a composer. Chelsea and Emily never orally expressed their ideas about thinking *in* sound; however, they regularly displayed thinking *about* sound by describing their ideal timbres and plans for how they wanted their scary music to sound and thinking *with* sound through humming and singing followed by transcribing.

Often, the sung, hummed, or intended ideas among the four participants did not transfer with much success to graphic notation within Hyperscore, and participants rarely seemed concerned or possibly did not notice their lack of success in notating their ideas. This could have been because they were not familiar enough with the notation tool they were using or had limited ability to transfer their musical ideas to graphic notation. It may have been that the focus composers in the present study needed more experience with Hyperscore to notate their sonic ideas more successfully.

Traditional notation. Hyperscore integrates principles of traditional notation with a graphic notation system. For example, composers can use the grid to create traditional note values, scalar melodies, chords, and specific intervals. Composers can use the sketchpad to create traditional musical structures and form. However, for the composers in the present study, Hyperscore's characteristics as a graphic notation tool overshadowed its parallels with traditional notation. I noted many more instances when graphic notation played a significant role in the focus composers' processes relative to the number of times when traditional notation arose as a concern, interest, or direct influence on the composition process (see Table 25, Appendix D). Although this observation might not be surprising considering the constructionist nature and design of the Hyperscore graphical user interface, it was of note that principles of traditional notation played a relatively small role in the focus composers' processes especially considering all had some previous exposure to traditional notation through their instrumental music experience.

There were two particularly compelling instances when the concept of traditional notation surfaced in Emily and Draco's processes. Emily, who plays bass and piano, stated in one interview that sometimes it might have been easier for her to use traditional notation:

> Being that I have prior experience in music, I think it would almost be easier for me if it (Hyperscore) would identify what note it is. But for people that haven't seen notes or letters for the notes, it would probably be easier for them. It would be helpful if I could see this is a C chord, [or] this is a minor chord. (interview, October 20, 2017)

In another interview with Emily, I noticed that she had carefully aligned many of her melody notes on the grid with consistent, evenly spaced droplet sizes, as shown in Figure 118 (link to Figure 118, Appendix D). After I questioned her further, Emily identified the notes she used as eighth notes and a whole note and expressed, "I wasn't really thinking about that then" (interview, September 8, 2017). Although Emily had not been thinking in traditional terms of eighth notes and whole notes, she appeared to apply her previous knowledge of traditional note values intuitively.

While developing his first composition, Draco discovered that a percussion window could have up to ten lines of music and that he could assign each line to either a pitched or unpitched instrument. At times, Draco used the ten-line percussion window to emulate a traditional music staff when composing melodies by assigning each line of the percussion staff to the same timbre. As illustrated in Figure 119, the 10-line window was Draco's way of 'hacking' the software to create a quasi-traditional staff that clearly delineated the separate pitches of his melody (link to Figure 119, Appendix D). Although melody windows in Hyperscore provide a grid for the same purpose, the grid lines in melody windows are much less defined than the obviously discrete lines in percussion windows:

> SD: Why did you decide to draw this [melody] in a percussion window instead of in a melody window?
> Draco: Because I guess I was like, this [percussion window] can be *not* drums. I'm like, this will give me a more structured like, A-B-C-D-E-F-G-A (pointing to the lines).
> SD: Like a staff.
> Draco: Yeah, I kind of wanted like a staff basically.
> (stimulated recall, October 18, 2017)

Graphic notation. Of all categories related to Sound and Sight coded during my analysis of the four focus composers' processes, graphic notation emerged as the most salient, far exceeding the number of instances I noted for other Sound and Sight categories. The participants in the present study used the graphic notation tools in Hyperscore in a variety of ways, including manipulating their sonic elements with droplets (i.e., notes), dots (i.e., chords), and lines (i.e., score components), and applying geometric concepts such as translation (i.e., transposition in music), reflection (i.e., inversion in music), patterns and sequences, and parallel, contrary and oblique lines. In this section of the cross-case analysis, I present the most compelling examples of these processes I identified as I observed the focus composers using Hyperscore as a graphic notation tool.

Exploratory and intentional graphic notation approaches. The focus composers in the present study used the Hyperscore graphic notation tools at times in exploratory, heuristic ways; at other times, their processes were more intentional and deliberate. These two processes aligned with the roles of planner (Stager, 2001; Turkle & Papert, 1990) and bricoleur (Lévi-Strauss, 1962; Papert, 1980a, 1993), respectively, which are elements of the constructionism-instructionism dyad I discussed in my Chapter 1 discussion of the theoretical framework for this study.

A close look at the four focus composers' individual and collaborative compositions revealed the use of exploratory and intentional strategies and illuminated the flexible nature of Hyperscore's graphic notation tools. At times, the composers drew with these tools in an exploratory manner by drawing freely or placing droplets and dots randomly on the screen, and occasionally they used the tools more intentionally and drawing carefully and meticulously. Figures 120-125 depict the exploratory and intentional strategies used by the four focus composers in their final individual and collaborative compositions.

As diagrammed in Figure 120, Emily's droplets, lines, and dots strategies for her final individual combination displayed a combination of exploratory and intentional processes (link to Figure 120, Appendix D). For his final individual composition shown in Figure 121, Ryan displayed extensive use of dots (notes) in both an exploratory and intentional manner among his eight complete sonic elements, and deliberate use of straight lines almost exclusively on the sketchpad (link to Figure 121, Appendix D).

Figure 122 is a screenshot of Draco's individual composition, for which he devoted most of his five composition sessions using the droplet tool to develop a highly organized and well-developed melody (light blue window). Because he had spent almost all of his time developing the melody, Draco promptly drew lines for his sonic element on the sketchpad on the last day. He spent a few minutes exploring bi-tonality by drawing two iterations of his melody (light blue lines) on the sketchpad at different pitch levels. The blue line is the harmony line that Draco created haphazardly and without understanding its function. However, this was a refreshing example of exploration from Draco, who typically worked very methodically throughout the 10-week study. Draco's harmony line resulted in several changes to the tonal center throughout the composition (link to Figure 122, Appendix D).

Although Chelsea asserted that the Hyperscore composition process was mostly trial and error, her final composition shown in Figure 123 revealed multiple intentional strategies including intentional drum patterns, a distinct cannon effect, a purposeful dynamic change, and use of inversion and contrary motion. Chelsea's intentional drum patterns likely stemmed from her experience as a drummer. Chelsea's exploratory spirit emerged when she briefly experimented with the harmony line and tinkered with overlapping multiple copies of the purple line on the sketchpad, which created an unexpected, interesting tremolando effect (link to Figure 123, Appendix D).

As illustrated in Figure 124, intentionality permeated Chelsea and Emily's collaborative process as they aimed to evoke eerie images for their scary story (link to Figure 124, Appendix D). Except for two exploratory moments when Chelsea drew quickly and extemporaneously, all of their other sonic elements emanated from extensive planning, reflection, and discussion. Intentional processes included creating their *Twilight Zone* variation (Figure 124, blue window), scouring Hyperscore for a creepy melody they could borrow, and transform through extension and timbre change. Other sonic elements created with intention and diligence were their accelerating footsteps (light green window), scraping effect (light blue window), decrescendos applied to the blue and orange motives, and lines drawn discretely on the sketchpad to isolate various story elements.

Two prominent exploratory moments emanated from Chelsea as she collaborated with Emily. In the first situation, Chelsea ignored Emily's advice to look for another pre-existing Hyperscore motive and pursued her earlier tendency to experiment freely with drawing more extemporaneously. The result was the triad in the yellow window (see Figure 124). In another exploratory moment, Chelsea drew their green motive (see Figure 124) in less than three seconds while simultaneously talking to someone across the room. Looking back at the computer screen, Chelsea commented, "Whoa. Look at this, Emily. This actually doesn't sound that bad" (Chelsea, collaborating with Emily, September 6, 2017). Chelsea's hastily drawn green melody remained unchanged and became an integral part of the pair's composition. Of the two composers, Chelsea was more inclined to explore and tinker with the graphic notation tools, and Emily was more of the intentional type.

As illustrated in Figure 125, Draco and Ryan's collaborative composition teemed with intentionality and incorporated a definitive A, A′, A″, B, A″, A,′ A 'palindrome' form (<u>link to Figure 125, Appendix D</u>). Although Draco and Ryan's B section liberally explored contour while intentionally sequencing pitches, an analysis of the other sections of their piece revealed a highly intentional, conservative approach to their composition.

Geometric graphic notation strategies. Notably, all four focus composers used the graphic notation interface provided by Hyperscore to explore at least one geometric approach at some point, although none of them had taken a formal course in geometry. These geometric strategies included translation (i.e., transposition in music), reflection (i.e., inversion in music), sequential patterns, and parallel, contrary and oblique motion. When I asked participants to identify these strategies by their geometric or musical terms, none could do so. These moments provided me with the opportunity to instruct participants spontaneously about the specific musical terms or composition strategies they employed and point out how they were integrating geometry and music intuitively. Table 26 provides a cross-case synthesis of geometric strategies used, composers who used these strategies, and references to figures within the present chapter depicting these strategies (link to Table 26, Appendix D). Subsequently, Figures 126-131 illustrate screenshots of prominent instances of geometric approaches not presented earlier in this chapter.

Inspired by recently learning *Phantom of the Opera* on the piano, and illustrated in Figure 126, Emily repeatedly sang a descending chromatic scale as she simultaneously translated (i.e., transposed in music) her droplets until they matched the range of her voice (link to Figure 126, Appendix D). Figure 127 depicts an occasion when translation became important to Chelsea and Emily and their aim to create scary music. At this moment, Emily explained to Chelsea how to translate their melody on the sketchpad to create a high-pitched, more eerie sound (link to Figure 127, Appendix D):

> Chelsea: What the heck? It sounds so much lower on there (the sketchpad).
> Emily: That's because the harmony line, when you put it (the melody) on the harmony line, it sounds exactly like the original [melody] when you put it

> lower it sounds lower than the [original melody].
> (collaborative composition, October 20, 2017)

Figure 128 illustrates how Draco was able to quickly translate three simultaneous iterations of his melody and immediately assess the resulting harmony. The erratic dark blue line is the harmony line that represents no musical material and with which Draco experimented by drawing it haphazardly (link to Figure 128, Appendix D). Draco and Ryan used the graphic notation tool to quickly create a complex sequence for the B section of their composition. Figure 129 depicts how Draco and Ryan translated an eighth-note motive two times to create a sequence (link to Figure 129, Appendix D).

In a particularly compelling sound with sight moment depicted in Figure 130, Draco sang pitches and drew droplets practically simultaneously while working out the end of one particular phrase. He ultimately ended the phrase by repeating the previous seven-note phrase member and reflecting (i.e., inverting) the last four notes (link to Figure 130, Appendix D).

On her first day of composition, Chelsea impulsively drew many droplets in an exploratory manner. Figure 131 illustrates from left to right how Chelsea explored translation as a strategy to modify one of the first sonic elements she created, which comprised a dense cluster of droplets that she moved down individually to create a denser cluster (link to Figure 131, Appendix D).

Graphic notation as an accessible alternative to traditional notation. From my perspective as observer as participant in the present study, Hyperscore provided a user-friendly way of creating sonic elements and transferring them to the sketchpad. Three of the composers (Draco, Emily, and Ryan) seemed to quickly and intuitively determine how to create sonic elements in discrete windows and combine them by drawing on the sketchpad. One composer (Chelsea) took more time to understand the relationship between the sonic elements she created in discrete windows and the process of combining these elements by drawing them on the sketchpad.

All four focus composers immersed themselves in the composition process within minutes on the first day with minimal instruction. There were minimal procedural questions, no concerns about drawing or proceeding in a particular manner, and no hesitations. The tendency for participants to jump immediately into the process and the relatively small amount of *scaffolding* (Duffy & Cunningham, 1996; Wood, Bruner, & Ross, 1976) during this study was likely attributed to the highly accessible graphical user interface and the constructionist-oriented atmosphere.

Traditional Composition Techniques in the Composers' Processes.

The four focus composers in the present study instinctively applied several techniques resembling traditional composition processes employed by professional composers, as displayed in Table 27 (link to Table 27, Appendix D). The focus composers' use of graphic notation tools discussed above to incorporate geometric approaches (see Table 26) such as patterns (i.e., sequences in music), translation (i.e., transposition in music), and reflection (i.e., inversion in music) and their use of other compositional devices (see Table 27, Appendix D) discussed in the next section typically considered the trademark of trained composers were rather impressive. In the following section, I discuss four of the most notable examples of how the focus composers used these compositional devices: contour, motive-making or borrowing, form, and repetition.

Contour. The novice composers in this study explored contour through the melodies they created in droplet windows and the phrases they drew on the sketchpad. The contour of their melodies varied from no apparent concern, as displayed by Chelsea on the first day of composition (see Figure 131), to a sophisticated approach to contour applied by Draco and Ryan in the B section of their collaborative composition (see Figure 125). The idea of contour as a musical concept or sonic element was never discussed or expressed explicitly or implicitly. However, I inferred a contour-oriented process 227 times while observing the four focus composers at work. I described four of these instances above, and 11 others earlier in this chapter summarized in Figure 113 (see Appendix D).

The contour of the phrases drawn on the sketchpad by the focus composers ranged from Emily's highly curvilinear final composition (see Figure 10) to Ryan's almost exclusively linear final composition (see Figure 53). The focus composers overall displayed and expressed dissatisfaction with the results of drawing curved lines on the sketchpad, probably because doing so created fluctuations in the tonal center. Often, a composer would experiment with drawing curved lines on the sketchpad, listen to the results, and either delete the curved iterations altogether or redraw them as straight lines. From the overall aversion to exploring contour on the sketchpad, I inferred that the focus composers were generally not interested in experimenting with changes of tonal center in their compositions. Next, I present two of the most telling examples in which attention to contour revealed itself in this study.

Chelsea and Emily's determination to emulate the contour of the four-note

Twilight Zone motive was an intriguing process to watch. During their sight with sound process, Chelsea notated droplets while both composers repeatedly hummed their desired contour. Figure 132, from top left to bottom right, illustrates some of the changes in contour that took place over a few minutes as Chelsea and Emily strived to emulate the *Twilight Zone* motive while humming, notating, and drawing in the air (<u>link to Figure 132, Appendix D</u>). Chelsea and Emily's approach to contour epitomized Turkle and Papert's (Papert, 1980a; Turkle & Papert, 1990) concept of *body-syntonic reasoning* (that which is firmly related to children's sense and knowledge about their own bodies) and paralleling the manner in which children in Papert's learning lab integrated body language with programming a robotic turtle. In the same way that Papert observed children using their bodies to simulate the geometric shape they wanted their robotic turtle to draw, Emily used her body to draw her desired melodic contour in the air.

While discussing how to end the main melody for his collaborative composition with Draco, Ryan displayed sophisticated insight into the effect of contour. As he applied *body syntonicity* by drawing his desired contour in the air and humming what he wanted Draco to transcribe, Ryan argued, "It should go higher instead of lower, 'cuz when it goes lower it sounds like the end of the song" (Ryan, collaborating with Draco, October 10, 2017). Ryan also displayed sensitivity to contour while composing individually. In one of the few instances when Ryan explored contour on the sketchpad, Ryan exemplified a sound before sight approach before drawing oblique motion on the sketchpad. Figure 133 depicts Ryan's action after saying, "Now I'm going to create a different, um, sound more of like going up" (individual composition, September 6, 2017) (link to Figure 133, Appendix D).

Motive-making. The brief Hyperscore tutorial each participant completed before starting composition activities referred to the melody window as "an intuitive editor where you can create thematic elements – 'motives' – which will then be used for composing a complete piece." Consequently, *motive* became a synonym for *melody* in this particular environment. There was an implicit bias toward short motives built into the software stemming from the small size of the default windows in which composers drew their motives. To create a longer melodic phrase, the composer must manually lengthen the window, an option the four focus composers in this study explored minimally. Also, many of the sample compositions in the Hyperscore library and the tutorial illustrated short motives rather than fully developed melodies, which possibly influenced some of the composers' motive-making processes.

Three individual composers (Chelsea, Emily, and Ryan) and one collaborative pair (Chelsea and Emily) composed predominantly short motives. Contrastingly, Draco (composing individually) and Draco and Ryan (collaborating) engaged in a melodic development process, creating longer phrases. None of the other cases I observed (Ryan individually, and Chelsea and Emily both individually and collaboratively) committed extended time to develop one melody. Working together, Draco and Ryan explored diminution and augmentation (see Figures 81, 82). Working individually, Draco and Ryan each applied an antecedent-consequent structure to their melodies (see Figures 36, 134). While composing alone, Ryan implemented four-part counterpoint in his first composition (see Figure 62), all of which are sophisticated compositional devices for a novice composer. Working together, Draco and Ryan combined two iterations of the same melody (one inverted) to create bi-tonality (see Figure 90), and Draco applied the same strategy (without inversion) as an individual composer (see Figure 122). Ryan's motive-making process evolved from short motives to longer, more developed melodies (see Figures 54, 55, 56), including a distinct three-phrase-member melody with extension in his final composition. Figure 134 illustrates Ryan's three-phrase-member melody (link to Figure 134, Appendix D).

Initially, Chelsea hurried through the motive-making process and created clusters of pitches rather than melodies (see Figures 14-16). After expressing dissatisfaction with the results, she eventually abandoned clusters. However, a close look at her final composition (see Figure 123) revealed that Chelsea progressed minimally as a melodic composer. Except for one extended melody (see exploratory blue melody in Figure 123), which she did not use in her final composition, all of Chelsea's melodic motives consisted of one note. Conversely, and probably because her prior instrumental experience was almost exclusively on drums, Chelsea's drum patterns were more sophisticated than her melodic motives.

Emily was the most prolific motive maker of the four focus composers. An inventory of her motive-making process determined that she drew no fewer than 45 motives during the individual composition phase of the study. Based on my inventory of Emily's motive-making process displayed in Figure 135. I suspect Emily might have departed this study with the idea that melodies are typically one measure long, or that one-measure melodies were expected in this situation (link to Figure 135, Appendix D).

Chelsea and Emily, as collaborators, were not particularly prolific motive makers likely because they spent much time discussing their story and seeking out ideal timbres for their scary soundscape. Besides making sound effects motives such as footsteps and a broken clock that involved no melody making, Chelsea and Emily focused much of their time on creating their quasi-*Twilight Zone* motive and the motive for Beethoven's *Fifth Symphony* finale, neither of which they included in their composition. Unlike Draco and Ryan, who took considerable time developing extended melodies, Chelsea and Emily only created short, one-measure motives with one exception. Their only two-measure motive (purple) was one they borrowed from the Hyperscore library and modified (see Figure 124). To modify the borrowed material, Chelsea and Emily engaged in a relatively long sound with sight process by singing, notating, listening, discussing, and reflecting on how the final few notes of their final motive should sound. Chelsea and Emily's reflexive process (Ackermann, 1996; Duffy & Cunningham, 1996) resonated strongly with Draco and Ryan's collaborative experience, which also showed signs of effective metacognition

Motive borrowing. Although all of the focus composers listened to sample motives in the Hyperscore library at some point for inspiration or out of curiosity, not all directly borrowed Hyperscore library motives as building blocks for their compositions. Although he listened to several Hyperscore motives, Draco did not incorporate any motives from the Hyperscore library for his individual composition. However, it was a Hyperscore library motive that provided the foundation for Draco's collaborative composition with Ryan. Draco and Ryan devoted considerable time to reviewing

Hyperscore drum patterns and melodies and seemed initially intent on borrowing motives in the ‘jazz-blues’ vein rather than composing their own. However, for their B section, Draco and Ryan decided to compose an original melody.

Ryan, Chelsea, and Emily also did not use any Hyperscore motives for their individual compositions. Chelsea “used motives as ideas but…didn’t use any motives directly” (interview, November 9, 2017). After Emily suggested using Hyperscore library motives a few times during the collaborative process, Chelsea ultimately asserted, “I don’t really want to use motives” (Chelsea, collaborating with Emily, October 26, 2017). Ultimately, one motive made its way into Chelsea and Emily’s collaborative composition near the end of the process. Chelsea possibly acquiesced because time was running out.

Form. To some extent, each of the focus composers exhibited a desire to incorporate structure into their compositions, either on a micro-level when creating discrete melodies, motives, and drum patterns, or on a macro-level when combining their sonic elements by drawing phrases (lines) on the sketchpad.

On the micro-level, Chelsea’s discrete melodies and motives usually displayed no intention to create form or structure. Chelsea’s process consisted mostly of erratic drawing in melody and percussion windows and on the sketchpad (see Figure 108). The occasional exception to lack of form was when Chelsea attempted to transcribe a drum pattern with which she was familiar as a drummer: “I think of a drumbeat and try to impersonate it” (individual composition, October 2, 2017). Chelsea’s drum patterns often had structure as a result of her previous experience playing drums. Form also began to surface in Chelsea’s final composition to some extent. Reflecting back on her final composition, Chelsea explained, “What I probably would have done differently is make it more organized in where I put everything so I can keep track of when I want to change something” (stimulated recall, November 7, 2017). Although Chelsea believed her piece lacked organization, there was structure on the macro-level exhibited by the intentionally staggered motivic entrances on the sketchpad.

Emily’s approach to creating melodies was generally quite structured and somewhat predictable. My inventory of Emily’s melodic motives and percussion pattern (see Figure 135) illustrates a distinctly deliberate approach to creating motives, the majority of which were highly structured patterns. On the macro-level, while drawing on the sketchpad, Emily displayed two vastly different approaches. Emily took a highly conservative approach to the form of her first composition (see Figure 7) by merely drawing four of her five motives in a straight line on the sketchpad, each one sounding simultaneously and repeating multiple times. To create variety in her first composition, Emily intentionally drew her fifth motive four times at various pitch levels: original, down a perfect fourth, up a tritone, and down a tritone “so it’s not perpetual the whole time” (individual composition, September 8, 2017). Emily’s second composition featured organized three-part counterpoint, with Emily’s three melodies sounding simultaneously and in contrary and oblique motion (see Figure 120).

The form of Chelsea and Emily’s collaborative composition emanated spontaneously from their daily discussions of how to create a scary story through music; however, Chelsea and Emily did not explicitly plan a story in advance. Consequently, the form of their composition emanated from impromptu discussions about timbres that sounded eerie, making creepy-sounding motives, and reflecting on the images these sonic elements evoked. The resulting structure was a series of five short melodies or sound effects moments that aimed to sound menacing (see Figure 112). As a result, Chelsea and Emily's collaborative composition was a through-composed, non-repetitive, programmatic piece of music emanating mostly from a reflexive process (Ackermann, 1996; Duffy & Cunningham, 1996) and thinking in and *with* sound.

Draco's individual composition revealed his intuitive ability to structure a melody comprised of six distinct phrase members that incorporated an antecedent-consequent approach, repetition for unity, and new material and inversion for variety (see Figure 27). Contrastingly, Draco's drawing on the sketchpad to create the large form was relatively simplistic. Overall, Draco expressed much interest in developing and refining melodic content on the micro-level but spent little time on the macro-level developing an overall form to the same degree of sophistication.

On a micro-level, in his first composition, Ryan created very short, simple motives comprised of mostly repetitive notes (see Figure 62). At the macro-level, Ryan's first composition was relatively sophisticated and similar in structure to Emily's second composition (see Figure 120). While working on his second composition, Ryan seemed to lose confidence, and the composition's lack of structure reflected his loss of confidence (see Figure 55). On the micro-level, Ryan drew five short motives, and only one demonstrated a commitment to development as Ryan carefully drew a descending chromatic scale. On the macro-level, Ryan drew six very short lines on the sketchpad, three of which were monophonic statements of three separate short motives, and the other three were layered to sound simultaneously. The form was a simple presentation of each motive once, with no repetition or any indication of an attempt to develop a piece with structure.

For his third composition, Ryan seemed to recover some confidence (see Figure 121). He developed four new extended melodies, borrowed his descending chromatic scale from his second composition, and created a relatively intricate drum pattern. On the macro-level, Ryan kept the form simple, once again focusing on successive monophonic statements of his motives similar to his second composition. However, because Ryan created significantly more melodic and rhythmic material at the micro-level for his third composition, the overall effect of his final composition was one of a more sophisticated structure than his first two compositions.

The structure of Draco and Ryan's final composition on both the macro- (see Figure 125) and micro- (see Table 20) levels stood out because of its intricate blend of variety and unity, and its distinct use of compositional devices. The form on a macro-level is ternary (A B A′) with an introduction and coda. On the micro-level, the form is Introduction, A, A′, A″, B, A″, A′, A, Coda.

Table 28 provides a cross-case synthesis of micro and macro-level form-oriented strategies discussed above, brief descriptions of the strategies used, and references to figures within the present chapter depicting these strategies (link to Table 28, Appendix D).

Repetition. Participants in the present study demonstrated, to some extent, an innate sense of repetition as a valuable compositional device. While Chelsea composed individually, she did not explicitly demonstrate an interest in repetition during her process but did comment one time about repetition while reflecting on her third composition: “I would probably add a little bit more background…so that it’s not just the same notes over and over again” (stimulated recall, November 7, 2017). Consistent with her overall lack of concern for form, repetition played a minimal role in Chelsea’s process. When Chelsea and Emily collaborated, they exhibited no interest in repetition on the micro- and macro-levels, ultimately creating a through-composed piece with no repetition.

An inventory of Emily’s melodies, motives, and drum patterns (see Figure 135) reveals her use of repetition on a micro-level as many of her sonic elements comprise repetitive patterns. Also, several of Emily’s think-aloud comments display her cognizance of repetition as something that can enhance or detract from a musical composition on a macro-level. For example, Emily explained, “I’m gonna try the strategy of different things coming in, like a real song and not too much repetition. The strategy of repetition was working at first, but then it got sort of worn-out” (individual composition, September 26, 2017).

As an individual composer, Draco exhibited an intuitive sense of how to incorporate repetition along with variety into his composition. He initially thought of repetition as exact duplication of pitch and rhythm,” about which he expressed his dislike: “I don’t like that the melody repeats itself. I really don’t like that" (stimulated recall, October 18, 2017). However, during our brief exchange about repetition, he displayed how repetition and variety can complement one another. Draco’s concept of repetition and variety as complementary strategies emanated from an examination of the main theme for his individual composition (see Figure 27).

Ryan's use of repetition was relatively consistent throughout the first five weeks of the individual composition process: "I'm trying to create a repetitive beat and every once in a while skip up a note" (individual composition, September 6, 2017); "Scoot it over, so it sounds more repetitive" (see Figure 59). Similar to Draco, Ryan also displayed that he could use repetition in combination with variation as a compositional device. As Ryan and I analyzed the main theme of his final composition (see Figure 61), his use of repetition as a compositional device became apparent:

> SD: Do you have any repetition in here?
> Ryan: Yeah, right here, the first two, uh…. (Pointing to the first two phrase members.)
> SD: Did you copy and paste?
> Ryan: No.
> SD: Did you know you could do that?
> Ryan: I can?
> SD: That would have saved you some time. So, you *meant* to do a repeat?
> Ryan: Yeah.
> SD: And is this third part (pointing to the third phrase member), is that anything like these two (pointing to the first two phrase members) or is it different?
> Ryan: It's the same until the end where it goes dun, dun, dun, dun—except it goes dun-dun-dun (pointing to the end of the third phrase member) and then higher.
> SD: Okay.
> (stimulated recall, September 18, 2017)

As collaborative composers, Draco and Ryan exemplified the use of repetition on a macro-level through their implementation of 'palindrome' ternary form: A, A′, A″, B, A″, A′, A. Examining the sonic elements within each section of their composition revealed how Draco and Ryan masterfully used repetition while concurrently infusing variety (see Table 20). On a micro-level, Draco and Ryan spent considerable time crafting two repetitive sequences to place within the context of a varied contour for the B section of their composition (see Figure 88, Sequence #2).

Chapter Summary

In this chapter, I presented within- and cross-case analyses of the four focus composers' individual and collaborative strategies and processes that emanated from multiple sources of data collected during the 10-week composition period. While analyzing each case, I applied Erickson's (2006) Type 1 inductive approach to the analysis of data from videotape and the constant comparison method (Barrett, 2014; Harding, 2018; Merriam, 2014) for inductive analysis. As suggested by Creswell (2007), I built patterns from the bottom up "by organizing the data into increasingly more abstract units of information" (p. 98), which led to four emergent themes.

The four emergent themes were: Inspiration Sources, Sonic Elements, Sound and Sight, and Traditional Composition Techniques was through these four lenses that I completed the cross-case analysis focusing on the most prevalent and impactful theme-related categories that revealed themselves among the four focus composers as a group. I also used the concept dyads and theoretical framework discussed in Chapter 1 as additional lenses to underscore connections between the composers' processes and strategies and the conceptual framework for my study.

Tables 29 and 30 illustrate the extent to which the four emergent themes manifested themselves and the range of theme-related categories that surfaced over the 10 weeks of the study and among the four focus composers' processes, respectively (link to

Table 29, Appendix D; link to Table 30, Appendix D). In Chapter 5, I will focus on my second research question by examining all eight participants' responses to the composition process and the products they created within this constructionist-oriented environment.

CHAPTER 5: PARTICIPANTS' RESPONSES TO THE COMPOSITION PROCESS AND THEIR COMPOSITIONS

For this chapter, I analyzed semi-structured interviews, think-aloud data, video-stimulated recalls, and nonverbal activity displayed or expressed by all eight participants to answer my second research question: What are the participants' displayed or expressed responses to the composition process and the compositions they created within this environment? As in Chapter 4, I combined Erickson's (2006) Type I inductive approach to video analysis with the constant comparison method to complete the within- and cross-case analyses presented in this chapter. Also, in this chapter, I underscored how the theoretically-oriented variables of interest that I identified in Chapter 1 revealed themselves as I analyzed participants' responses to the composition process and their compositions.

After using NVivo to transcribe verbal and non-verbal activity for more than 80 hours of video data, I coded the transcriptions and related video data and created crosstab and time-ordered matrices. The crosstab and time-ordered matrices helped me initially identify patterns from the bottom up and ultimately determine themes "by organizing the data into increasingly more abstract units of information…working back and forth between the themes and the database" (Creswell, 2007, p. 38). Table 31 is the time-ordered matrix of themes and related categories as they surfaced to varying degrees over the 10 weeks of the study (link to Table 31, Appendix E). Table 32 contains the crosstab matrix displaying the extent to which each theme and related category manifested itself within each participant's process (link to Table 32, Appendix E). Figure 136 represents the emergent themes and related categories pertinent to my second research question (link to Figure 136, Appendix E).

As an additional step during the within-case analysis process, I examined each participant’s individual and collaborative composition experience through the lens of each theme, began building word tables, and engaged concurrently in constant comparison to prepare for the subsequent cross-case analysis. As I applied the constant comparison method, I noted similarities and differences and confirming and discrepant evidence among the eight participants’ composition experiences. Word tables and network displays provided the foundation for my subsequent cross-case analysis. All participants chose their own pseudonyms.

Bri’s Response to the Composition Process and Her Compositions

Bri stated she had taken private music lessons for less than one year and had never created original music before participating in this study. Bri exhibited a nonchalant, playful approach to composition that reflected Papert’s (1980a) concept of *affective computing*. Although Bri was somewhat laconic about her process and products compared with other participants during interviews and stimulated recall moments, her demeanor was one of openness and curiosity. She visibly explored composition in a spirited and inquisitive manner. Bri provided some compelling data regarding composer traits, developing a composition, and how she valued the composition process and her resulting products.

Composer Traits

In our first interview, it became clear that Bri thought of composers and conductors synonymously:

> SD: Do you know what a composer is?
> Bri: Yes.
> SD: What do you think a composer is?
> Bri: So, there are all these people who got their instruments. This guy's got some drums, this guy's got like a violin. Then the composer, he has his conducting stick, and he goes (waving her arms) *you* be quiet, *you* be louder, *everyone* play the same!
>
> (interview, September 8, 2017)

Over time, Bri's concept of a composer as a conductor seemed to remain consistent as evidenced by comments such as, "To be a composer you have to tell this one to be quiet and this one louder" (interview, September 26, 2017) and, "A composer controls everyone. The composer is the mind, and the instruments are the fingers" (interview, October 12, 2017). However, Bri's idea of herself as a composer apparently evolved, based on three of her interview responses:

> SD: Do you consider yourself a composer at this point?
> Bri: (looking perplexed) I don't know.
> SD: Did you think of yourself as a composer before today?
> Bri: Definitely not.
> (interview, September 8, 2017)
>
> SD: How are you feeling about your progress?
> Bri: I feel like I am getting into the nice composer water. Like soft sand, nice calm waves. Sort of there, like we're on the bus to the beach, but we're not quite there.
> (interview, September 20, 2017)
>
> SD: Do you think your ability to compose has improved? Why or why not?
> Bri: I think it did because I kind of know what to look for now. Things that would make the piece sound better if I was actually like a composer.
> SD: Can you think of an example of something you might look for?
> Bri: A chord, maybe. Like I learned stuff.
> SD: Did you not know about chords before?
> Bri: No.
> (interview, November 9, 2017)

Developing a Composition

The participants' desire to develop their compositions and be persistent surfaced numerous times as I analyzed their responses to their processes and products. At one point, reflecting on my role as observer as participant, I noted, "I am feeling like I need to give more specifics about how to develop compositions" (researcher notes, September 26, 2017). Whether to provide more direct instruction led to an ever-present source of tension for me. Nevertheless, developing their compositions was apparently on the minds of several participants, as evidenced by their remarks.

Bri expressed a desire to develop her compositions in a few ways. Initially, she expressed interest in creating longer pieces. At the end of her first session, Bri commented, "I made a nice little short one, but I think I want to make a longer one" (September 1, 2017). Although I suggested she might develop her first composition into a longer piece, Bri chose to start something completely new during the second session, which was similar in length to her first composition. Although Bri's initial idea of developing and persisting was to increase the length of her compositions, all four of her individual compositions were similar in length and relatively short. Over the five-week individual composition phase, however, Bri also expressed interest in developing her compositions by adding instruments, varying when melodies played or dropped out, and creating patterns with the graphic notation tools.

During the fourth composition session, Bri experienced a breakthrough ostensibly fueling her desire and ability to develop her final composition. When I asked Bri to describe what she discovered, she explained how she used dots and lines to create repeating patterns. This newfound strategy, which appeared to stem from being a bricoleur rather than a ‘planner,’ infused coherence that had not been present in her previous pieces. Bri’s excitement about her composition spiked. She listened to her piece repeatedly, asked other participants and me to listen to her piece, and was exceptionally excited about her piece. Bri devoted most of her final composition session to celebrating the success of her composition rather than developing it further. Although Bri never created the extended composition she talked about on the first day, her persistence ultimately led to her successful final composition, which she selected for our end-of-study performance (link to Figure 137, Appendix E).

Value of the Process and Products

Throughout the composition process, I explicitly asked participants to reflect on their processes and products during semi-structured interviews, stimulated recalls, and the composition process itself. Implicit, and sometimes explicit in the data were various indicators of how participants valued the composition process and their products. I noted that Bri seemed excited about the process during the first composition session, and outwardly enjoyed it, as evidenced by her *affective computing* (Papert, 1980a). Observations such as upbeat singing and spontaneous laughter and comments like, “That sounds cool” (September 1, 2017) surfaced at the outset, were consistent throughout, and indicated that she enjoyed the process. Although she expressed interest in a few intentional ways of developing her compositions, as discussed above, Bri’s process was generally carefree, playful, and unintentional. One of Bri’s comments in her final interview epitomized her demonstrated response to the process. She said, “I would get excited about once a day about something new I did, and I would call Brittany to come look at it" (interview, November 9, 2017).

My impression was that Bri completed this experience ultimately valuing composition as an enjoyable activity and feeling somewhat more like a composer, but not necessarily understanding significantly more about composition or music:

> SD: Did you learn anything about composing music today?
> Bri: Not really. I don't really think I learned anything about composing.
> SD: That's good.
> Bri: That's good? (She displays an incredulous expression.)
> SD: Yes, honest answers are good.
> (interview, September 8, 2017)

Bri's think-aloud comments about the value of her compositions were relatively regular and distinctly genuine. Her responses equally included negative, critical, positive, and satisfied remarks. Even when dissatisfied with her results, Bri's tone always reflected a low-stakes disposition. Although she expressed overall dissatisfaction with her first three compositions, she never appeared discouraged. Bri sometimes articulated sensitivity to aspects of her composition using basic musical terms, but rarely demonstrated an interest in manipulating these elements to a significant extent. This might explain why she tended to move on to a new composition when she was unhappy with the results.

Until she found a way to develop her final composition into something about which she was particularly proud by creating patterns, Bri seemed to enjoy residing in 'composer land,' readily responding to the quality of her products. She exhibited a strong sense of *ego syntonicity* (Papert, 1980a) by expressing strong sentiments of like and dislike for her compositions, although without a firm grasp of musical terminology.

Comments such as, “[A good composition] has a harmony that goes together, nothing is too loud or too quiet” (interview, October 12, 2017) and, “[My final composition] sounds good but it’s like different instruments, it has like, different sounds…it has harmonies sort of; it kind of comes together in a weird way. And I *love* this part (the final chord)” (interview, October 2, 2017) indicated that Bri aimed to describe her products in abstract musical terms but did not yet have the musical experience to do so articulately.

Brittany’s Response to the Composition Process and Her Compositions

Brittany stated that she had taken private lessons for more than one year and had never created original music before. Brittany understood a fair amount of musical terminology, probably because of her experience studying the piano. She would use musical terms fluently as she described her process and discussed her compositions. Brittany’s think-aloud data and responses to my interview and stimulated recall prompts provided rich data about the process of developing her compositions, her Hyperscore experience, and how she valued the composition process.

Developing a Composition

Brittany spent little time developing her first composition but expressed a desire to expand her second composition. She occasionally invoked a sandwich analogy, saying, “I just kind of want something like the meat of a sandwich. If you just make a bunch of different melodies at once and you’re not really listening to what you have, it doesn’t really all connect” (interview, September 26, 2017). Consequently, she devoted four of the five individual composition sessions to developing her second and final individual composition, striving daily to make it a coherent piece of music by modifying motives continually, creating a distinct form, and adding dynamics. Brittany spent a great deal of time listening and reflecting on her piece, exhibiting a metacognitive tendency deemed essential to the constructionist environment as described by Papert (1980a, 1993).

Reflecting on her final composition in our concluding interview, Brittany stated, "I wish I had more colors (timbres), so I could add more melody, and just kind of develop it better and have a little bit more meat inside the middle" (stimulated recall, November 6, 2017). Similarly, Brittany referred to the many components needed for developing a composition with comments such as, "There's so many components to composing. It's not just like writing out music. There's more to it, and it's a lot harder, and it takes a long process" (interview, November 1, 2017). Like a bricoleur, having several components to manipulate seemed important to Brittany, as evidenced by her second and final individual composition in which the texture was relatively "meaty" (link to Figure 138, Appendix E).

Hyperscore as a Mediating Tool

For some of the participants, the idea of Hyperscore as a mediating tool (Ackermann, 1993; Duffy & Cunningham, 1996; Goldman, Black, Maxwell, Plass, & Keitges, 2012) emerged from think-aloud, interview, and stimulated recall data as a prominent theme. Although the primary purpose of the present study was not to focus on Hyperscore explicitly, its efficacy as a mediating tool for music composition provided some compelling data in some cases. For example, on the first day of composition, Brittany commented that Hyperscore instruments "don't sound like real instruments" (interview, September 1, 2017), which implied a shortcoming of Hyperscore as a tool.

Also, in her final interview quoted earlier, Brittany viewed Hyperscore's limit of using only eight simultaneous timbres as a constraint. Brittany mentioned this limitation at least three times, suggesting that she equated interesting harmonies with the ability to create numerous timbral combinations. Her response to Hyperscore's timbral limitations indicated that this sonic element was important to her as a composer. Brittany perceived of Hyperscore as an assistant. In one particular interview, she alluded to Hyperscore's artificial intelligence characteristics:

> It's cool that you have all these different functions that maybe a human could not do…On Hyperscore, maybe a person can't play those things or play as fast. You can make it faster than maybe a human can't do. It's like a robot. (interview, November 1, 2017)

Brittany's comments about Hyperscore as a robot alluded to the concept of *technological scaffolding* (Duffy & Cunningham, 1996; Wood, Bruner, & Ross, 1976) and the potential for artificial intelligence to support learning.

Value of the Process

Brittany's responses and demeanor indicated that she valued the process as somewhat challenging and rather enjoyable. Comments such as, "It's a lot harder and takes a long process" and, "Sometimes it's hard to find the right note you're thinking of" (interview, November 1, 2017) indicated that she encountered some difficulties along the way. Comments such as, "It was fun to actually find like, the right notes" (interview, September 26, 2017) and, "I'm really satisfied with this piece that Bri and I made. It's really nice we were able to make something like this. I was really happy" (stimulated recall, November 7, 2017) demonstrated Brittany's relative enjoyment of the process. Despite these comments, Brittany never appeared to struggle to a significant degree. She created discrete, cohesive musical ideas fluently, combined and manipulated them quickly and easily on the sketchpad, and intuitively developed her compositions to include sophisticated phrasing, dynamics, and form. Overall, Brittany's display of a process that was only somewhat challenging but rather enjoyable has implications for Papert's (1996, 1999b) concept of *hard fun* as one of the eight big ideas underpinning constructionism. For Brittany, rather than hard fun, the process seemed only *somewhat* hard and *relatively* fun.

Part of the design of the present study included imposing no particular guidelines or constraints, which Brittany indicated was something she appreciated. Several of Brittany's comments conveyed how much she valued the autonomy associated with the composition process. For example, "When you compose, you have no limits. I mean, you kind of do, but you can kind of decide on how you want your music to sound. You're not playing a piece that's already made" (Brittany, interview, September 14, 2017), and "It's kind of like a free-for-all. It's like, you kind of want to do whatever you start…You kind of just do whatever (interview, September 20, 2017).

Brittany also expressed that the autonomous environment supported self-expression, and it appeared that the freedom to compose without restrictions was something she valued most during this experience: "There's no rules to composing that much, [it's] not like, limited" (interview, September 20, 2017). In the following excerpt, Brittany expressed how the composition experience might benefit herself and others in a personal manner:

> I feel like composing makes it easier to express yourself to everyone else if you share this music. It makes it easier to like, show who you are instead of actually speaking. You still kind of get your message around, but it likes a silent message. It still gets to them. That's what I like…It (composing) kind of expresses how you like to think without actually saying things. You still kind of get your point across. (interview, November 7, 2017)

Jeff's Response to the Composition Process and His Compositions

Jeff stated that he had created original music before this project and had taken private lessons for more than one year. Jeff worked quickly, was noticeably animated and engaged, and demonstrated that he had definite ideas of what he liked and disliked about the process and his products. For Jeff, his decisive expression of like and dislike indicated that his composition process was likely a somewhat *ego-syntonic* (Papert, 1980a) experience. My observations of Jeff's process produced a diverse set of responses, the most compelling of which related to composer traits, developing a composition, peer collaboration, Hyperscore as a graphic notation tool, and how he valued the process and his products.

Composer Traits

Although Jeff indicated he had created original music before participating in this study, in our first two interviews, he expressed that he did not yet consider himself to be a composer. Although he had explored GarageBand to some extent (interview, September 28, 2017) before participating in this study, his comments in our first two interviews made it apparent that he did not equate his previous experience making music in GarageBand with composition:

> SD: Before this project, did you ever think of yourself as a composer?
> Jeff: No.
> SD: What do you think a composer does?
> Jeff: Makes music, and I didn't think I made music [before].
> SD: Do you have a concept of what a composer does besides making music?
> Jeff: He makes sure everyone is doing their part. He's kind of like the manager.
> SD: I kind of would say you have been managing all these different pieces.
> Jeff: Well, these ones (pointing) are just playing around and don't sound good.
> (interview, September 12, 2017)

Based on our first two interviews, it appeared Jeff held a concept of a composer not as someone who 'played around' or experimented, but as someone who combined elements of music that worked together successfully and 'sounded good.' Despite my implication that what he was doing was actually composing, he did not openly concur at this point in the process. As I checked in with Jeff about the composition experience throughout the 10-week study, he gradually qualified his definition of a composer, indicating that he was "kind of like a composer [but] not like one of those orchestra ones" (interview, September 22, 2017).

My exchanges with Jeff led me to believe that he held a concept of a composer as one who creates a specific type of music, possibly classical, or perceived of composing as an elitist activity reserved for 'serious' musicians. This was not surprising to me and is consistent with Paynter's (2000) assertion that students often have the impression that "real composing is what other, specially talented, people do" (p. 25). Although I assured him that I was not looking for a particular answer, Jeff's idea of a composer seemed to change throughout the next few interviews.

In a later interview, Jeff agreed that his final individual composition sounded good, but still implied that he did not consider himself a composer. Jeff told me that good composers create organized music and, although his compositions often "sound good," they don't "look organized" (interview, October 18, 2017). Jeff was referring to the relatively abstract looking graphic notation he created. However, two factors combined to make Jeff's piece sound rather cohesive despite its somewhat disorganized appearance.

First, Jeff's individual motives were relatively coherent discrete musical ideas that complemented one another rhythmically. Second, he had enabled the 'general harmony' setting in Hyperscore, which launches algorithms that, "impose a pitch envelope on the motive's repetitions but do not alter the melodic contour to the point that the new material is unrecognizable from the original motive" (Farbood, Kaufman, & Jennings, 2007, p. 51). When Jeff contrasted his disorganized notation with the relatively organized aural result, he intuited that Hyperscore's algorithms improved his composition. The software was functioning as a type of artificial intelligence, and Jeff's response above indicated that the lack of visual structure in his composition was incongruent with the aural results (link to Figure 139, Appendix E).

Jeff's first impression of himself as a composer seemed to evolve during the final two interviews, from thinking of composition as an elitist activity to a broader concept of composition. In our final interview, I posed the same question again, and Jeff still seemed to be formulating his idea of a composer at that point, saying, "I think if you make something, it's composing, but if you share it, it is considered like a *real* composer. You can hit a piano key, and you're a composer. You don't have to have a license or like, a Ph.D. to be a composer" (interview, November 3, 2017).

Asking Jeff if he thought of himself as a composer several times over the 10-week period seemed to prompt him to think deeply about what is required to be a composer. Jeff's comments indicated that he was conflicted as if influenced by a predetermined model he held about composers while also considering that he was actually composing despite his lack of experience. As I compiled and listened to Jeff's comments chronologically, it seemed as though I was witnessing a type of Piagetian assimilation and accommodation in action.

Developing a Composition

Jeff was the most prolific of the eight composers but demonstrated little interest in developing extended compositions. Although he sometimes indicated his intent to develop a particular composition with such statements as, "I might extend it, and maybe over here add some blue and green (interview, September 6, 2017), and "I might add on to that one a lot next class" (stimulated recall, September 12, 2017), he did not come back to his compositions to lengthen them from one composition session to the next.

Although Jeff would often listen to what he composed during the previous session, he displayed a preference for creating new music rather than persisting with his previous work. Consequently, by the end of the five weeks of individual composition had created five short compositions, two of which he considered fully developed and wanted to share in the performance. Ultimately, Jeff distinguished himself by creating five variations of his final individual composition, which was a relatively quick and easy process of drawing on the sketchpad. However, like a quintessential bricoleur, Jeff persisted with creating variations until he identified the one he wanted to include in the performance.

Jeff often made comments about his preference for keeping compositions simple, which seemed to be part of his rationale for determining when a composition was finished, even if he only worked on it for a brief period. Comments such as, “It sounds bad ‘cuz it’s too many notes at the same time” (stimulated recall, September 22, 2017) and, “It was like, too much. I like simple” (stimulated recall, October 4, 2017) indicated that he preferred thinner textures for his compositions. When asked to reflect on his previous compositions, Jeff would usually focus on simplicity first, making comments such as, “I really like it. It’s just nice and simple” (stimulated recall, November 9, 2017). From what I could discern based on Jeff’s comments, he seemed to think of developing a composition as adding more notes and instruments. As the texture of his composition thickened, he usually displayed dissatisfaction and moved on to something new.

Peer Collaboration

At various points, Jeff expressed strong opinions about the collaborative aspect of composition. Although he commented at one point that he liked learning from his partner, all of these other responses indicated that he preferred working on his own. One reason for Jeff’s preference was because he felt like working alone was a more productive experience. Jeff indicated that sharing the mouse was an obstacle to productivity, and he felt like he was assisting his partner rather than collaborating when he did not have control of the mouse.

Jeff’s focus on mouse control indicated that he valued the hands-on aspect of composition, and possibly did not see himself as actually composing unless he was in control of the mouse. This ‘tension’ was consistent throughout the five-week, collaborative aspect of the study. When Jeff was in the ‘driver’s seat’ using the mouse, he was engaged and enthusiastic; however, when his partner controlled the mouse, Jeff spoke very little and often appeared disinterested. Jeff’s predilection for mouse control resonated with Ackermann’s (1993) model of a dynamic mediated experience, which requires three elements, hands-on, heads-in, and playback. When he worked alone and was in control of the mouse, Jeff appeared to have a dynamic mediated experience.

Jeff also indicated that working with a partner was difficult because he and Josh had very different strategies. According to Jeff, Josh was more interested in planning and organization while Jeff preferred experimentation. Jeff’s style aligned more with Papert’s (1996) notion of *bricolage*, which consists of tinkering, adding things, pushing elements around, and remolding something to grow it into something more complex.

Hyperscore as a Graphic Notation Tool

Jeff was familiar with traditional notation from trumpet lessons, and, at one point, contrasted traditional notation with Hyperscore’s graphic notation approach. As Jeff spoke, he often quickly manipulated his sonic elements on the screen, and his comments sometimes implied that he appreciated the option of easily modifying his music and perceived of traditional notation as being somewhat inflexible. Jeff shared that he doesn’t “really like sheet music that much” and preferred the quick, “boom, boom” (drawing on the screen) facilitated by Hyperscore’s graphic notation approach (interview, November 3, 2017). Other comments Jeff made, such as, “I like how it’s not too many technical things; you just draw it, and it sounds good” (interview, September 22, 2017) indicated that the process was enjoyable but not very challenging for him. This finding had implications for Papert's (1996, 1999b) concept of *hard fun,* which I elaborate on in the next chapter.

At another point, while we were talking about Hyperscore, Jeff intuited connections among Hyperscore as a graphic notation tool, the constructionist nature of the present study, and autonomy, saying, "In most classes, they make you follow certain rules. I like that the first day you didn't explain it. I don't like directions " (interview, November 3, 2017).) Jeff's juxtaposition of creative drawing with his disdain for directions implied that the Hyperscore graphic notation environment and the absence of explicit instruction complemented one another. He also expressed appreciation for autonomy, and his explicit aversion to rules and directions alluded to the constructionism-instructionism dyad presented in Chapter 1 as part of the theoretical framework for this study.

Value of the Process and Product

During our conversations about Hyperscore as a graphic notation tool, it was apparent that what Jeff valued most about the composition process in the present study was autonomy, saying, "I don't like when teachers lecture you on how to use something for like, five hours. I like to figure this stuff out by myself. I do not like lectures at all" (interview, October 24, 2017. It was also evident in his response to working with a partner that Jeff did *not* value the collaborative composition process as much as composing individually. This is likely because he felt like he could not contribute unless in control of the mouse and the drawing process.

When Jeff talked about working with a partner, he usually focused on what was difficult about it. Conversely, when he spoke of the individual composition process, his comments often conveyed sentiments such as, “I like using Hyperscore. It’s really easy and fun” (interview, October 24, 2017). Although Jeff emphasized the fun and easy aspect of Hyperscore in his comments, two of his comments indicated that it also took time and effort to create a good composition. Jeff implied that the quality of a composition was proportional to time spent and effort put forth, saying, “This one I took 20-30 minutes [to] make sure it sounded good” (stimulated recall, September 12, 2017) and, “It took more effort, and it sounds better” (stimulated recalled, September 6, 2017).

Jeff’s comments over the ten weeks included references to time and effort as well as a fun and easy process, intimating a relationship among time, effort, and easy fun. He usually described the results of ‘messing around’ (i.e., easy fun) as more inferior in quality to something on which he spent considerable time. The screenshot in Figure 140 exhibits how Jeff created four versions of the same composition, three of which he referred to as ‘messing around’ and one that, “took more effort and…sounds better” (stimulated recall, September 6, 2017) (link to Figure 140, Appendix E).

On the final day of collaborative composition with Josh, Jeff’s ‘messing around’ strategy led to an unexpected satisfactory result. Jeff and Josh struggled with combining their motives on the sketchpad to produce satisfactory results. As time began to run out, Jeff used “the graffiti approach” (stimulated recall, November 9, 2017) on the sketchpad out of desperation to finish the piece. The ‘careful’ version consisted of all sonic elements layered on top of one another, and the ‘graffiti’ version was scribbled quickly (link to

Figure 141, Appendix E). After listening and reflecting, Jeff agreed that "the graffiti approach" produced the better result, which was the first time he expressed satisfaction with the results of 'messing around.' In the end, committing time and effort and 'messing around,' two modes of composition Jeff generally valued differently, led to success.

Josh's Response to the Composition Process and His Compositions

Josh indicated he had never created original music before and played clarinet in the band for two years but not taken private lessons. Josh exhibited a minimalist approach to composition when working individually, creating relatively short musical ideas, and drawing short phrases on the sketchpad. Figure 142 is a screenshot from one of Josh's individual compositions exemplifying his minimalist approach (link to Figure 142, Appendix E). Josh's minimal verbal responses to the process and his products paralleled his minimalist approach to composition. Although I regularly encouraged participants to think aloud by sharing their processes and strategies, Josh infrequently responded to my prompts. When I would ask Josh questions intermittently during his composition process, he often seemed unable to share his thoughts at the moment. Possibly, it was difficult for Josh to respond to questions about his process while engaged in composition.

It might be that *cognitive complexity* (Perkins, 1992) played a role in Josh's limited verbal reporting and generally laconic demeanor while composing. Josh's responses during semi-structured interviews outside of the composition process were more forthcoming than those during his composition process, although his responses were relatively brief. Despite the limited scope of Josh's verbal responses, he exhibited some telling verbal and non-verbal responses about being a composer, collaborating with a partner, and how he valued the composition process.

Being A Composer

As I observed Josh's individual composition process, I noted that he seemed uncertain of how to expand his musical ideas or was satisfied with creating compact compositions comprising short motives and brief phrases. I was unable to discern whether it was the former or the latter until the fourth individual composition session when I observed Josh speaking to Draco:

> Dude, I just need help. I know this isn't the group (collaborative) one (composition) yet. I almost kind of want to work with you because I don't understand how to make the long things like you do. I just make short little things (individual composition, September 28, 2017)

The above comments confirmed that Josh was at a loss for ideas of how to expand his musical ideas. Although Draco explained one of his strategies to Josh, and I suggested that Josh draw longer or more curvilinear phrases on the sketchpad, he never applied our suggestions. Josh rarely asked for assistance and exhibited a less exploratory tendency than other participants while composing individually, which made me wonder if he would have benefited from more direct instruction. Josh's possible need for more direct instruction had implications for the constructionism-instructionism dyad I presented in Chapter 1 as part of the theoretical framework.

Although I regularly sat beside Josh to observe his process, ask questions, and offer assistance, I was sometimes unable to discern his level of engagement in and comfort with the process. In a subsequent stimulated recall moment, Josh indicated that he experienced a bit of a challenge, saying, “I feel like I am trying to use everything, and it’s making it so overwhelming. The technology has almost backfired on me, I guess” (stimulated recall, October 24, 2017). Based on Josh’s comments, which were often accompanied by an uncertain tone, I inferred that while he composed individually, he was either overwhelmed and disinclined to explore the composition process and the Hyperscore software, needed more encouragement and guidance (i.e., scaffolding) (Dick, 1992; Kirschner, Sweller, & Clark, 2006), or experienced *cognitive complexity* (Perkins, 1992). Conversely, when Josh collaborated with Jeff, he demonstrated more enthusiasm about the process and appeared to be more motivated and much less overwhelmed.

Some of Josh’s comments indicated that he might have lacked confidence and might have held a preconceived notion of composition as something out of his wheelhouse. Josh explained that a composer has “experience on instruments…[can] write the music for all the instruments…[and knows[s] how to put the notes down (notate) (interview, September 18, 2017). As my conversations about being a composer continued with Josh, it became more apparent that he likely held a notion of composition as a lofty profession for trained musicians. Josh’s concept of composers and the composition process resonated with Cage (1961), Kennedy (2002), and Paynter (2000), who asserted that people typically view composition as an activity for an elite group.

Josh expressed general dissatisfaction with the outcome of his individual composition. When I asked him how he was feeling during the last few minutes of the individual composition process, he only talked about what he did not like. For a second time, I suggested he experiment with the shape of the lines he drew on the sketchpad, but he shared that the drawing tools were somewhat confusing to him. Josh's comments, including, "I never really tried to learn it" and, "Maybe [I could] experiment with more things" (individual composition, October 4, 2017) underscored his apparent diffidence about experimenting with the software and the composition process. Josh implied that he preferred a conservative approach, at least at that point. However, Josh's experience with peer collaboration evolved into a more adventurous and gratifying experience than working alone.

Peer Collaboration

Josh's comment to Draco during the individual composition phase, "I just need help…I almost kind of want to work with you," indicated that Josh looked forward to the collaborative composition process. Although I paired Josh with Jeff for collaborative composition and not Draco, Josh exhibited more enthusiasm about and engagement in the process while working with Jeff compared with his individual composition process. Although his partner Jeff tended to control the mouse and do much of the drawing, Josh was comfortable contributing his ideas orally and asking Jeff for control of the mouse when inspired to do so. Josh exhibited more curiosity and a spirit of exploration while working with Jeff. At one point, as shown in Figure 143, Josh decided to test out the results of drawing a starship for one of his motives, which was antithetical to the much more conservative approach he took while working individually (link to Figure 143, Appendix E).

At the end of the first collaborative composition session, Josh expressed excitement about what he and Jeff produced, saying, "What I really liked about it is it takes both of our ideas that we had individually" (interview, October 10, 2017). The spirit of exploration that emanated from his collaborative process with Jeff also came through in some of Josh's interview comments, along with excitement about the process that was not evident while composing individually. For example, "I like composing because with a partner you get to make songs that you both enjoy and are interested in. I just like trying all the new things the website (software) can provide" (interview, October 24, 2017).

Josh's partner (Jeff) became less engaged in the process as it proceeded, ostensibly because Jeff preferred working alone and having more mouse and drawing control, which he expressed in his interviews. Consequently, Josh and Jeff experienced a decline in productivity. However, as Jeff contributed less, Josh tried to remain invested and offer ideas, Josh suggested that they return to their respective individual composition computers and "get inspiration from what we used to be (doing)" (Josh, collaborating with Jeff, October 24, 2017).

Subsequently, Josh and Jeff experimented with building on their composition by borrowing motives from their respective individual compositions and inserting them into their collaborative composition. Josh's effort to reignite the collaborative process by looking back at previous work to gain inspiration was an indication of his investment in the collaborative process. When the next lag in productivity surfaced, Josh was once again the motivator, saying, "We actually need to make some progress" (Josh, collaborating with Jeff, October 24, 2017). Josh took the initiative to keep the process going, and although his partner viewed reaching Hyperscore's eight-timbre limitation as the end of the process, Josh suggested adding to what they had already created.

Value of the Process and Products

The contrast in Josh's demeanor between the five-week individual composition process and the five-week collaborative composition process was sharp. During the individual composition process, Josh's productivity was relatively low, and his brief comments focused on his shortcomings as a composer. Conversely, during the collaborative process, Josh encouraged Jeff to remain productive, made suggestions for developing their composition, and exhibited much more enthusiasm and curiosity about the process. While collaborating with Jeff, Josh's process evolved from conservative as an individual to more exploratory during collaboration. Based on the contrast I observed between Jeff's demeanor as an individual composer, his affect during collaboration, and his explicitly stated preference for "composing with a partner [because] you have more ideas" (interview, November 9, 2017), I concluded that Josh keenly valued the collaborative experience and the productivity and more developed composition that had sprung from working with a partner.

Over the 10 weeks of the present study, I asked Josh to reflect several times on his concept of a composer and the composition process. Josh's responses cited above indicated that he thought deeply about composers and composition and seemed to value the intricacy of the process. Although his elevated idea of composers and composition appeared to curb his progress during the individual composition process, comments such as, "Most composers get ideas from their lives" (interview, October 30, 2017) and, "I feel like a composer makes like, really thoughtful music that they put a lot of time into" (interview October 24, 2017) demonstrated that Josh valued composition as an intricate form of artistic expression.

Emily's Response to the Composition Process and Her Compositions

In Chapter 4, I examined Emily's and the three other focus composers' composition processes and strategies. For this section of Chapter 5, I re-examined the focus composers' *responses* to the composition process and their compositions through lenses of the four emergent themes underpinning this chapter (see Figure 136). Emily's response to the individual and collaborative composition experience brought to light her thoughts about composers and composition traits, developing and persisting, generating ideas, and her value of the process and her products.

Composer and Composition Traits

During our second semi-structured interview, Emily indicated that she held two opposing views of a composer. Emily expressed that 'classical' music by composers such as "Mozart, Beethoven, and Bach" comes to mind first when she thinks of a composer. However, she also conceded that she "wouldn't think of Taylor Swift as a composer, even though she technically is" (interview, September 8, 2017). Emily also indicated that she had composed before but did not notate her compositions and subsequently tended to forget them. Her reference to notating music implied that she considered preservation as an essential part of the composition process. Some of Emily's other comments indicated that she perceived composition as a time-consuming, challenging process unless the composer is an experienced or gifted musician. For example, "I've learned that it takes a long time to get the piece where you want it" (interview, September 26, 2017), and "It's hard (laughing), and it takes a long time! It's not just boom; I have a piece" (interview, October 2, 2017).

As our conversations about being a composer continued over the ten weeks of the study, Emily demonstrated an increasingly philosophical view about the nature of composition, gradually placing less attention on difficulty, time, and the technical aspects of composition. Emily's comments and her general enthusiasm throughout the 10 weeks conveyed an appreciation for the affective aspect of composition, similar to Papert's (1980a) idea of *affective computing*. Also, Emily's comments in her final interview about being a composer indicated that she expected to learn *how* to compose during this project and not merely experience being a composer, saying, "I have much more of an open mind now into what creating music [is]. I thought it was this strict system, but [it] really could be anything (interview, November 7, 2017).

Persistence

Emily was a persistent composer, and I noted that her response to setbacks was often to draw on previous experience to help her move forward. For example, she borrowed ideas from pieces she had learned on the piano (i.e., *Phantom of the Opera* and *Arabesque*), which she cited as sources of inspiration, and displayed or expressed that her understanding of music theory and notation also helped her make progress. Like a bricoleur, Emily drew on a range of experience and previous knowledge to help her persist and develop her compositions.

Persistence also permeated Emily's process when she collaborated with Chelsea. Whether they were diligently trying to create a variation of Beethoven's *Fifth Symphony* finale motive or devoting extended time to creating a decrescendo despite Hyperscore's limitations (as described in Chapter 4), Emily and Chelsea responded with perseverance to the challenge of creating an effective soundscape. At times, Emily's remarks about determination resonated somewhat with Papert's (1996, 1999b) concept of *hard fun*, which also related to the affect-cognition dyad I presented in Chapter 1. For example, "We have [only] six entire lines, but we worked really hard on them" (stimulated recall, October 20, 2017), exuded a sense of hard work that was gratifying to Emily.

New Ideas

Emily once remarked, "When I walk in with an idea, I can walk out with a completely different idea" (interview, September 20, 2017), which epitomized her relationship with new ideas. Although Emily once claimed that she often has trouble expressing herself, her relatively high productivity implied that she was able to generate new ideas fairly easily. Possibly, Emily was referring to the *quality* of her ideas more than her ability to generate new ideas when she alluded to her challenged expressivity.

For Emily, thinking aloud and reflecting appeared to be an innate strategy for coming up with new ideas, and resonated with Papert's (1980a, 2005) model of constructionism, which included an emphasis on metacognition. I noted Emily's fluid and iterative cycle of listening and reflecting sometimes accompanied by thinking aloud, followed by creating new melodic or percussion motives and experimenting with drawing on the sketchpad. Regular comments such as, "Now I need to extend it a little more, might throw it off a bit but, (pause) sacrifices" (individual composition, September 20, 2017) and, "Now let's make a really long melody" (individual composition, September 14, 2017) led me to infer that Emily generated new ideas relatively quickly.

Emily was the most productive ‘motive generator’ of all participants, as evidenced by the inventory of her motive-making process displayed in Figure 135. On various occasions, Emily indicated that new ideas seemed to flow easily for her with remarks such as, “You start out with an idea, and it turns into something so much different” (interview, October 2, 2017), “I had…something that builds up to the melody,…then I was moving on to the melody, and all sorts of things just came into my head, and I didn’t know how to, yeah” (stimulated recall, November 1, 2017).

Value of the Process and Products

Emily’s think-aloud and interview comments often demonstrated overall satisfaction with the outcome of her process. Remarks such as, “I’m really proud of myself right now, that was pretty good” (individual composition, September 14, 2017) surfaced more frequently than unfavorable comments, indicating that Emily generally approved of her results. Disapproving comments such as, “I think I was super disappointed (laughing)” (stimulated recall, November 1, 2017) were fleeting and almost dismissive in tone. Emily approached the composition process with a spirit of exploration and curiosity that often emanated from think-aloud comments such as, “I kind of like it, but I think it needs one more harmony. No, I don’t like it too busy. Why not try? It won’t hurt” (individual composition, September 20, 2017). For Emily, the ‘low stakes’ environment seemed to inspire her process, which I inferred from frequent carefree comments such as, “I’m just gonna play around” (individual composition, October 2, 2017).

In addition to commenting on general satisfaction with her pieces and displaying comfort with the process, Emily sometimes expressed a sense of accomplishment and appreciation for the challenges that sometimes surfaced:

> The harder part is when you're trying to figure out what will fit and what will co-exist together nicely. The great part is when you finally get that right combination, and you're really impressed with yourself, and it makes you feel really good (laughing). (interview, September 14, 2017)

Combined with the sense of perseverance discussed earlier in this chapter, Emily's comments about the challenges she sometimes encountered reinforced my inferred connection between Emily's value of the process and Papert's (1996, 1999b) concept of *hard fun*. The purposefulness with which Emily embraced challenges when things did not work out easily was consistent throughout the 10 weeks of the study, which connects with the affect-cognition dyad I presented in Chapter 1 as part of the theoretical framework.

Chelsea's Response to the Composition Process and Her Compositions

Chelsea's verbal responses to my questions were direct and forthcoming. Chelsea 'thought aloud' more than most of the other participants and was a demonstrative participant. Chelsea's transparency reinforced my ability to document observations and make inferences about her response to the process and her products. She provided noteworthy data that conveyed her ideas about composer and composition traits, fitting things together, drawing on prior experience, peer collaboration, and her value of the process and her products.

Composer and Composition Traits

During our second semi-structured interview, I asked Chelsea if she considered herself a composer. Her response was definitive, saying, “No. I would call me a ‘tryer’ because I am just trying things and hoping they sound good. But I have no clue where to go.” The more questions I asked about composers, the more it seemed Chelsea might have been trying to provide the ‘correct’ answer, so I usually moved on to another question. However, her initial response indicated that Chelsea had a relatively open mind about the definition of a composer.

Chelsea equated the quality of her products with her qualifications as a composer with comments such as, “A composer just makes overall good music” (interview, November 1, 2017) and, “Last time, I didn’t think I was a composer because I didn’t think any of my compositions were good, but they’re getting better. *Now* [her emphasis] I would call myself a composer…” (interview, October 26, 2017). As was the case with other participants, Chelsea’s idea of a composer merely as someone who makes music evolved over time. However, she also continued to make references to what she and others typically think of when they envisioned composers and continued to differentiate herself from composers as “proper people:”

> Chelsea: If I think of a composer, I only think of composers that are successful.
> SD: Can you name a composer?
> Chelsea: Beethoven?
> SD: So, you think of classical music when you think of composers?
> Chelsea: Yeah, I think of like, proper people.
> SD: So, if you’re not as good as that, what would you call yourself?
> Chelsea: Composer in training. Hah!
> (interview, October 26, 2017)

Fitting Things Together

When thinking-aloud about or responding to questions about the products she created, Chelsea placed much focus on her desire to fit things together, which appeared to be a reference to creating pleasing harmonies and complementary melodies and rhythms. Fitting things together emanated as a crucial process to Chelsea in remarks such as, “I think a good composition is [when] it all goes really well together” (interview, October 12, 2017). Chelsea typically created melodic and percussion motives rather quickly. Based on her responses to my questions, creating raw material quickly apparently afforded her more time to focus on her priority, which was figuring out how to fit things together.

Chelsea’s concept of making sure things fit together also came through in some of her comments while collaborating with Emily. Remarks such as, “We’re trying to build off of this [motive], but we haven’t found a good [match]” (Chelsea, collaborating with Emily, October 6, 2017) and, “It sounds good like this [alone]. Wait, let’s see if it sounds good together” (Chelsea collaborating with Emily, October 20, 2017) indicated that fitting things together was still in Chelsea’s consciousness as a composer.

Prior Experience

Chelsea sometimes commented about or demonstrated how she drew on her prior experience as a drummer to help her with the composition process. She also responded to the composition experience with *body syntonicity* (Papert, 1980a) as she integrated her identity as a drummer. Chelsea’s occasional references to herself as a drummer and her deliberate attempts to “think of a drumbeat and try to impersonate it” (individual composition, October 2, 2017) also hinted at how composing music might have been a somewhat ego-syntonic experience for her (Papert, 1980a). Chelsea, the drummer, exuded “that which is coherent with children’s sense of themselves as people with intentions…" (p. 63).

Creating vocal percussion sounds and playing air drums intermittently throughout the process ostensibly helped her create drum patterns. Although Chelsea was not able to transcribe the percussion patterns she vocalized exactly, she sometimes appeared to attempt emulating her vocal percussion patterns using the graphic notation tools in Hyperscore. Think-aloud comments such as, "Okay, I'm gonna make a little t-t t-ch-t right after that drumbeat starts" (individual composition, September 14, 2017) embedded in an iterative cycle of notating alternating with vocal percussion sounds were a regular occurrence for Chelsea. At other times, Chelsea would imitate the drum patterns *after* she notated them on Hyperscore by simulating the drum timbres with her voice, which was another example of body syntonicity.

While she collaborated with Emily, Chelsea continued her habit of creating vocal sounds but expanded into singing definite pitches, which appeared to influence Emily's process as well. As Chelsea and Emily collaborated, they often sang along with their motives, used their voices to transcribe their quasi-Beethoven *Fifth Symphony* and quasi-*Twilight Zone* melodies, or vocalized the creepy effects they were trying to create. Their spirited, *body-syntonic* singing and humming resonated with Papert's (1980a) concept of *affective computing*.

Peer Collaboration

Chelsea responded particularly well to the collaborative phase of the project, and like most other participants, expressed a preference for collaborating over working alone. Although she spent considerable time creating percussion motives, and her drum patterns were particularly coherent when she composed individually, Chelsea did not seem invested in creating melodic material until she began collaborating with Emily. Before working with Emily, Chelsea tended to sketch melodies erratically and in a somewhat carefree manner. Because they were inspired to create creepy music for their programmatic composition, Chelsea and Emily engaged in a playful and adventurous process of looking for eerie sounds and creating mysterious-sounding melodies. Their collaborative process almost immediately included singing their ideas, making sound effects with their voices, and reveling in the various timbres they discovered. On a few occasions, Chelsea remarked about the positive experience she had collaborating with Emily with comments such as, “We like that we both get to give ideas, it really helps” (interview, October 20, 2017).

Hyperscore as a Mediating Tool

During the initial five-week individual composition phase, Chelsea was particularly attuned to Hyperscore’s limitations and technical challenges, and her progress at times appeared to be held back by focusing on software limitations. Chelsea rarely asked for assistance with technical problems, and it might be that she assumed she was supposed to find solutions on her own. It was notable that one of Chelsea’s first interview comments was about the lack of guidance provided by the software, saying, “It would have been nice if it kind of told you like, it gave you a little bit of a guideline if you wanted to make some things you Could build off” (interview, September 1, 2017). Here, again, the idea of Hyperscore as a mediating tool capable of scaffolding (Duffy & Cunningham, 1996; Wood, Bruner, & Ross, 1976) a novice composer’s process arose.

This time, however, the concept arose as a result of a participant wishing the *software* had been more helpful.

As Chelsea continued composing over the next few weeks, I noted many instances when she focused on technical problem-solving and ‘hacking,’ which sometimes absorbed several minutes of her time and affected her productivity. Chelsea was frustrated by the confusing timbral aspect of the software. Consequently, like a bricoleur, she devoted extended time trying to overcome this problem. Chelsea commented a few times on the limited timbres available with remarks such as, “The software doesn’t have every instrument there is” (interview, October 20, 2017). However, Hyperscore included 128 General MIDI timbres, and Chelsea’s impression of few instrument choices appeared to be a lack of interest in exploring the software or asking for help.

Chelsea occasionally commented on other apparent software limitations that constrained her composition process. Remarks such as, “You can’t make the notes louder, you can only make them longer” (stimulated recall, October 6, 2017) were impactful because she assumed the software could not do these things, and she did not ask for help. Chelsea’s remarks and her reticence about asking for help underscored my suspicion that Chelsea might have felt she was supposed to problem-solve on her own without guidance, which had implications for the constructionism-instructionism dyad I presented in Chapter 1 as part of the theoretical framework for this study.

After Chelsea began collaborating with Emily, they learned how to do at least two of the things that Chelsea believed were not possible (i.e., editing out specific parts and adding dynamics), and they spent considerable time exploring General MIDI timbres to create sound effects for their creepy soundscape. I inferred that either the collaborative experience instilled Chelsea with more curiosity, or it merely took time for her to identify how to use Hyperscore to meet her composition needs. In her final interview, Chelsea shared that it would have been helpful to know more about the software before beginning to compose, which resonated with her comments cited earlier about the lack of guidance she articulated on the first day.

Value of the Process and Products

Chelsea was one of the most orally expressive participants and was often explicit about what she did or did not like about her products. I also inferred that her experience was distinctly *ego-syntonic* (Papert, 1980a); that is, she expressed explicit "goals, desires, likes, and dislikes" (p. 63). Chelsea readily expressed her sense of like and dislike throughout the composition process and intimated that her goal was more about the process and personal satisfaction. Remarks such as, "It's all about the process. Because not every time you're gonna get a piece that sounds perfect together"), and exemplified Chelsea's easy-going attitude about the results of her process" (interview, November 1, 2017). As Chelsea reflected back on her individual composition process at two points in the project, she underscored her value of learning more than the result, saying, "[At that point], it was kind of also learning, so I don't think I had high expectations" (stimulated recall, November 1, 2017).

Draco's Response to the Composition Process and His Compositions

Draco was one of the more expressive and demonstrative participants orally and in his demeanor, and he regularly exhibited and articulated his self-ascribed trait as “a mechanical kind of guy” (interview, October 30, 2017). Draco often became absorbed with fine-tuning his melodies for several minutes at one time and appeared to gain much satisfaction from manipulating his melodies on a micro-level. At one point, he likened the tools in Hyperscore to a microscope that has both fine and coarse tuning functions. Draco’s interest in the mechanics of music was reminiscent of Papert’s (1980a) childhood experience of being fascinated with mechanics, and how “gears, serving as models, carried many otherwise abstract ideas into [his] head” (p. vi). According to Papert, such models help bridge the concrete with the abstract, and cognitive experiences “with a positive affective tone” (p. vi).

In addition to his implicit interest in the mechanics of music, Draco shared his thoughts about the composition process and composers and demonstrated persistence and enjoyment of developing melodic material. Draco also conveyed his preference for collaboration over individual work, shed more light on his preference for ‘mechanics,’ and revealed how he valued the composition process and the products he created.

The Composition Process and Composers

During the first two interviews in which Draco and I discussed composition and composers, he shared his concept of a composer as someone with pre-formulated ideas in their head. Like several of the other participants, Draco also emphasized knowledge of instruments and being very familiar with how each instrument sounds. Initially, Draco did not directly associate a composer with a conductor, orchestras, or classical music, as did other participants:

SD: Do you have a concept of what a composer does?
Draco: They kind of sit there with like, an idea of what they want in their head, and then they try out different sounds. They have to know what all the instruments sound like; so they can be like, yeah, I think it'll be this note for this instrument to get the sound that I want. If the composers don't have that, they can't get the sounds.
(interview, September 12, 2017)

Draco's initial emphasis on thinking in sound aligned with his consistently *body-syntonic* (Papert, 1980a) approach described in more detail later in this section. Draco identified thinking in sound as an essential trait for composers, saying, "They kind of sit there with like, an idea of what they want in their head, and then they try out different sounds. They have to know what all the instruments sound like" (interview, September 12, 2017). On a few occasions, Draco discussed how a composer thinks and expressed self-doubt about whether he qualified as a composer:

> [Composition] requires a lot of different types of thinking. It requires the mechanical, how does this work, how does this work? And then it also requires the really creative, abstract thinking, which I, I'm really a mechanical kind of guy. Big grand ideas, thinking of ideas, and mechanisms to make, and 99% of them I can't even make. (Draco, interview, October 30, 2017)

Draco's comments above resonated strongly with Turkle and Papert's (1990, 1991) concept of *epistemological pluralism.* Draco's idea of a composer was one who can bridge the gap between abstract musical ideas and the mechanics of composition, and he implied that he had trouble bridging his musical ideas with their physical construction. Similar to Chelsea, Josh, and Emily, Draco associated the quality of his composition with his qualifications as a composer.

Draco continued to differentiate his abilities from his concept of a composer for the duration of the project with comments such as, “Composing is something that just comes easily to some people…I do not think it’s something that comes easily to me” (interview, November 3, 2017). Consistent with other participants in this study, Draco held a somewhat elitist view of the composition process and expressed doubt about his ability as a composer.

Developing, Persisting, and Fitting Things Together

Draco’s think-aloud data and interview comments occasionally revealed his sense of persistence and commitment to developing melodic material:

> For the past two minutes or so, I have been doing from here (pointing to the screen with the mouse) to here. I’ve just been kinda like, humming out a tune in my head over and over and over again, and trying to match that on here (pointing to the screen). (Draco, individual composition, September 18, 2017)

Draco’s reference above to humming a tune “over and over and over again” epitomized much of his process. He seemed to enjoy dwelling on an idea or section of music for several minutes at a time, and at times, it seemed as though he might have experienced something similar to a state of flow (Csikszentmihalyi, 1991).

Draco’s persistence and commitment to developing melodic material continued into his collaborative process with Ryan. For example, Draco was determined to create a precise inversion of their main theme, and he devoted many minutes to this process while Ryan mostly observed and sometimes lost interest. Although Draco attempted to keep

Ryan involved through conversation, his ‘mechanical’ nature and persistence seemed to commandeer the process at times like these.

Similar to Emily and Brittany, Draco responded to the challenge of developing his compositions through persistence, but his development path took a different direction than the others. Instead of trying to develop compositions by adding musical elements and creating denser textures, Draco persisted by being a less prolific composer who committed more time to expand fewer musical ideas. Draco’s persistence manifested itself in extended periods devoted to developing sophisticated melodies more than any other participant.

Contrary to Draco’s claim that he was more of a ‘mechanical guy’ and not an abstract thinker, he often demonstrated a tendency toward abstract musical thinking that appeared to *support* his inclination as a mechanic. For example, Draco held a concept of melody that was more complex than the short motives created by most participants (see Figure 39). He was explicit about his desire to avoid repetition and demonstrated that he conceived of melody as a series of phrase members. Draco’s sophisticated concept of melody led him to focus on creating extended melodies rather than short motives and percussion patterns.

Similar to Chelsea, Draco often focused on getting things to fit together, and regularly commented on his dissatisfaction with the results. He made comments such as, “I like this bass…and I kind of like this [drum pattern] separately. Together they’re bleh, bleh!” (stimulated recall, October 18, 2017). One of his final interview comments suggested that combining multiple musical elements remained difficult for him throughout the process: “The challenge for me was trying to compose a good piece that fit together well” (interview, November 9, 2017)

Peer Collaboration

Although Draco was noticeably immersed in the individual composition process and was highly productive when working alone, he expressed that he preferred working with a partner. Draco seemed to prefer being in ‘the driver’s seat’ doing the ‘mechanical’ work of drawing the music. Draco controlled the mouse for the majority of the collaborative composition phase, although he occasionally suggested switching seats so Ryan could draw with the mouse. Draco also sometimes attempted to include Ryan in the process by asking for his approval or encouraging him to contribute ideas.

Draco held firm to his earlier idea that he was more of a mechanic than a musician as he collaborated with Ryan. Draco’s ‘mechanic identity’ might explain why he felt more comfortable when he was in physical control of the mouse. Draco sometimes suggested he and Ryan think of ideas first before drawing them on the sketchpad. Draco was apparently interested in thinking more abstractly in these moments, but Ryan often became disengaged. Draco and Ryan’s occasionally incompatible modes of thinking in these moments underscored Turkle and Papert’s (1990) emphasis on abstract thinking that “is on tap, not on top” (p. 113). At these moments, it seemed that abstract thinking was on *top* for Draco not on *tap*, which resulted in productivity decline and intermittent losses of Ryan’s connection with the process. At other times, Draco and Ryan worked together more equitably.

Although Draco tried to include Ryan in the process, and Ryan occasionally initiated ideas, Draco ultimately made most of the musical decisions and completed most of the drawing on Hyperscore. This appeared to be a result of Draco controlling the mouse most of the time, Ryan deferring to Draco much of the time as the “more capable peer” (Vygotsky, 1978, p. 86), and the occasional incompatibility in their styles. Despite my impression that Draco and Ryan had an uneven partnership and somewhat incompatible levels of musical ability, Draco articulated a sense of a successful partnership and appreciation of the collaborative process, saying, “With Ryan and I, I think he’s very good at making up the beat in his head…then I can put it down on the thing” (pointing to the screen) interview, October 30, 2017).

Hacking the Software

Consistent with his interest in mechanics, Draco spent significant amounts of time hacking the software in two ways. Based on the amount of time he devoted to workarounds, it appeared Draco might have enjoyed hacking more than the composition process itself. Other participants often asked Draco to explain Hyperscore functions in general, even when not attempting to hack the software. Draco seemed to enjoy being the resident expert ‘mechanic.’

Hyperscore’s graphic notation approach does not display discrete pitches played by each instrument on the sketchpad, which Draco deemed a disadvantage. Draco responded to this challenge by repurposing a percussion window to create a miniature quasi-traditional conductor’s score allowing him to see the notes for his bass line and drum beat in the same window (see Figure 28). Draco shared this strategy with Jeff, who shared it with Josh. Subsequently, Jeff and Josh expanded Draco’s tactic by creating a quasi-traditional full conductor's score for their composition (link to Figure 144, Appendix E).

Draco also shared with me that repurposing the percussion window, as described above, also provided a workaround to Hyperscore's limit of eight simultaneously sounding timbres. Draco's method opened up the possibility for composing a multi-timbral melody in one window and increasing Hyperscore's limit of eight simultaneously sound timbres (see Figure 30). Draco's creative problem-solving response to software challenges earned him the reputation as 'hacker' and helper.

Value of Products and the Process

Draco was highly expressive, articulate, and responsive throughout the 10-week study. He was comfortable thinking aloud and provided thoughtful answers to my questions. Draco was a young composer with a strong sense of himself as a person "with intentions, goals, desires, likes, and dislikes" (Papert, 1980a, p. 63), which fostered his *ego-syntonic* composition experience, to use Papert's term. Draco seemed to value persistence, and he readily expressed goals, likes, and dislikes throughout the process.

As I reviewed Draco's various ways of responding to his products, I noted his extensive focus on melody, more like a planner than a bricoleur. To Draco, the melody seemed to be the key to a good composition. The extended periods Draco devoted to creating, and refining melodies also reflected how he valued melody. When commenting on his products, Draco would often refer to the melody as his reason for liking or disliking something: "What I don't like is there's absolutely *no* melody" and, "The melody's okay. I could've done a little better" (stimulated recall, October 18, 2017) underscore Draco's emphasis on melody.

The data showed that Draco valued the inner workings of composition on a micro-level. For example, Draco regularly committed several minutes at one time to shaping a single melody, note by note, until it was satisfactory. Draco was one of only two composers in this study who devoted time to creating distinct phrase members while using the antecedent-consequent approach (see Figure 36). Draco demonstrated no interest in being a prolific composer but preferred devoting time to less, yet more sophisticated material.

In one of his collaborative sessions with Ryan, Draco spent almost the entire time copying and pasting their melody and its inversion in various combinations. Their objective was to have the melody and its inversion sound together and separately at various times and incorporate two different timbres as well. Draco evidently enjoyed working with music as a mechanic, music editor, and arranger more than a composer. Draco's reference to having control over the music in one of our early interviews was an indication that composition was emerging as more of a technical process than a primarily music-making endeavor. Draco's reference to "total control" (interview, September 22, 2017) resonated with Bri's synonymous notion of composer and conductor who "controls everyone" (interview, October 12, 2017), and Jeff's idea of a composer who is "kind of like the manager" (interview, September 12, 2017).

Ryan's Response to the Composition Process and His Compositions

As I observed Ryan's response to the process and his products, some compelling evidence emerged that allowed me to make inferences about his experience as an individual composer, experience collaborating with Draco, and his value of the composition process and products.

Ryan demonstrated distinctly different responses to the individual and collaborative composition processes, as described below. As an individual composer, he generated musical ideas relatively fluidly but struggled to develop his discrete ideas into compositions and was not noticeably inspired by the results. As a collaborative composer, Ryan was often deferential to his partner but was visibly and audibly more engaged than when working alone. He appeared to enjoy the collaborative process and expressed that he appreciated the resulting product.

Being a Composer

Much like other participants, Ryan often emphasized knowledge of instruments when responding to questions about the composition process and being a composer. When I asked him if he had composed before this project, Ryan commented, “Not really, because I only have so many instruments at my house” (interview, September 12, 2017). When I asked him to elaborate on his idea of composition, one of his responses included, “As I said earlier, when I think of composing I think of an orchestra, when I think of an orchestra, I think of a lot of instruments” (interview, September 22, 2017). A few weeks later, when I asked Ryan to describe anything he thought was fun about composing music, he conveyed his appreciation of autonomy and connected it with instrument choice.

Overall, Ryan expressed and displayed insecurity more often than confidence about his qualifications as a composer. Ryan occasionally exhibited some moments of self-assurance with comments such as, "My composing ability has definitely improved" (final interview, November 9, 2017). However, these types of remarks were less frequent than expressions of doubt:

> Ryan: I don't think I'm creative enough to do more things.
> SD: So, you think creativity is important. What else might be important for a composer?
> Ryan: Creativity, easily being able to change things around in your head like, 'cuz you have to do a lot in your head rather than just placing everything down.
> (interview, October 30, 2017)

Ryan's disclosure above was an impactful moment. Ryan assumed that thinking abstractly in music was a requisite skill for successful composition and seemed to associate this skill with creativity. He seemed to be placing abstract thinking "on top rather than on tap," and assigning "a privileged position to knowledge that is abstract" (Papert & Harel, 1991, p. 10). Ryan's compelling response implied that composition required more abstract thinking than he believed he was capable of. Despite Ryan's expression of his shortcomings as a composer, in our final interview, he indicated that he got better at thinking in sound, and appeared to have gained more confidence about his ability as a composer, saying:

> I think I'm better at like, before I would go to class, I would think of a melody that I think would go with my composition. And then I'd try to put that out in notes and see how it sounds. (interview, November 9, 2017)

Although Ryan conveyed increased confidence about his composition ability in the final interview, many of his comments and much of his demeanor throughout the 10 weeks of the study displayed uncertainty. I inferred from Ryan's comments and regular periods of minimal progress that he might have had higher expectations for his compositions than he was able to produce or was overly conservative about exploring with the software. Although his productivity improved for a brief period as he created his third individual composition, Ryan spent much of his time creating short melodies and percussion patterns that he either deleted or never used in his compositions. After creating melodies and percussion patterns, he typically briefly experimented with combining them on the sketchpad and abandoned them quickly. His tendency to start over reflect a ‘planner’s’ approach more than a bricoleur, who would have continued to work with the sonic elements at hand to create something rather than tossing things out. Comments such as, “I don’t know what I should do with this part to create more melody…it’s just like going all over the place” (stimulated recall, October 4, 2017) were followed by abandoning or discarding material.

Ryan also seemed to struggle with combining two or more melodic or percussion patterns to his satisfaction. Almost invariably, Ryan would combine one or more melodies and delete one or both of them immediately, expressing dissatisfaction with the result: “I didn’t really get as much done as I’d like…I added some things and took a lot of things out…because it made it confusing” (stimulated recall, September 28, 2017): “At some points that sounded pretty good, but some just sounded like a blur” (individual composition, September 6, 2017). Rather than experiment more with the graphic notation tools to gain better results or ask for help, Ryan responded by leaving many of his ideas ‘on the table.’ For example, Figure 53 is a screenshot of Ryan’s final composition exhibiting how Ryan did not use five of his nine musical ideas. Ryan’s tendency to abandon ideas when they did not work the first time resembled the response of a planner rather than a bricoleur: “For planners, mistakes are missteps; for bricoleurs they are the essence of a navigation by mid-course corrections” (Turkle & Papert, 1990, p. 136).

I noted at one point, after the individual composition phase of the study was over that, “Ryan had some good ideas he could have developed but never did. I wish I had worked with him more. For example, his September 6 composition was a good start that he did not develop” (researcher notes, October 10, 2017). It is possible that Ryan thought more about his desired outcome and focused on avoiding undesirable results rather than engaging in hands-on exploration. One particular stimulated recall comment was somewhat telling: “I changed that right there. I actually like the end even though I just kinda put stuff in, didn’t think about it” (stimulated recall, November 9, 2017). Ryan seemed surprised that he liked something he composed even though he “didn’t think about it.”

Peer Collaboration

As a collaborative composer with Draco, Ryan was sometimes deferential and diffident, especially later in the process, when Draco’s enthusiasm for mechanical manipulation took precedence while Ryan often observed or disconnected. Draco was noticeably articulate and confident, and although Ryan experienced some successes as an individual composer, his individual composition experience did not seem to inspire much confidence. Early in the collaborative process, Ryan shared his ideas occasionally, and more so when Draco encouraged Ryan with comments such as, “I’m better at technical stuff, I think…and you’re better at actual composing…does that sound better?” (Draco, collaborating with Ryan, October 24, 2017). However, very often, Draco made decisions while Ryan observed.

Most of the time, Draco controlled the mouse, until I noticed and reminded the pair to change seats. On one occasion, Ryan reminded Draco that it was time to switch seats; however, he usually allowed Draco to do the drawing for most of the period. Draco frequently asked for Ryan's approval *after* making decisions and implementing them with Hyperscore, and Ryan usually approved. On one rare occasion, Ryan asserted himself but eventually acquiesced:

> Ryan: Wait! You gotta put another measure that way. Get over (pointing to the screen).
> Draco: No, we don't (drawing with the mouse).
> Ryan: Yes, we do.
> Draco: No, we don't!
> Ryan: Yes, we do; yes, we do; just look.
> Draco: No, we don't.
> Ryan: Let me talk to you.
> Draco: This is better; just trust me on this. Ready? Just listen.
> Ryan: I'm listening. (He hums along and applauds approvingly at the end.)
> (collaborative composition, October 30, 2017)

The above encounter was one of the few incidents of *socio-cognitive conflict* I observed throughout the 10 weeks of the study. Ryan appeared confident of his solution to the problem but ultimately deferred to Draco, who took control of the mouse and drew his solution without trying Ryan's solution. Ryan only occasionally disapproved of something Draco suggested, but even on those occasions, he ultimately deferred, ostensibly, because of Draco's confidence. Despite Ryan's deferential demeanor, he expressed that he enjoyed the collaborative process:

> Ryan: I think it was fun working with a partner.

SD: Why?
Ryan: I don't know, you had more ideas. It's not just yours. And it's more like, he knows some more things than I do.
(interview, October 10, 2017)

Ryan also stated that he preferred working with a partner more than engaging in individual composition:

> I prefer [working] with a partner because with a partner, you can learn a lot more things. I feel like, being with a partner, maybe he's a little bit better than you. Even if they're not as good, you can still learn something from them. Get a different perspective. (Ryan, interview, November 9, 2017)

Possibly, Ryan viewed Draco as a "more capable peer" (Vygotsky, 1978, p. 86), and he preferred working with someone he perceived as a more competent or confident composer: "I'm not good at finding new things like my partner, Draco. He's good at seeing the measures and all the technology parts of it." (Ryan, interview, October 30, 2017). It appeared from Ryan's consistent deference to and expressed high regard for Draco as a capable composer that he might have felt somewhat inadequate. Although the data available only allowed me to conjecture about this dynamic, it was notable that Ryan explicitly articulated how he valued peer collaboration largely because of his partner's musical and technical competence. Possibly, Ryan's high regard for Draco's musicianship and technical ability was augmented by the relatively frustrating and unfruitful experience Ryan had as an individual composer during the first five weeks of the study.

Value of the Process and Products

Based on Ryan's comments throughout the process, he evidently valued a composer's ability to think in sound, and he experienced both successes and challenges with thinking in sound. For example, during one particular interview, Ryan expressed, "I would think of something in my head, and then I couldn't put them with the other thing I was thinking of that might be really different" and, "What me and Draco did a lot is, we played it, and then afterward we would think of stuff in our heads that kept on going" (interview, November 9, 2017).

Ryan ultimately expressed confidence about his ability to think in sound, but Ryan's productivity level indicated he might have struggled with combining his ideas into a composition on the sketchpad. Ryan abandoned many of the melodies that he created and never used them in his compositions, and his compositions were short and comprised relatively few musical ideas. From this, I inferred that he felt confident about his ability to think of ideas but was dissatisfied with the results when he tried to combine them on the sketchpad. Comments such as, "I didn't really like the way they went with each other. I think I was trying to do something different, and that was not what I was thinking of" (stimulated recall, October 6, 2017) indicated that Ryan did not easily bring his abstract musical ideas to life given the concrete graphic notation tool (i.e., Hyperscore) in this situation. Ryan's challenge had implications for Turkle and Papert's (1990, 1991) assertion that a constructionist-oriented environment fosters *epistemological pluralism*—that is, bridging the abstract and concrete.

As an individual composer, Ryan's struggle with turning his ideas into more developed compositions was evident in his minimal productivity and comments such as, "I'm honestly not feeling that great right now…the beginning is pretty good…then I don’t really know where I’m gonna go from there” (interview, September 12, 2017) and, “[I’m] not feeling so good about my progress today” (interview, September 28, 2017). Ryan’s remarks often indicated that he felt he could have been more productive, and sometimes his responses indicated a lack of assurance such as, “I’m not sure how it sounds…it might sound really bad” (interview, September 22, 2017) and, “I’m not sure if this is very successful or not” (interview, November 9, 2017). Ryan’s diffidence, minimal productivity, and his apparent dissatisfaction with his final individual composition indicated that the individual composition phase of the study might not have been particularly rewarding for him, overall.

Conversely, Ryan expressed and displayed satisfaction with his collaborative composition process and product with Draco. Although he often deferred to Draco’s ideas and sometimes disconnected entirely from the process, he was also more physically animated, sang or hummed along, offered suggestions, and demonstrated that he enjoyed the process. Draco and Ryan both seemed to think of Ryan as the ‘ideas’ person as evidenced by comments such as, “Ryan has a lot of like, good melodies in his head” (Draco, interview, November 3, 2017) and, “I think that I’m better at thinking of things and coming up with melodies” (Ryan, October 30, 2017). However, and ironically, their collaborative composition did not include any of Ryan’s original melodic or rhythmic ideas. At one point, Ryan created an original melody and drew it in Hyperscore when Draco was absent. When Draco returned, he asked Ryan if he could delete Ryan’s melody, and Ryan acquiesced.

It was disconcerting to see Ryan abandon his contribution so readily because he had dedicated several minutes to create the melody. However, Ryan's consenting manner was consistent with his general tendency to defer to Draco during the collaborative process. It was evident as I observed Ryan collaborating with Draco for five weeks that Ryan was satisfied with 'playing second fiddle,' contributing his ideas intermittently and expressing approval while Draco did most of the hands-on work. It is also possible that Ryan deferred to Draco because he looked up to him as a "more capable peer" (Vygotsky, 1978, p. 86):

> SD: About how much of the time did I help you? Do you remember?
> Ryan: You definitely helped me find new instruments, and you showed me the motives. But, I think what really helped me was actually like, Draco learned a lot of things and he said them to a lot of people. I feel like whenever I asked a question, sometimes you would ask Draco what it (the answer) was.
> (interview, November 9, 2017)

Cross-Case Analysis

In the following section, I discuss the results of a close examination of the word table data I compiled during the within-case analysis process. As I examined these tables (see Tables 33–45, Appendix E referenced below), intricate networks of categories and sub-categories for each theme surfaced (see Figures 145–148, Appendix E referenced below). The networks that developed revealed additional theme-related sub-categories, which prompted me to disassemble and reassemble the data to some extent. Subsequently, I grouped participants according to their common theme-related categories and sub-categories. Ultimately, I used the network displays to compare and contrast the data within each theme-related category and sub-category, illuminate the similarities and differences among cases within categories and sub-categories, and identify discrepant or negative cases.

This cross-case analysis includes the most compelling data that emerged from the cross-case analysis process exemplifying the various theme-related categories and sub-categories within each theme. At times, the most impactful data within a particular category or sub-category coincided with data presented earlier during the within-case analysis, which functioned as a type of internal validation and called for additional emphasis in the cross-case analysis. At other times, new data emerged as the most compelling examples of resemblance or contrast between or among cases. I also noted how the theoretically-oriented variables of interest that I identified in Chapter 1 revealed themselves during my cross-case analysis of the eight participants' displayed or expressed responses to the composition process and their products.

Being a Composer

"Being a mathematician, again like being a poet, or a composer or an engineer means *doing* [his emphasis] rather than knowing or understanding" (Papert, 1972a, p. 1). The participants in the present study experienced *doing* composition rather than being taught to compose. During the 10 weeks of the study, participants exhibited a wide range of rich responses to their experiences being composers and their ideas of what composition and a composer are. The network display in Figure 145 illustrates extended relationships I identified within this thematic sphere during the constant comparison process (Link to Figure 145, Appendix E). Tables 33–37 referenced below delineate the categories and sub-categories that provided various lenses through which I examined the Being a Composer theme, along with textual evidence representing participants' responses. In the following sections, I synthesize and illustrate some of the most compelling evidence with brief anecdotes and participant quotations. Also, I identify some of the most impactful similarities and differences and discrepant evidence that surfaced among the eight participants' experiences of being a composer.

Composer and composition traits. Table 33 elucidates the primary textual evidence I drew on to supporting my findings in this section related to composer and composition traits as expressed or displayed by participants (<u>link to Table 33, Appendix E</u>). Approximately three to four times over 10 weeks, I asked each participant to consider whether they were composers. Overall, the participants expressed a lack of confidence in their composer qualifications, and their preconceived ideas about composers might have influenced some of their responses. Except for Bri, none of the participants identified themselves as composers at the outset. In two cases, the participants' responses (Jeff and Ryan) evolved from excluding themselves as a composer to including themselves with a qualified reply, and Jeff's idea evolved from one extreme to another. In other cases (Chelsea, Draco, Emily, and Josh), participants' qualified their answers consistently.

There was a wide range of preconceived notions about composer and composition traits including: (a) composers are conductors (Bri), (b) composers should not need help from artificial intelligence (Brittany), (c) the quality of the composition determines whether someone qualifies as a composer (Chelsea and Draco), (d) composers benefit from life experience and theoretical knowledge (Josh and Emily), (e) composers have innate ability (Emily and Draco), (f) composers think in sound (Draco and Ryan), (g) composers are classically-oriented musicians (Chelsea, Emily, and Jeff), and (h) composers know about a lot of different instruments (Josh and Ryan)

Bri was the only participant who initially thought of herself as a composer because, to her, a composer and conductor were synonymous. She considered herself a composer because, when composing with Hyperscore, she was essentially saying, “You be quiet, [and] you be louder” (interview, September 8, 2017), like a conductor. The other seven participants’ ideas of themselves as composers evolved, were qualified, or both.

Five participants (Brittany, Draco, Chelsea, Ryan, and Josh) expressed explicit ideas of what qualifies someone to be a composer. Brittany indicated that getting help from Hyperscore partly disqualified her as a composer, and she was only “kind of a composer because you have to know how loud and the length of notes” (interview, September 8, 2017), about which she evidently felt confident. Draco and Chelsea both indicated that the quality of a composition counts toward being a composer, saying, “A composer makes overall good music” (Chelsea, interview, November 1, 2017) and, “I’m a junior composer, but it hasn’t been a really good, nice piece” (Draco, October 30, 2017).

Ryan initially did not consider himself a composer because he felt composers should know about many instruments, which he ostensibly did not. Similarly, Josh asserted that composers have “experience on instruments so they know how to play the notes” (interview, September 18, 2017). Later in the process, and possibly influenced by Draco, Ryan focused more on a composer’s ability to think in sound than on instruments and noted that his ability to think in sound (Kaschub & Smith, 2009; Reimer, 2003; Webster, 2002b) improved.

Like Ryan, Jeff's idea of himself as a composer also evolved but underwent the most drastic change of all participants. On the first day, Jeff did not think of himself as a composer. His idea evolved into one of a composer as a manager to someone who makes music even if he is not "one of those orchestra [composers]" (interview, September 22, 2017). By the end of the study, Jeff had decided that anyone can be a composer, saying, "You don't have to have a license or like, a Ph.D. to be a composer" (interview, November 3, 2017).

Josh and Emily were both somewhat reflective and philosophical about a composer's purpose. Josh explicitly referred to trained composers who "make thoughtful pieces" (interview, October 24, 2017) and "get ideas from their lives" (interview, October 30, 2017). Josh also expressed that 'real' composers write music using traditional notation and sheet music. Similar to Josh, Emily thought deeply about composing, saying, "It's more than a system" (interview, November 3, 2017), and indicated that composers make music to inspire others. Emily also alluded to the benefit of formal training by saying she felt her ability to compose improved because of her music theory knowledge.

Draco and Emily each expressed that innate ability affects your success with composition. Emily consistently remarked how composition was a challenging and time-consuming process, except for "musical prodigies [who] can match pitch really well" (interview, September 26, 2017). Draco acknowledged the influence of both nature and nurture, saying, "You can be born with an affinity for music, but you also need to train your ear" (Draco, interview, November 3, 2017). Also, Draco explicitly indicated that innate ability to think in sound was important and something about which he was not personally confident.

Chelsea, Emily, and Jeff held similar notions of composers as classically-oriented musicians. Chelsea said, “I think of [composers as] as successful, proper people, like Beethoven” (interview, October 26, 2017). Similarly, Emily said, “I would think a composer is more kind of classical music. I wouldn’t think of Taylor Swift as a composer” (interview, September 8, 2017). Jeff qualified himself as a composer in relation to his previous idea of a composer, saying, “I’m not like, one of those orchestra composers” (interview, September 22, 2017).

Composition is hard. The idea of composition being difficult emerged as a sub-category from participants’ responses to questions about what they have learned. Seven of the eight participants in the present study comparably expressed that composition was “hard” at various times throughout the 10 weeks. Jeff was a discrepant case, who generally referred to composition as not very challenging and exuded a sense of ease about the process.

Comments such as, “It’s kind of hard to get all of this information at once” (Bri, interview, November 9, 2017) and, “I knew it was going to be really hard, but I think it’s a lot harder than I thought. It takes a lot of time, especially with so many instruments to learn” (Josh, September 22, 2017) were relatively frequent responses. In his penultimate interview, I asked Draco to expand his response on this subject:

> I have learned that there are many moments when composing can be easy, though not many, and then I also learned that there are many moments when I find that

composing is very hard, and you appreciate that there are other people like Beethoven or Mozart that already compose great pieces for you. interview, November 3, 2017)

In response to the same question, Ryan responded, “I’ve learned that it’s hard, but that’s why a lot of singers have people who come up with stuff for them” (interview, October 30, 2017) and Emily remarked, “I’ve said this many times, but composing is really hard” (Emily, interview, October 20, 2017). During Brittany’s penultimate interview, I asked her to reflect on the entire process so far, and she began by saying, “There’s so many components to composing. It’s not just like, writing out music. It’s just like, there’s more to it and it’s a lot harder, and it takes a long process” (interview, November 1, 2017)

Because references to composition as a “hard” process surfaced frequently, I looked more closely through the lens of the “composition is hard” sub-category for a potential connection or lack thereof with Papert’s (1996, 1999b) idea of *hard fun*. Although there was some evidence of hard fun, most of the time, participants used the word “hard” apart from expressing enjoying a challenge, and did not display or express Papert’s idea of learning that is fun *because* it’s hard. However, there were a few occasions when participants persisted on a challenging task and outwardly demonstrated they were enjoying themselves, which I deemed as *hard fun*.

Developing and persisting. For the eight participants, developing and persisting as a category manifested itself in two primary ways during the 10 weeks, extending compositions and fitting things together. Table 34 highlights the primary textual evidence

I drew on to support my findings in this section related to developing and persistent as expressed or displayed by participants (link to Table 34, Appendix E). Draco, Josh, and Bri expressed a desire to make their compositions longer, and all of the participants except Bri conveyed interest or concern about combining multiple sonic elements vertically and creating denser textures. Jeff was a discrepant case, who exhibited persistence uniquely from the others. Rather than developing the texture of or lengthening his compositions, he demonstrated persistence and bricolage by creating multiple versions of the same composition using multiple sketchpads. Creating variations was a relatively quick and easy process of drawing on the sketchpad; however, Jeff persisted until he created the variation he deemed best for the upcoming performance.

Extending compositions. Although I imposed no specific length requirements, Draco, Josh, and Bri intimated that creating a more extended piece was desirable with comments such as, “It’s gonna be hard to do a longer composition with the time we have” (Draco, interview, September 18, 2017), “I don’t understand how to make the long things like you do” (Josh, individual composition, September 28, 2017) and, “I made a nice little short one; I think I want to make a longer one” (Bri, interview, September 1, 2017). None of these three ultimately made a significantly longer piece than their first relatively short one. Draco indicated he would need more time to do so, and Josh and Bri seemed at a loss for how to elongate their pieces. Instead, Draco devoted more time to developing his melodies, Josh maintained a low-risk approach of creating short musical ideas and drawing modestly on the sketchpad, and Bri focused on making her short composition denser in texture.

Fitting things together. The most prominent aspect of persisting and developing was evident in participants' responses to the challenge of fitting multiple sonic elements together vertically to create harmony or polyrhythms. Seven of the eight participants conveyed either implicit or explicit concern about the challenge of fitting things together. Although Jeff never explicitly talked about the challenge of fitting things together, he stated that he preferred simpler textures with comments such as, "I really like it. It's just nice and simple" (stimulated recall, November 9, 2017) and, "It sounds bad 'cuz it's too many notes at the same time" (stimulated recall, September 26, 2017). I conjectured that maintaining simplicity was Jeff's intuitive response to the challenge of fitting multiple sonic elements together, which he achieved in one of his compositions by composing four brief, straightforward motives that organically combined well on the sketchpad.

Emily responded to the challenge of fitting things together by being persistent and creating an extensive number of sonic elements (see Figure 135). Like a bricoleur, Emily drew from her extensive number of sonic elements and treated them much like objects to think with. Emily once remarked, "It takes a long time…[and] you have to work with it and make sure everything works together well and complements each other" (interview, October 2, 2017).

Ryan left many ideas 'on the table' (see Figure 53), and often deleted ideas soon after previewing them in combination with other sonic elements. Similar to Ryan, Josh often appeared dissatisfied with the results after he layered multiple melodic motives vertically. Josh responded by taking a conservative approach, carefully layering no more than three musical ideas at one time, each lasting no more than three measures at one time.

Brittany was a discrepant case as the only composer who explicitly referenced repetitive listening as a way of responding to the challenge of fitting things together, although others could have been doing so and did not express this strategy orally. Brittany once explained, “If you just make a bunch of different melodies at once and you’re not listening, it doesn’t connect. This time I listened two or three times to what I already had to see what I needed to add, and it all fit together” (interview, September 26, 2017).

Draco’s predominantly monophonic approach was similar to Jeff, who emphasized simplicity several times in his comments. He once remarked, “The challenge for me was trying to compose a good piece that fit together well” (interview, November 9, 2017). I inferred from Draco’s comment and his process that he surmounted this challenge by layering very few simultaneously sounding sonic elements, emphasizing monophony, and devoting his time to developing the quality rather than the number of musical ideas.

After collaborating with Emily, Chelsea also commented on the challenge of getting things to fit together and suggested that the key to solving the problem might be committing more time, “I got them to sound good together over time. I feel like we had a lot longer [for the individual composition]” (interview, November 1, 2017).

Taking or needing time. While reflecting on their processes, seven of the eight participants mentioned either taking or needing more time. Table 35 elucidates the primary textual evidence I drew on to support my findings in this section related to taking or needing time as expressed or displayed by these participants (link to Table 35, Appendix E). Jeff, Chelsea, and Emily expressed that taking time was important while Ryan, Brittany, Chelsea, Josh, and Draco conveyed a need for more time. Bri was the discrepant case in this category and neither expressed nor displayed specific concerns about or interest in time.

The idea of time and quality being related was similarly reflected among responses from Jeff, Chelsea, and Emily. Jeff and Chelsea both implied or asserted that quality was related to the amount of time taken on their compositions, saying, "I like this one cuz it took more effort and it sounds better" (Jeff, interview, September 6, 2017) and, "I got them to sound good together over time" (Chelsea, interview, November 1, 2017). Emily commented, "All the time we spent, and we only have six lines. But we worked really hard on them" (stimulated recall, October 20, 2017), implying that it took time to generate satisfactory material. Emily also asserted that developing a piece is a time-consuming process, saying, "It takes a long time to get a piece to where you want it" (September 26, 2017).

Ryan, Brittany, Chelsea, Josh, and Draco comparably expressed needing more time to develop their compositions. Ryan remarked, “I think my composition could be better. If I had more time, I’d put more melody in it" (stimulated recall, November 9, 2017). Brittany twice mentioned that she would give her composition more "meat" if she had more time, meaning she wanted to develop her piece more. However, she also expressed satisfaction with her results considering the relatively short amount of time available, remarking, "It was really good that I was able to make something like this for

[only] a second composition" (stimulated recall, November 3, 2017).

Chelsea and Josh conversely conveyed that more time would have allowed them to be more methodical and experimental, respectively. Chelsea elaborated on how she would have worked more systematically developing her compositions if she had more time, saying, “If I had more time each day, I think I could go through step-by-step processes like, one, what sounds good; two, what else sounds good; and then what sounds good together (interview, September 14, 2017). In contrast to Chelsea, Josh expressed that he would have been able to experiment more if he hadn’t run out of time, saying, “I think I did it decently well. Maybe [I would] experiment with more things. Kinda ran out of time.” (Josh, interview, October 4, 2“17)

Draco was somewhat of a discrepant case because he often immersed himself for several minutes in developing one melody or a small part of his composition. Draco once remarked, "I don’t see how I could have changed it this little [amount] in that whole time...How could that have taken me this whole time?" (stimulated recall, November 9, 2017). This comment, which came on the last day of the study, indicated that Draco might not have been aware of how much time he was devoting to isolated parts of his compositions. However, this anecdote underscores how Draco responded differently to the process than the other participants by concentrating intensely for relatively long periods on isolated components of his composition. Draco’s stimulated recall above also supports the possibility that he might have experienced something like a state of flow (Csikszentmihalyi, 1991) that made him lose track of time.

Generating ideas. The challenge of generating ideas surfaced as a sub-category among six of the participants' processes (Brittany, Draco, Ryan, Jeff, Chelsea, and Emily). Table 36 illuminates the primary textual evidence I drew on to supporting my findings in this section related to generating ideas as expressed or displayed by these participants (link to Table 36, Appendix E). As the negative cases in this category, Bri revealed no particular concern about generating ideas, and Josh only briefly mentioned that working with a partner had the advantage of generating more ideas.

Although I inferred that Hyperscore's constructionist design led most of the participants to work as bricoleurs at some point, "guided by the work as it proceeds" (Papert & Harel, 1991), Jeff and Brittany were the only participants who distinctly articulated generating ideas through bricolage. Jeff once started a new composition, saying, "I'll tell you in 10 minutes what's happening once I mess around," (individual composition, September 22, 2017) and Brittany once commented, "Sometimes I really don't have anything in my mind that I can come up with, so then I just kind of have to play around" (interview, November 1, 2017). Both of these comments conveyed that Jeff and Brittany sometimes preferred to 'jump right in' and use the tools at hand without having a particular musical idea in mind.

Thinking in sound. As discussed earlier in this chapter, Draco and Ryan comparably emphasized thinking in sound in their oral responses, and in Chapter 4, I described how Emily and Chelsea exhibited evidence of thinking in sound as they collaborated to generate ideas. Contrastingly, among these four participants, Ryan and Chelsea additionally exhibited compelling evidence of reflexivity (Ackermann, 1996; Duffy & Cunningham, 1996), through which they demonstrated they were turning their sonic thoughts back on their composition process to help them learn.

Ryan described thinking of ideas before coming to class and trying them out with Hyperscore, saying, “Before I go to class, I think of a melody that would go with my composition. And then I try to put that into notes and see how it sounds” (interview, November 9, 2017). Ryan also described a process he and Draco used, saying, “What me and Draco did a lot is, we played it, and then afterward we would think of stuff in our heads that kept on going” (interview, November 9, 2017). Similarly, Chelsea thought aloud, saying, “Let’s listen, so I know how to build on it” (individual composition, September 26, 2017) and described her reflexive process in more detail at one point, saying, “I’d listen to one, then I would listen to the other, then I would listen to them together and like, tweak it” (Chelsea, interview, September 20, 2017).

Original ideas. The idea of originality surfaced among five of the eight participants’ verbal and non-verbal responses to the composition process. Bri, Emily, and Josh were discrepant cases that did not exhibit any specific thoughts or actions that indicated a particular concern about generating original ideas. For the others, the notion of originality appeared to stem from whether borrowing sample composition excerpts or loops (referred to as motives in Hyperscore) from the Hyperscore library compromised originality (Jeff, Chelsea, Ryan), or to what extent originality mattered (Brittany and Draco).

Using loops compromises originality. Jeff and Chelsea both appeared to take pride in generating their own material and not using loops. While composing individually, Jeff demonstrated that he was able to generate ideas quickly and expressed that he did not feel the need to borrow material from the Hyperscore library. When listening to others' compositions, he sometimes would ask participants if they used loops from the library and seemed proud of his ability to be original, saying, "The other people used a ton of [library] samples…I never used a sample" (interview, November 3, 2017). Similar to Jeff, Chelsea seemed proud of not using Hyperscore loops in her individual composition, saying, "I used motives as ideas, but I didn't use any motives directly in the piece. I didn't really feel like that was my work if I used a motive" (interview, November 9, 2017).

While collaborating with Emily, Chelsea unequivocally resisted using loops, saying, "I don't really want to use motives" (collaborating with Emily, October 26, 2017). Emily waited until she was in control of the mouse to explore the library. Ultimately, Chelsea acquiesced when Emily located a loop that sounded good to her. However, Chelsea suggested they vary it to make it more their own, and Emily agreed.

Similar to Chelsea, Ryan did not use Hyperscore loops during the individual composition phase and expressed his value of originality while collaborating with Draco. After devoting much time during their first two collaboration sessions modifying and inverting one borrowed Hyperscore loop, Ryan advocated for creating more original material. Ryan suggested, "[Let's] make our own ending…it should go higher instead of lower" (collaborative composition, October 10, 2017). A week later, Ryan suggested pursuing even more originality, which seemed to inspire Draco to move out of his comfort zone as a 'mechanical guy' who preferred editing existing music over creating something from scratch.

Originality matters. Comparable to Ryan and Chelsea, Brittany created only original material for her individual composition, but while reflecting on her collaborative composition with Bri expressed concern about borrowing Hyperscore motives (loops), saying, “If we had more time to expand, we would not use the motives and use whatever *we* [her emphasis] like (stimulated recall, November 7, 2017) Similar to Brittany, while reflecting on this process later in the study, Draco suggested that using loops to a great extent process compromised originality: “When you are going for that original sound, like, it’s *yours* (his emphasis), you shouldn’t use the [Hyperscore] motives (interview, October 4, 2017)

Prior knowledge, experience, compositions. Five of the eight novice composers (Chelsea, Draco, Emily, Jeff, Josh) talked explicitly about prior knowledge or experience in relation to the composition process at some point. Table 37 presents the primary textual evidence I drew on to supporting my findings in this section related to prior knowledge, experience, and compositions as expressed or displayed by these participants (link to Table 37, Appendix E).

Brittany was a relatively discrepant case because she never spoke explicitly about her prior musical experience or knowledge; however, her think-aloud data and interview responses unmistakably revealed a command of musical terminology from which I inferred her prior piano training likely informed her process. Comments such as, “I found these chords, but I don’t really like them” (individual composition, September 26, 2017) frequently surfaced, which exhibited Brittany’s fluency in musical terminology and the likelihood that she was capitalizing on prior knowledge. I considered Bri and Ryan as negative cases within this thematic area because none of their responses indicated they drew explicitly on prior experience or knowledge to create their compositions.

Chelsea, Emily, and Draco comparably demonstrated evidence of drawing on previous instrumental experience to generate ideas. As a drummer, Chelsea shared that she sometimes tried to “impersonate” the beats she heard in her mind. Emily talked of how she learned a chromatic scale from playing *Phantom of the Opera* on the piano and how she tried to emulate a chordal pattern from Burgmüller’s *Arabesque*. Emily also ostensibly responded to challenges by using her music theory knowledge, saying, "Music theory kind of helped me navigate through the program" (interview, November 7, 2017). Together, Chelsea and Emily created variations of Beethoven’s *Fifth Symphony* finale motive, the theme from *The Twilight Zone*, and a *Harry Potter* theme, another indication of responding to the process by taking advantage of prior experience.

Similar to Chelsea and Emily, Draco talked about his trumpet playing experience vis-à-vis his composition experience on four occasions with comments such as, "I play trumpet, so I don’t do chords" (interview, October 4, 2017) and, "I just realized this is like a solo section on my trumpet" (Draco collaborating with Ryan, October 30, 2017). I also noted how Draco once implied that playing trumpet and thinking in sound were mutually exclusive:

> SD: Do you ever imagine just playing the trumpet...would that work?
> Draco: No, actually it doesn’t because I kind of like prefer to hear the notes in my head and then put ‘em [on Hyperscore].
> (stimulated recall, October 18, 2017)

Although Josh did not overtly relate playing an instrument to composition like

Chelsea, Emily, and Draco, he talked about pieces he played in the school band and evidently held those as a model of what good compositions sound like, saying, "It's hard making songs like you might play at school. You know, like the books? How they all match. How they all sound good together" (interview, September 22, 2017). As he reflected back on his 10-week composition experience, Josh concluded that he was not a composer because he wasn't "composing like, writing the notes down [and] having a whole band be able to play it" (November 3, 2017).

Referring back to previous compositions surfaced in two cases, Jeff and Josh. Although Jeff never explicitly talked about using previous work as a way of developing his composition, he briefly alluded to how he combined elements of previous work while reflecting on one of his previous compositions, saying, "This was just a remix of that one and that one" (Jeff, stimulated recall, November 9, 2017). Jeff was referring to how he created five variations of the same piece, which I inferred was his method of using previous work to create new music. Whereas other participants typically created one version of each composition, Jeff created five versions of this particular composition and chose one of them as the final version for the performance.

Conversely, Josh did not draw on previous work for his individual composition, but he once 'thought aloud' about possibly capitalizing on previous work while reflecting on his earlier compositions, saying, "I could just go back to my old work, and I could combine it all. I could just go back to my old music and just like, put the same stuff, but change it from what I know now" (Josh, stimulated recall, October 18, 2017). Josh's reflection on his previous work possibly led to an impactful moment one week later when he responded to an impasse he and Jeff experienced. Josh suggested he and Jeff separate from one another and listen to their earlier individual compositions seeking out musical ideas to borrow. Evidently, Josh's reflective time one week earlier evolved into a reflexive process (Duffy & Cunningham, 1996) that helped Jeff and him identify a strategy for working their way out of a standstill. Josh's reflexivity was one of the more compelling responses to the composition process I observed. Josh reinvested what he learned from reflecting on his individual process to benefit and advance his collaborative process with Jeff.

Individuality and Collaboration

In Chapter 1, I described in detail how tenets of constructionism, cognitive constructivism, and social constructivism informed my third research question and design of the present study, which included participants working individually and collaboratively for five weeks, respectively. Participants expressed and displayed various advantages and disadvantages of having two composers generating ideas and bringing different perspectives to the process. Also, mouse control emerged as an influential factor in the collaborative process for some participants. In this section, I present the eight participants' positions by elucidating similar and contrasting responses to individual and collaborative composition.

Tables 38–40 referenced below delineate the categories and sub-categories that provided various lenses through which I examined the Individuality and Collaboration theme, along with textual evidence representing participants' responses. The network model in Figure 146 illustrates extended relationships I identified within this thematic sphere during the constant comparison process (link to Figure 146, Appendix E). In the following sections, I synthesized and illustrated some of the most compelling similarities and differences and confirming and disconfirming evidence with brief anecdotes and participant quotations.

Generating ideas while considering two perspectives. Tables 38 and 39 summarize the primary textual evidence I drew on to support my findings in this section related to generating ideas from two perspectives as expressed or displayed by participants (link to Table 38, Appendix E; link to Table 39, Appendix E). Chelsea, Ryan, Josh, and Draco expressed a preference for collaborating for a variety of reasons summarized below. Conversely, Jeff and Emily shared personal dispositions that explained their preference for working alone. Brittany uniquely noted the benefits of both collaborating and individual work, although she ultimately chose collaborative composition as her preference for reasons different from the others. Bri was a discrepant case, who expressed general dissatisfaction with the collaborative process.

Collaborating. Chelsea stated that she preferred collaborating because, "You are not the only one coming up with ideas...if you get stuck, someone else might have a better idea." (interview, November 9, 2017), and it was "cool to work with Emily [because] she has ideas, and I have ideas, and we use them together" (interview, October 20, 2017). Implicit in Chelsea's comments is that combining ideas from two perspectives can be advantageous. Conversely, her partner Emily stated that she preferred to compose alone because she tends to "just let others do it" (interview, November 7, 2017). This was consistent with what I observed—Emily regularly deferred to Chelsea in the process even though they had a congenial relationship and seemed to enjoy working together. Despite being deferential, Emily remarked that she appreciated Chelsea's exploratory nature, saying, "[Chelsea] is much more open-minded and experimental than I am" (Emily, interview, October 20, 2017).

Similar to Chelsea, Ryan stated a preference for collaborating, saying, "[When collaborating], you had more ideas. It's not just yours. And it's more like, he knows some more things than I do" (interview, October 10, 2017). Ryan also indicated that working with a partner was more enjoyable because of the learning aspect of the process, remarking, "With a partner, you can learn a lot more things. I feel like, being with a partner, maybe he's a little bit better than you" (interview, November 9, 2017). Ryan was also similar to Emily in his tendency to be deferential to his collaborative composition partner. Also, like Emily, Ryan appreciated his partner's strengths; however, Ryan *also* seemed to view his partner as a "more capable peer" (Vygotsky, 1978, p. 86), saying, "I think what really helped me was…Draco learned a lot of things, and he said them to a lot of people" (Ryan, interview, November 9, 2017).

Josh's perspective about collaborating paralleled Chelsea and Ryan's appreciation for combining ideas, saying, "I prefer [composing] with a partner because you just have more ideas between you two…It's a lot easier, in my opinion, because we could work together and get a lot more done" (interview, November 9, 2017). Similar to Ryan, Josh was noticeably more engaged and adventurous during the collaborative process than the individual process. Working alone, Josh often seemed at a loss for ideas and adopted a conservative approach like Ryan. However, unlike Ryan, who was somewhat deferential, Josh was often the motivator while collaborating with his partner.

Like Josh, Chelsea, and Ryan, Draco stated a preference for collaborating but expressed contrasting rationale. Draco emphasized the benefit of having two different *thinking styles* more than the benefit of having two people to generate more ideas. Draco indicated that he and Ryan were complementary composers as the 'mechanical guy' and 'ideas guy,' respectively.

Brittany was a discrepant case as the only participant who espoused the benefits of both individual and collaborative composition. While reflecting on the 10-week process, Brittany commented on the advantages and disadvantages of individual and collaborative composition, but ultimately favored the social aspect of collaborative composition over the benefits of working individually: "I like both [approaches] because first of all, individually it's kind of cool 'cuz you have your own ideas, not to be selfish, but you get to base it around yourself. But it's cool when you have a partner because you can have two different types of ideas and make it something you totally didn't expect (Brittany, interview, November 7, 2017).

Working alone. Emily expressed that she appreciated Chelsea's "much more open-minded and much more experimental" style (interview, October 20, 2017), but ultimately stated that she preferred composing individually. Emily's explanation of why she preferred working alone was uniquely personal, saying, "I just always worked better individually because I really don't feel that I have to double-check with someone else. I know myself more than anyone else (interview, November 7, 2019).

Similar to Emily, Jeff seemed to be particularly self-aware when expressing his preference for working alone. Both Emily and Jeff articulated an awareness of personal traits that influenced their partiality to individual composition. Emily knew that she tended to let others take the lead when collaborating, while Jeff articulated that being hands-on was important to him. As Jeff remarked, it was frustrating when "You don't get to touch [the computer] that much…it's really fun working alone. Personally, I like working alone way more" (interview, October 18, 2017).

Bri's rationale for her preference to work alone contrasted from Jeff and Emily's explanations, and stemmed more from her dissatisfaction with the collaborative process than a preference for working individually: "I liked composing independently better because like, when you're with a partner you do get better ideas, but you also have to compromise on a lot of things" (interview, November 9, 2017). Bri's detachment from the collaborative process was often apparent. For example, during their second day collaborating, Bri and Brittany experienced a lack of productivity. Reflective of her overall planner style, Bri once suggested using the piano, saying, "I feel like the piano might help us" (collaborative composition, October 20, 2017). Bri went to the piano and started playing while Brittany continued working with Hyperscore. Eventually, Brittany joined Bri, and they played piano for about three minutes, occasionally discussing their composition. Although Bri and Brittany ultimately did not generate any new ideas with the piano, this situation underscored Bri's stated impression of the collaborative process as somewhat one-sided. I inferred that Bri stated a preference for working alone primarily because she sometimes did not feel included in the collaborative process, or possibly their contrasting planner-bricoleur styles made collaboration difficult.

Contrasting styles. Regardless of their preferences for collaborative or individual composition, four of the eight composers (Josh, Jeff, Draco, and Ryan) overtly expressed awareness of their partner's contrasting style or approach. Josh, Draco, and Ryan embraced the contrast to some extent, and Jeff thought of the contrast as a detriment to the process. Bri and Brittany's contrasting styles were noticeable to me, but ostensibly not to them. Overall, Chelsea and Emily exhibited similar styles, which transitioned from being bricoleurs at the outside to planners later in the process.

Jeff once remarked that working with Josh felt like they were creating Josh's composition rather than a collaborative piece, saying, "We're kind of making, like his [composition] (interview, October 18, 2017). Jeff was noticeably less invested in collaborating than he was in his individual composition process, which may have stemmed from his preference for trial-and-error being in conflict with Josh, who "kind of likes to have things precise" (Jeff, interview, October 24, 2017). Jeff implied that collaborating inhibited intuitiveness, and sharing the technology hindered productivity, saying, "With a partner, it's really hard to share when you're composing music" (interview, November 9, 2017). Conversely, Josh interpreted their disparate styles more positively. Josh felt collaborating was more productive, expressing that he and Jeff had "more ideas" and got "a lot more done" than working alone.

Based on my observations over 10 weeks, Jeff's assertion that the collaborative process was *less* productive than his individual process was accurate. Working alone, Jeff generated ideas and compositions quickly and prolifically and was impatient with the perceived slower collaborative process. Paradoxically, Josh's assertion that his collaborative process with Jeff was *more* productive than working alone was also accurate from his perspective. Despite their contrasting styles, Josh and Jeff's collaborative composition was more complex and developed than Josh's individual composition. Ultimately, because of their contrasting approaches to composition, Josh and Jeff's polar opposite interpretations of their productivity as collaborators were both accurate from each of their perspectives.

Draco held to the idea of himself as the 'mechanical guy,' and Ryan as the 'ideas guy' as evidenced by his comment, "I'm good at the mechanics of it (composition). I'm not great at actually composing a tune in my head…With Ryan and I, I think he's very good at making up the beat in his head" (October 30, 2017). Draco also expressed that he is "much better at the mechanical thinking and Ryan is much better at the abstract thinking" (interview, October 30, 2017, Draco expressed appreciation for Ryan's ability to think in sound, and intimated that they were an effective collaborative team because of their complementary skill sets.

Although Ryan agreed to delete the only original sonic element he composed for their collaborative piece, he seemed content with being the 'ideas guy' as Draco referred to him at least twice, allowing Draco to do most of the drawing in Hyperscore. Ultimately, both Draco and Ryan expressed more satisfaction with their collaborative composition than with their respective individual compositions. To be sure, their collaborative composition was more complex and sophisticated than any of their individual compositions, and Draco and Ryan expressed mutual respect for one another, saying, "Ryan and I have a project that I am proud of, and I think sounds nice. When I was alone I was a composer, but not a very good one" (Draco, interview, November 3, 2017) and, "Draco did really good on [fitting things together] in the partner [composition], so that's why I think our composition was pretty good" (Ryan, interview, November 9, 2017).

Mouse control. Mouse control was a noticeable issue to some extent for three of the four collaborative pairs. Although mouse control might seem like a negligible issue on its face, I found that this issue resonated Ackermann's (2009) assertion:

> Papert noticed that when students were making something with their hands (such as soap sculptures), they were in a deeply engaged state, whereas when they were making something rather abstract in their minds alone (such as solutions to math problems), they were much less engrossed. (p. 89)

Mouse control also relates to Papert's (1996, 1999b) first 'big idea' of learning by doing. It is possible that less mouse control created a feeling of less 'doing' by at least one participant. Table 40 provides the primary textual evidence I used to make inferences about mouse control (link to Table 40, Appendix E).

According to Jeff, mouse control was essential. He cited mouse control as a concern a few times when I asked him to talk about composition challenges: "If you don't have a plan, you're both just fighting over the mouse" (Jeff, interview, November 9, 2017). I noted just one time when Josh asked for control of the mouse, saying, "So let me use the mouse for a sec" (collaborating with Jeff, September 18, 2017). Otherwise, Josh was generally happy to wait for his turn and did not seem concerned about mouse control overall.

I noticed that Ryan often allowed Draco to draw with the mouse, ostensibly because they had come to an implicit agreement, whereas Draco was the ‘mechanical guy’ and Ryan was the ‘ideas guy.’ Draco once admitted, “It’s kind of weird to not have the mouse in your hand” (collaborative composition, October 18, 2017). After that day, I reminded Draco and Ryan at least one other time to switch positions, and I noticed they sometimes did not follow my suggestion, or they switch and subsequently switched back. Much of the latter part of their process involved creating an inversion of their main melody, which was a painstaking, note-by-note process. Draco seemed to enjoy the process, which was technical and methodical, more than Ryan. Ryan was a supportive observer.

Mouse control was only somewhat of a concern for Chelsea and Emily. Although I noticed that mouse control affected their process to some extent, neither Emily nor Chelsea mentioned mouse control nor seemed concerned about it. Emily often relinquished mouse control to Chelsea. However, this did not appear to affect their collaborative process to a great extent, with one exception. When Emily re-gained control of the mouse at one point, she unilaterally chose to adopt a Hyperscore library motive despite Chelsea’s stated aversion to using unoriginal material.

Bri and Brittany appeared to share the mouse relatively equally, although Bri occasionally appeared to be disconnected from the process and probably controlled the mouse slightly less than Brittany as a result. However, the disconnect I noted seemed to be more about a lack of interest in sharing ideas than the physical issue of mouse control.

The Hyperscore Experience

Participants in the present study responded in myriad ways and provided impactful data about their Hyperscore experience, which sometimes included specifically Hyperscore's efficacy as a mediating tool (Duffy & Cunningham, 1996; Goldman, Black, Maxwell, Plass, & Keitges, 2012). The three theme-related categories that emerged as I partially disassembled and reassembled the data were: Learning with Hyperscore, Traditional Notation, and Agency. Six participants (Bri, Brittany, Chelsea, Draco, Emily, Josh) displayed or expressed vivid responses to learning with or getting help from Hyperscore. Six participants (Brittany, Draco, Emily, Jeff, Josh, Ryan) demonstrated evidence of relating, comparing, or contrasting Hyperscore's graphic notation system with traditional notation, sometimes attempting to reconcile the two systems. Agency-related data emerged in various ways and to varying extents among all participants' experiences. Also, the network display in Figure 147 illustrates relationships I identified within this thematic sphere during the constant comparison process (link to Figure 147, Appendix E). Tables 41-43 referenced below delineate the categories and sub-categories that provided various lenses through which I examined the Hyperscore Experience theme, along with textual evidence representing participants' responses.

Learning with Hyperscore. When asked to reflect on what or how they learned during the course of the project, six of the participants (Bri, Brittany, Chelsea, Draco, Emily, Josh) provided impactful data about Hyperscore as a tool for learning. Table 41 illuminates the primary textual evidence I relied on for this section related to learning with Hyperscore (link to Table 41, Appendix E). Bri, Brittany, Draco, and Emily similarly conveyed explicitly or implicitly how they regarded Hyperscore as an able assistant, and Chelsea, Emily, and Josh's responses each included explicit references to instruction in the context of using Hyperscore.

Technological scaffolding. The data presented in this section underscore how Hyperscore functioned as a mediating tool capable of scaffolding (Duffy & Cunningham, 1996; Wood, Bruner, & Ross, 1976) novice composers' processes, and how Emily, Brittany, and others, even if briefly or intermittently, might have experienced a phenomenon Papert (1980a) referred to as *affective computing.*

Bri was a unique and somewhat discrepant case among the seven participants included in the present theme-related category. Her responses over 10 weeks demonstrated a noticeable transformation in her self-assessment about learning, which started out somewhat skeptical. However, Bri ultimately identified some strategies that seemed to work for her, and closer to the end of the process, "Bri focused on Hyperscore tools when I asked her to reflect on her experience as a composer so far. At that point, Bri gave me a 'tour' of Hyperscore and showed me how she used the tools within the context of her composition, saying, "It makes it easier. It can help you like, use items like tools [that] you can use to make it sound better or to help you grow in your knowledge" (interview, October 20, 2017). In the final interview, Bri indicated that composing with Hyperscore improved her awareness and understanding of some musical concepts. I inferred from Bri's comments and her process that she maintained her concept of a composer and conductor as synonymous, and she might have interpreted this experience mostly as a technical exercise in learning how to use Hyperscore.

Brittany once alluded to Hyperscore as a form of artificial intelligence, saying, "You can make it (your composition) faster, that maybe a human can't do. It's like a robot. If you didn't have the software, and you were only using humans, you couldn't play all these instruments at once" (interview, November 1, 2017). Brittany also considered the Hyperscore motives library as a source of inspiration and assistance, commenting, "It's cool that…they have motives so you can kind of have an inspiration, instead of, it's all you" (interview, October 20, 2017).

Although Draco did not explicitly refer to Hyperscore as an assistant, as did Brittany, he often exhibited a process that reflected the type of partnership Brittany described when she referred to Hyperscore as a robot. During the following stimulated recall moment, I asked Draco to elaborate on a common process he used that comprised iterative humming, notating, and playing back a melody on Hyperscore:

> SD: I am wondering what came first, drawing…and then you started humming or did you hum it first?
>
> Draco: Together. I knew parts of the tune, and while I was playing it [on Hyperscore], I was able to recall it…Sometimes, I mess up [transcribing], and it's different [on Hyperscore]. Maybe Hyperscore changed it. All I know is it sounded the way I eventually wanted in my head. I may have wanted it one way, heard it another [on Hyperscore] and realized I like it that way better. (stimulated recall, November 9, 2017)

As Draco played back his melodies repeatedly on Hyperscore, he sometimes adjusted the notation to emulate his singing and sometimes adjusted his singing voice to match Hyperscore's playback instead. My interpretation of this relationship was one of reciprocity between Draco and Hyperscore. In both Draco and Brittany's cases, Hyperscore functioned as a technological partner for learning.

Similar to Draco and Brittany, during the fourth individual composition session, Emily benefited from Hyperscore's technological scaffolding ability, and her demeanor changed noticeably. After applying the 'classical' harmony setting and listening to the results, Emily became recognizably pleased. As she listened to and reflected on her composition, she commented, "It's really good, and I'm very proud of myself" (individual composition, September 20, 2017). The powerful Hyperscore algorithms that transformed Emily's dissonant harmonies into consonant 'classical' sonorities had a visible and audible positive impact on Emily.

Similar to Emily, Brittany responded with excitement when she also discovered Hyperscore's 'classical' harmony setting. Brittany expressed a noticeable gasp and smile after hearing the result, which provided an opportunity for me to engage in direct instruction.

Direct instruction. The idea of direct instruction surfaced in my conversations with four participants, along with three contrasting perspectives. Chelsea thought instruction would have been helpful in the beginning but appreciated autonomy in the end, Emily and Draco mentioned their similar need for instruction, and Josh seemed slightly conflicted about the value of instruction. One of Chelsea's first interview comments was about the lack of guidance provided by the software, remarking, "It would have been nice if it kind of told you like, it gave you a little bit of a guideline if you wanted to make some things you could build off " (interview, September 1, 2017). Although I encouraged all participants to use the Hyperscore tutorial on the first day, I did not make it a requirement. Chelsea bypassed this option and 'jumped right in.' However, by the final day of the study, Chelsea seemed to appreciate the autonomous environment, saying, "I think it's good we got to figure it our ourselves. I think that was kind of the whole process, figuring out how to use Hyperscore in your own way" (interview, November 9, 2017)

The need for instruction arose somewhat emphatically early in Emily's process and in my final interviews with Draco and Josh. At the end of the third week, Emily reflected on her process, saying, "I need to be more open-minded and get in touch with my creative side more" (interview, September 14, 2017). When I asked, "What stops you?" she asserted that she sometimes needs more direction and cannot lead herself. Similarly, Draco intimated that his mechanical tendency was incompatible with creativity, saying, "People like me… may be helped by some training" (interview, November 9, 2017). In our penultimate interview, I asked Josh what he learned about composition, and he was evidently conflicted about wanting more help or instruction:

> I wish there was a better tutorial, and I also wish there wasn't 'cuz it let you explore more. I just liked exploring it. The tutorial would have made me think that I should definitely incorporate this [specific requirement] no matter what I do in my music. (Josh, interview, November 3, 2017)

Traditional notation. The idea of traditional notation surfaced among five of the participants' responses to the composition process (Draco, Emily, Jeff, Josh, Ryan). Table 42 summarizes the textual evidence I used to draw conclusions about how traditional notation manifested itself for these five participants (link to Table 42, Appendix E). Jeff and Emily similarly noted the contrast with traditional notation and expressed appreciation for graphic notation. Jeff explicitly conveyed his dislike for sheet music and his favorable opinion of Hyperscore, saying, "It's not like when you look on sheet music.

It's so much different. I don't really like sheet music that much" (November 3, 2017). Similarly, on the first day of the project, Emily communicated contrast between traditional notation and graphic notation, saying, "It's nice not having to worry about different notes" (interview, September 1, 2017) and, "The way this is set up, it's allowed me to scrap it and then try again. When I'm trying to do it on paper [with traditional notation], it's like, oh no, it just takes longer" (interview, September 20, 2017).

Conversely, there were five either implicit or explicit responses from Ryan, Draco, Jeff, Josh, and Emily that displayed their desire to incorporate knowledge and understanding of traditional notation or reconcile their knowledge with Hyperscore's graphic notation system. At various times, it was evident that attempting to reconcile traditional notation with Hyperscore was time-consuming and unproductive and at others, relating Hyperscore to traditional notation or attempting to 'hack' Hyperscore to mimic traditional notation seemed helpful.

Hacking. Although the Hyperscore sketchpad functioned as a quasi-conductor's score, each sonic element appears as a curved or straight line, and it is not possible to discern discrete droplets representing specific pitches and note values. Evidently, Draco, Ryan, Jeff, and Josh saw this as a disadvantage and responded by 'hacking' the software to simulate a traditional conductor's score. This strategy allowed them to see and manipulate collections of droplets resembling traditional note values rather than solid lines that bore no resemblance to traditional notation.

Ryan's quasi-medieval hocket strategy (see Figure 47) was one of the earliest indications of a participant attempting to simulate traditional notation. When I asked him about his tactic, he responded, “I was just doing that ‘cuz I wanted them (the motives) to line up (stimulated recall, October 10, 2017). Similar to Ryan, Draco repurposed a percussion window to create a miniature quasi-traditional conductor’s score allowing him to see the notes for his bass line and drum beat in one window (see Figure 28).

Comparable to their respective individual strategies, Draco and Ryan, as collaborators, minimized the need for drawing on the sketchpad by combining all of their melodies in one window outside the sketchpad. This tactic allowed them to visualize their melodies in a form closer to that of traditional notation (see Figure 85). Draco explained their objective, saying, “This seems easier in my mind ‘cuz you can see it together as the whole melody” (collaborating with Ryan, October 18, 2017). Akin to Draco and Ryan’s tactic, Josh and Jeff ‘hacked’ the software to create a seven-line quasi-traditional conductor’s score. Their objective was to collectively visualize distinct pitches and rhythmic values as they occurred over time, much like a conductor referring to a full score (see Figure 144). Jeff explained their objective, saying, “It’s kind of like composing (i.e., conducting). The conductor follows along, and we can follow along easily and nicely” (interview, October 24, 2017).

Incorporating traditional notation or reconciling it with Hyperscore. The idea of incorporating or reconciling traditional notation with Hyperscore arose explicitly during three particular semi-structured interviews. Emily once indicated that she intuitively applied her knowledge of traditional notation while using Hyperscore: During our second interview, Emily equated Hyperscore droplets with traditional note values as we were discussing her composition. About six weeks later, Emily apparently became more cognizant of her connection with traditional notation and seemed to contradict her earlier preference for graphic notation, saying:

> Being that I have prior experience in music, it would almost be easier for me if it would identify what note it is. It would be helpful to see, this is a C chord, [and] this is a minor chord. (interview, October 20, 2017)

Like Emily, Josh also indicated that using traditional notation rather than graphic notation would have been preferable, and implied that *not* using traditional notation didn't feel like composing and disqualified him from being a composer. Josh's preference for using traditional notation was evidenced by comments such as:

> This website doesn't really feel like the composing, like writing the notes down [and] having a whole band be able to play it. I don't say that's always what composers do. I feel like it would have been harder to understand if these were [traditional] notes, but it would have also been more composer-ish. (interview, November 3, 2017)

Agency. In the present study, agency impacted all participants' responses to their Hyperscore experience in some manner, sometimes positively and sometimes negatively. Table 43 elucidates the primary textual evidence I drew on to supporting my findings in this section related to agency as expressed or displayed by participants (link to Table 43, Appendix E). In this section, I compare and contrast how self-expression, creativity, autonomy, and constraint manifested themselves among participants' processes.

Self-expression. The idea of self-expression emerged from five of the participants' responses and resonated strongly with Papert's (1980a) idea of *ego syntonicity.* That is, "that which is coherent with children's sense of themselves as people with intentions, goals, desires, likes, and dislikes" (1980a, p. 63). Jeff and Chelsea remarked similarly about self-expression, focusing on their personal ideas. Jeff focused on personal expression, saying, "It's fun when you get to put in your ideas" (Jeff, interview, October 18, 2017) and, "I like to make my own [graphic] designs" (Jeff, interview, November 9, 2017). Like Jeff, Chelsea focused on "putting ideas to life" and how Hyperscore enabled you to "just put it [your ideas] together and then make it sound good" (interview, October 26, 2017). In Chelsea's optimistic view, with Hyperscore, "Technically, anything is possible" (interview, October 20, 2017). Conversely, Bri was a negative case in this category, explicitly commenting on the extensive compromise that occurred during the collaborative process. Bri conveyed disappointment that a lot of her ideas did not get used.

For Josh and Emily alike, the Hyperscore experience evidently nurtured reflection *about* self-expression, although they might have struggled with being personally expressive themselves. Josh alluded to self-expression a few times with comments such as, "You get to make music that you like" (Josh, interview, October 20, 2017), but also expressed doubt about the quality of his work and ability to be personally expressive. For example, on one of the few occasions when Josh voiced approval of his composition, he immediately qualified his opinion, saying, "I like that it appeals to me, it's just that it sounds a little not professional (interview, September 22, 2017). A few weeks later, Josh intimated that he needed to make his music more personal, saying, "I need to make more thoughtful pieces…I feel like a composer makes really thoughtful music" (interview, October 24, 2017) and, "Most composers probably get ideas from their lives (interview, October 30, 2017).

Similar to Josh, Emily emphasized the potential for self-expression through composition, saying: but conveyed some doubt about her own ability to be personally expressive as a composer:

> A good composition has a meaning or a story behind it. Whenever you're writing a piece of music, you always have something in your mind of what is this symbolizing. Does it tell a story about what is happening in my life? What is happening in other people's lives? (interview, October 12, 2017)

A few weeks later, Emily shared her insecurity about self-expression, saying, "I have a hard time expressing what I am thinking musically" (stimulated recall, November 1, 2017).

Both Josh and Brittany indicated that the features of Hyperscore negatively impacted opinions of themselves as composers. Although Brittany extolled how Hyperscore helps a novice composer learn, she also suggested that Hyperscore's artificial intelligence traits might have detracted from her identity as a composer. According to Brittany, Hyperscore's functions, such as its algorithms that smooth out harmonic dissonances and its interpretation of lines and dots as musical content, were "like [having] a robot," (interview, November 1, 2017), which compromised her notion of herself as a composer. Josh also held to a notion of himself as not being a composer. In Josh's case, he believed the graphic notation approach undermined his credibility as a composer. To him, a composer writes notes down with traditional notation, and although Hyperscore "would have been harder to understand if these were [traditional] notes, it also would have been more composer-ish" (Josh, interview, November 3, 2017).

Creativity. Both Ryan and Draco suggested that their composition experience was not particularly creative, but for different reasons. Ryan indicated that technology might have inhibited his creativity, and Draco intimated that his tendency to think mechanically was somehow mutually exclusive of creative thinking. Sensing that Ryan was somewhat frustrated with the outcome of his individual composition, I asked him to express the challenge with which he seemed to be wrestling. He initially indicated that he was not good with technology and that a technically savvy composer might be more creative, saying, "The more technical you are with it, the more variety of choice, you can do more things" (interview, October 30, 2017). Ryan's comment implied that more technical ability allows someone to be more creative and intimated that knowing the Hyperscore software better would have enhanced his creativity. In Ryan's case, it is possible that Hyperscore undermined confidence in his creativity and, consequently, agency.

Conversely, Draco seemed to embrace Hyperscore as a useful tool and enjoyed immersing himself in technical processes such as editing, copying, pasting, re-arranging, and inverting phrases note-by-note. Draco held fast to the notion of himself as a 'mechanical guy' throughout the 10 weeks of the study and once likened interacting with Hyperscore to working with a microscope in a science lab. Draco also intimated that his preference for mechanical thinking was not a creative process, remarking, "[Composition] requires really creative abstract thinking. I'm good at the mechanics of it (composition). I'm not great at actually composing a tune in my head" (October 30, 2017). I conjectured that Draco ultimately viewed Hyperscore as more of an editing tool than a mediating tool fostering creativity.

Autonomy. Jeff, Brittany, and Ryan expressed appreciation for the autonomous nature of their Hyperscore experience in three distinct ways. Brittany articulated awareness of autonomy most explicitly of all participants, remarking, "You have no limits. I mean, you kind of do, but you can kind of decide on how you want your music to sound" (interview, September 14, 2017) Jeff appeared to correlate autonomy with creativity, saying, "I like the creativity. You don't have to follow a script or anything." (interview, November 3, 2017). Jeff also expressed appreciation for the absence of teacher directions and lecture, commenting, "I think it's better if you find it out yourself" (interview, November 9, 2017) and, "You get to choose your notes…and can make your own beats, not like other programs" (interview, September 22, 2017). Ryan distinguished his idea of autonomy from Brittany and Jeff by considering both the pros and cons:

> You have the freedom to do whichever notes you'd like. That's also kind of a disadvantage too because sometimes you're just too lazy to make all the notes and put them in the right places and make them sound the way you want to. Sometimes a suggestion is nice. (Ryan, interview, September 28, 2017).

Constraints. For all participants except Brittany, two specific software constraints impeded their processes to some extent, and comments about these constraints were relatively pervasive. Draco, Chelsea, and Jeff were dissatisfied with the inability to include more than eight simultaneously sounding timbres in their compositions., and Draco diverted his attention away from composition for considerable amounts of time while trying to 'hack' the software and create a multi-timbral melody window. Josh also expressed frustration with limited timbres, saying, “My whole music is screwed up. I’m messing with the colors to get this to sound right with what I want to do…I’m trying to get these two together, but I’m one color short” (Josh, individual composition, September 28, 2017).

Also, Chelsea, Emily, Ryan, and Bri expressed concern about the unrealistic quality of the General MIDI timbres and often committed extended periods to looking for new timbres. For example, Chelsea and Emily originally wanted to compose a techno piece but abandoned the idea because “nothing really sounds electric” (collaborative composition, October 6, 2017). Similarly, Ryan was also looking for more contemporary sounds, saying, “I am looking for electric type sounds” (individual composition, September 22, 2017). After stumbling upon “creepy” timbres while looking for electric sounds, Chelsea and Emily decided to proceed with a haunted house theme instead. When they could not find one of their desired creepy timbres, Chelsea asked, “Can we get that sound from the internet and put it in?” (collaborative composition, October 12, 2017), which was not an option in Hyperscore.

As a bass player, Emily exclaimed, “That’s not what bass is” (individual composition, September 26, 2017) and spent the next few minutes looking for a more acceptable bass timbre. Bri, who focused on instruments more than any other aspect of her individual composition, expressed dissatisfaction after searching for timbres, saying, “It was hard trying to find an instrument that actually matched what I wanted to do” (individual composition, September 14, 2017). Considering the amount of time diverted from composition because of Hyperscore’s timbral limitations, and participants’ expressed dissatisfaction with timbral options, I inferred that this limitation compromised productivity and possibly agency to some extent for seven of the eight participants.

Value of the Process

As I examined the data through the lenses of the previously discussed themes, theme-related categories, and sub-categories (see Figure 136), I inferred that participants in the present study valued the composition process and their products in myriad ways. Table 44 delineates the categories and sub-categories that provided various lenses through which I examined the present theme, along with textual evidence representing participants' responses (link to Table 44, Appendix E).

Within the present theme, five specific value-oriented categories stood out among various combinations of participants: affective composition (Bri, Chelsea, Emily, Josh), persistence (Brittany, Jeff, Emily, Chelsea, Draco), thinking in sound (Ryan, Draco, Chelsea, Emily) mediated learning (Draco and Jeff), and control (Bri, Brittany, Ryan, Draco, Jeff, Emily). Also, there were distinct differences among participants when I examined to what extent and how they valued their individual and collaborative compositions, which I discuss in this section.

Affective composition. In the foreword of his pioneering work, *Mindstorms*, Papert (1980a) pointed out, "This book is an exercise in an applied genetic epistemology beyond Piaget's cognitive emphasis to include a concern with the affective" (p. vii). Papert emphasized the importance of affect within the context of mathematics education and constructionism and underscored the tendency of psychologists to set up a dialectical relationship between cognitive functions and "considerations of affect, of feeling, of sense of beauty" (1980a. p. 194). To Papert, constructing knowledge must infuse the affective, and he contended that *affective computing* was essential to constructing knowledge. Bri, Chelsea, Emily, and Josh each responded in two contrasting ways, either through their demeanor (Bri and Chelsea) or by orally expressing appreciation for the affective aspect of the composition process (Emily and Josh).

For Bri and Chelsea, affect revealed itself through their demeanor. As individual composers, Bri and Chelsea had similarly effusive and optimistic responses to the process. Bri was markedly playful in her approach, and Chelsea orally expressed a carefree, process-oriented spirit. Conversely, as a collaborator with Brittany, Bri exuded a much less satisfactory experience ostensibly because her ideas did not get used to a great extent. Chelsea was also less outwardly excited during her collaborative process with Emily, but, unlike Bri, did not display a severe change of affect after moving from the individual process to the collaborative process.

As an individual composer, Bri demonstrated that the process was a highly affective experience. As I observed her in action, she seemed to wander joyfully through 'composer land' and exhibited *ego syntonicity* (Papert, 1980a) by expressing strong sentiments of like and dislike during her journey. The final several minutes of the individual composition phase epitomized Bri's composition experience as she invited anyone who would listen to revel with her in the vibrant quality of the culminating chord in her composition. Similar to Bri, although not as lively, Chelsea passionately expressed likes and dislikes but also exhibited a low-stakes demeanor by focusing more on the process than the product. Chelsea immersed herself in an exploratory process, and when the results were not what she expected, she exemplified her feeling that "it's all about the process" by optimistically and adventurously moving on to trying out other ideas.

For Emily and Josh, it was their occasionally reflective stance about the purpose of music composition that stood out. Emily and Josh were unique in the way they talked about the affective aspects of composition, although they did not demonstrate that their own composition experience was particularly affective. However, they demonstrated sensitivity to the composer's purpose and suggested that composition should go beyond the technical manipulation of sonic elements to instill the composer's personal intent. To Emily, a composition should inspire the listener, and to Josh, a composition should convey personal meaning.

Perseverance. Five of the novice composers (Brittany, Jeff, Emily, Chelsea, Draco) expressed the importance of perseverance or the benefit of committing time. Brittany, Jeff, Emily, and Chelsea explicitly articulated the benefits of perseverance emanating from taking more time to develop their pieces. For Jeff and Brittany, perseverance was associated with quality. Jeff intimated that "messing around" produced lower quality than the piece to which he committed more time and effort. Brittany beamed, when she shared her individual composition with me and described how her "long process" of two weeks paid off, obviously satisfied with the quality of her work.

Emily was unique in her view of perseverance, remarking, "It was good for me to experience how hard and time-consuming it (composing) is because then when I can't come up with something immediately, I don't completely discourage myself" (interview, October 20, 2017). Emily's comment intimated that perseverance was a generally beneficial habit. Chelsea's response was also unique because she claimed that coming up with ideas was easy, but *combining* them into a piece that sounded good required perseverance. When I asked Chelsea how she surmounted the challenge of getting various sonic elements to fit together, she stated that she merely spent a lot of time.

Draco was unlike all other participants in his outwardly declared decision to stay with developing one composition. During his second interview, Draco articulated that he wanted to focus all of his effort on one piece to "make it nice," which is what his process conveyed implicitly as well. While most of the other participants were still experimenting to a great extent in the second week, Draco had firmly decided and explicitly stated that he was going to focus on developing one piece, and he followed through with his plan. Draco brought his preference for focusing on one composition into his collaborative process with Ryan, who tacitly adopted Draco's preferred approach. I inferred from the high quality of their final product that Draco's value of perseverance contributed to their successful collaborative composition.

Thinking in sound. For Ryan, Draco, Chelsea, and Emily, thinking in sound was something about which they explicitly or implicitly displayed or expressed importance. These four participants frequently talked about hearing sound 'in their heads.' Thinking abstractly in sound combined with using Hyperscore's concrete drawing tools resonated strongly with Turkle and Papert's (1990, 1991) concept of *epistemological pluralism*. These four composers explicitly or implicitly indicated that, for them, creating music in this constructionist setting resided "on the border between an abstract idea and a concrete physical object" (Turkle & Papert, 1990, p. 131).

Ryan articulated that "easily being able to change things around in your head" (interview, October 30, 2017) was important, something he felt he personally improved during the course of this study. Although Draco thought of himself as a "mechanical guy" and claimed he was not good at thinking in sound, he exhibited that he was doing so continuously during his individual and collaborative processes. While collaborating, Draco and Ryan sometimes intentionally took time to think of melodies before composing, and one time challenged themselves explicitly to think in sound *before* notating anything on Hyperscore. Their mutual interest in thinking in sound seemed to fuel their collaborative process.

Chelsea claimed that she "always had a song in [her] head" and explained how she tried to "impersonate" drumbeats that she was thinking when notating on Hyperscore. Emily asserted she is "pretty good at setting up music in [her] head" and that she *knows* sounds but doesn't know what *makes* the sounds. As an individual composer, she recalled previous pieces she had learned, such as *Arabesque* and *Phantom of the Opera*, and while collaborating with Chelsea, recalled a *Harry Potter* melody, Beethoven's *Fifth Symphony* motive, and the *Twilight Zone* theme for inspiration. Similar to Draco and Ryan, Chelsea and Emily seemed to value thinking in sound.

Mediated learning. Ackermann (1993) once asserted, "Hands-on is not enough without heads-in and play-back," (p. 2) and argued that all three elements must be present to realize the potential of mediated experience. After observing Draco and Jeff for 10 weeks and repeatedly reviewing their processes on video, I inferred that Draco and Jeff valued experiencing all three components of Ackerman's model of mediated learning.

Jeff thrived when he worked individually and had agency over all three components of the mediated learning process. When his partner controlled the physical playback or the hands-on drawing aspect, Jeff sometimes became disinterested and disconnected, sometimes physically removing himself from the situation. Similarly, Draco orally admitted that it was difficult for him when he did not have control of the drawing process. Although he demonstrated an effort to maintain a “heads-in” disposition even when he was not in control of playback or drawing, he also once expressed that composing is fun “because you have complete and total control over it” (Draco, interview, September 22, 2017). It was when Draco was in complete control of all three aspects of the mediated experience that he seemed most engaged and sometimes demonstrated something like a state of flow (Csikszentmihalyi, 1991).

Control. Draco and Bri similarly and explicitly expressed their value of control. Draco’s appreciation for total control in the context of agency discussed above implied that being able to make all of the decisions was an exciting component of this process for him. Similarly, two of Bri’s highly animated moments occurred when she pantomimed conducting an orchestra, equating composing and conducting, saying, “A composer controls everyone” (interview, October 12, 2017) and, “*You* be quiet. *You* be louder. Everyone play the same!” (interview, September 12, 2017).

Three participants equated mouse control with their ability to make decisions. Draco and Jeff stated this position explicitly, as described earlier, and Emily expressed this implicitly by patiently waiting until she had mouse control to incorporate a loop about which she had spoken several times while not in ‘the driver’s seat.’ Also, when control was compromised by the low quality of General MIDI sounds, the number of simultaneously sounding timbres, the ability to view notation in more traditional means, or lack of control over gradual tempo and dynamic changes, participants noticed, commented, and sometimes 'hacked' the software to gain more control.

Value of Products

To a lesser degree than the composition *process*, participants expressed or displayed how or to what extent they valued their *products*. Although I reserved time during interviews and stimulated recall sessions for participants to reflect on their products, this item was sometimes last on the agenda, and time ran out. Also, Bri and Ryan were absent for two interviews, during which I asked participants to respond to their products. Despite these limitations, I was able to gather enough data through interviews, stimulated recall moments, and spontaneous comments and discussions to make limited inferences about participants' responses to their products. Screen recordings of the participants' final products are available online at https://www.youtube.com/playlist?list=PLTLPLSaYn2ssCtiX5oaS_YMK1xVp1JlvD.

Table 45 delineates the categories and sub-categories that provided various lenses through which I examined the present theme, along with textual evidence representing participants' responses (link to Table 45, Appendix E). Also, the network model in Figure 148 illustrates extended relationships I identified within the process-product thematic spheres I examined word table textual evidence (link to Figure 148, Appendix E).

Individual compositions. Josh, Ryan, Chelsea, and Draco expressed overall dissatisfaction with the outcome of their individual compositions. For Josh and Ryan, a slightly frustrated affect accompanied their remarks of dissatisfaction. Conversely, Chelsea and Draco were much more matter-of-fact when they expressed dissatisfaction. Josh, Ryan, and Chelsea each regularly expressed dissatisfaction with the outcome of their individual compositions throughout the process as well as during stimulated recall moments.

Draco seemed unconcerned about the product itself until he played back and listened during intermittent stimulated recall moments prompted by me. When commenting on his initial individual efforts, Draco focused mostly on the lack of melody in his work and the incongruity of his sonic elements. His comments about his final product consisted mostly of critical remarks such as, “How did that take me the whole time?” and, “I don’t love the ending” (stimulated recall, November 9, 2017). Also critical while reflecting on his individual composition at the end of the process, Josh remarked how his composition sounded unprofessional and how “the ideas were there, but they just weren’t developed” (interview, November 9, 2017).

During the final several minutes of the individual composition phase, Ryan was visibly frustrated with his composition and conveyed some concern about sharing his piece in public, although he ultimately agreed to allow parents to view and hear it. Similar to Ryan and Josh, Chelsea expressed much dissatisfaction with all of her products and abandoned many of her initial efforts. Conversely, however, Chelsea was never severely disheartened and continuously and optimistically emphasized the process over product. Comments such as, “It sounds bad, but that’s okay” (individual composition, September 8, 2017) were not uncommon coming from Chelsea. Nevertheless, Chelsea expressed relative satisfaction with her final composition after explaining that committing time was the key to getting things to fit together.

Similar to Chelsea, Bri demonstrated mostly dissatisfaction with the outcome of her productions with comments such as, “It doesn’t sound good. The instruments don’t match” (stimulated recall, October 2, 2017). Also, like Chelsea, Bri ultimately achieved satisfaction through persistence, and on the last day of the individual composition phase, Bri serendipitously discovered how to make patterns and use the droplet tool. This discovery led to creating a dramatic chord for her ending, and she celebrated her piece for several minutes by asking others to listen.

Jeff was the only individual composer who asked to ‘perform’ two of his individual compositions in the performance and exhibited the most pronounced confidence and satisfaction with his pieces among all of the composers. Jeff was proud of how he created several variations of the same piece and how he took time and put in the effort to develop the quality of his individual composition. Jeff preferred the simple and smooth texture of his final composition, often expressed a preference for relatively thin textures and expressed pride in his ability to maintain simplicity.

Emily and Brittany also expressed pride in their individual compositions. Similar to Jeff, Emily commented on the simplicity of her piece, saying, “It’s really simple but pretty good for my first piece” (Emily, stimulated recall, November 9, 2017). Brittany commented favorably on her two individual compositions, saying, “I thought both were pretty successful… the first one had really nice drums” (stimulated recall, October 12, 2017) and, “I’m really satisfied with this piece. If I had more time, I would layer everything. I wish I had more colors (timbres) so I could add more melody and develop it better with more 'meat'" (Brittany, stimulated recall, November 7, 2017).

Collaborative compositions. Brittany and Bri had different opinions about the outcome of their collaborative process. Although Brittany stated she was happy with the outcome of collaborative composition with Bri, she also focused on the lack of originality in their collaborative composition and implied that using loops detracted from the quality of the composition. Bri expressed little enthusiasm for their collaborative piece ostensibly because she felt her ideas "didn't get used a lot" (interview, November 9, 2017).

Although they never explicitly commented on the quality of their collaborative composition, I inferred Emily and Chelsea were satisfied with the results as they regularly smiled and laughed approvingly when they played back their creepy music and reflected on it. Also, they seemed particularly proud of their quasi-*Harry Potter* and quasi-*Twilight Zone* themes and their morendo effect to which they devoted much time.

Conversely, Jeff and Josh were not satisfied with the sound of their piece until the final few minutes on the last day. Although they were excited about their visual strategy of creating a quasi-conductor's score while they composed, they did not express satisfaction about the aural result. Their dissatisfaction with their product continued through the last few minutes on the last day, at which point they drew quickly and randomly on the sketchpad, launched Hyperscore's 'general harmony' algorithm, and expressed much more satisfaction after hearing the quasi-modern jazz result.

Draco and Ryan's approval of their final product emanated more from their generally complementary partnership (i.e., leader and follower, respectively), mutual focus on thinking in sound, and high level of productivity than explicit remarks. When reflecting on their collaborative composition, Ryan focused mostly on how he and Draco learned from each other. Ryan attributed the success of their collaborative piece to Draco's ability to create cohesiveness, saying, "Draco was really good on [connecting things] in the partner [composition], and that's why I think our composition was pretty good." Similarly, Draco acknowledged his successful partnership with Ryan, remarking, "Ryan and I have a project that I am proud of, and I think sounds nice. When I was alone, I was a composer but not a very good one" (Draco, interview, November 3, 2017).

Chapter Summary

In this chapter, I presented within- and cross-case analyses of all eight participants' displayed or expressed responses to their composition processes and products. Their responses emanated from multiple sources of data collected during the 10-week composition period. Crosstab and time-ordered matrices generated with NVivo (see Tables 31 and 32, Appendix E) helped me initially identify patterns from the bottom up "by organizing the data into increasingly more abstract units of information" (Creswell, 2007, p. 38). As in Chapter 4, I combined Erickson's (2006) Type I inductive approach to video analysis (p. 17) with the constant comparison method (Barrett, 2014; Harding, 2018; Merriam, 2014) for inductive analysis and ultimately identified four overarching themes, each with multiple related categories (see Figure 136). The four emergent themes were: Being A Composer, Individuality and Collaboration, The Hyperscore Experience, and Value, and it was through these four lenses that I completed the within- and cross-case analyses.

As an additional step in preparing for the cross-case analysis, I created word tables that proved essential to verifying categories and identifying sub-categories within the four emergent themes (see Tables 33–45, Appendix E). As I constantly compared textual evidence within and among word tables, intricate networks of categories and sub-categories surfaced (see Figures 145–148, Appendix E). As additional sub-categories emerged, higher-level categories sometimes evolved or solidified. I also used the concept dyads and theoretical framework discussed in Chapter 1 as additional lenses to underscore connections between the composers' processes and strategies and the conceptual framework for my study. In Chapter 6, I will discuss my findings and relate these findings to previous studies in my literature review, place my findings within the context of the present study's theoretical framework and my third research question, consider implications for music educators, and provide suggestions for further research.

CHAPTER 6: DISCUSSION AND CONCLUSION

The purpose of this study was to examine 7th-grade composers' strategies, processes, and perceptions and the compositions they created using music technology in a constructionist-oriented learning environment. I analyzed participants' composition strategies and their displayed or expressed responses to their processes and products in the context of a *mathetic* (Papert, 1980a, 1993) constructionist environment. In Chapters 4 and 5, I presented within- and cross-case analyses to answer my first two research questions: (a) What composition strategies and processes do participants display or express while composing music within this constructionist-oriented environment?, and (b) What are the participants' displayed or expressed responses to the composition process and the compositions they created within this constructionist-oriented environment?

Also, in Chapters 4 and 5, I referenced prominent instances in which the theoretically-supported concept dyads discussed in Chapter 1 surfaced and shed light on my third research question: To what extent and in what ways do the constructionism-instructionism, concrete-abstract, and affect-cognition concept dyads manifest themselves within participants' composition processes? In the present chapter, I review the major findings concerning each of the three research questions and relate my findings to previous literature, reflect on implications of the present study for music education, and provide suggestions for further research.

Research Question #1: Participants' Composition Strategies and Processes

The four focus composers in this present study demonstrated a wide range of composition strategies and processes, and an exhaustive discussion of these strategies is beyond the scope of this dissertation. However, Figure 94 (see Appendix D) provides a comprehensive list of the strategies and processes I observed among the four focus composers throughout the 10-week composition period. Also, various crosstab and time-ordered matrices and word tables (see Tables 2–30) illuminate the extent to which each of these processes and strategies manifested themselves as well as textual references to particularly impactful strategies and processes. In the following section, I summarize my findings concerning the first research question and elucidate connections to previous literature.

Inspiration

Participants in this study were not explicitly asked to articulate their sources of inspiration, yet they implicitly or explicitly displayed or expressed that inspiration factored into the process. This finding was unlike Kaschub's (1999) conclusion that the sixth-graders in her study could not identify particular sources of inspiration. Similar to participants in Nelson's (2007) study, Chelsea was immediately inspired to jump right in and use the concrete tools available; conversely, Draco, Emily, and Ryan took more time to get started and seemed shy of immediate inspiration.

The four focus composers in the present study found or sought inspiration for their compositions in three ways: (a) through imagery prompted by analogy, metaphor, or story, (b) by adopting a genre or style, or (c) or from listening to or recalling others' music, which resembled Kennedy's (1999) conclusion that composers relied on inspiration as a significant component of their process. Chelsea and Emily relied heavily on imagery for their collaborative scary soundscape. Draco analogized his penchant for mechanical processes to working with coarse and fine tuners on a microscope. As collaborators, Draco and Ryan drew an analogy between the form of an essay and musical structure, a finding that resonated with Carlin's (1998) observation that training in the writing process influenced musical structure.

The four focus composers gained inspiration from others' (not necessarily peers') music. Chelsea made a point to listen to Emily's compositions at least twice to "get some inspiration" and listened to Hyperscore sample compositions while "trying to get ideas." Emily drew inspiration from piano pieces she knew. Draco and Ryan listened extensively to Hyperscore loops looking for 'jazz-blues' inspiration. Chelsea and Emily listened considerably to various Hyperscore loops in search of 'creepy sounds' and gained inspiration from familiar classical and movie themes. Similarly, listening to others' music for inspiration was essential to the composers in Kennedy's (2002) study.

A surprising finding in this study was the minimal extent to which the focus composers displayed an interest in listening to each other's compositions. Although Chelsea occasionally listened to Emily's compositions explicitly to "get some inspiration," Emily, Draco, and Ryan rarely listened to others' music. I found no evidence that listening to each other's compositions was particularly influential for the focus composers. It appeared that most listening to others' compositions stemmed from mere curiosity, needing a break, or being asked to listen by another participant. I did not explicitly notice any participants borrowing techniques from each other, a finding in contrast to Tobias (2010), who noted that the high-school-age participants in his study wanted to try new techniques after listening to peers' compositions, and "create songs and tracks that incorporated elements of the music to which they enjoyed listening" (p. 434). Also, unlike Tobias's conclusion that composers demonstrated an overt desire to incorporate elements of the music to which they listened personally into their compositions, none of the composers in the present study displayed or expressed this intent.

Sonic Elements

Sonic elements emerged as a theme partly from my analysis of think-aloud data and unstructured interviews and partly from inferences I drew as I analyzed screen-captured and webcam video data. Sonic elements, or elements of music, appeared in various contexts within the literature reviewed for the present study. Carlin (1998) asked participants to describe "what elements they [were] concentrating on or featuring in their pieces" (p. 170) and explicitly drew participants' attention to sonic elements during the composition process, unlike my inductive approach through which sonic elements emerged as a theme.

I discussed particular sonic elements with participants only when they appeared to focus on a specific element during the composition process and coded their engagement with specific sonic elements primarily based on videoed observations. Contrastingly, Younker (1997) used unstructured interviews to question participants *explicitly* about their use of musical elements. Compared with participants in the present study, the composers in Younker's study similarly focused on timbre, rhythm, and tempo. However, composers in the present study focused on texture to a lesser extent than composers in

Younker's study.

Participants in the present study focused extensively on instruments and timbres more than any other sonic element. Similarly, Nelson (2007) also found that "timbre or tone color was a large part of children's creativity, either as a starting place or for musical exploration" (p. 261), and Savage (2005) found that pupils focused on timbre early in the process and structure later. Also, composers in Christensen's (1992) study "perceived music mostly as how it 'sounds,' meaning the instrumental or vocal tone quality or timbre" (p. 156),

I found that two composers (Draco and Ryan) focused more on the horizontal (i.e., temporal and melodic) aspects of their sonic elements while the other two (Chelsea and Emily) paid attention to the vertical (i.e., harmonic and polyrhythmic) implications as well as the horizontal aspects. However, these two composers only minimally overlapped sonic elements vertically, often explaining that things did not fit together and sound good when layered vertically. Hyperscore's unique design also enabled composers to notate their music curvilinearly; that is, without regard to traditional horizontal and vertical constructs related to music composition (e.g., measures, beats, staff lines). At times, all four focus composers, but primarily Chelsea and Emily, explored curvilinear processes. Figure 113 (See Appendix D) summarizes the various directional approaches to composition displayed or expressed by the four focus composers.

Similar to the directional approaches I described above, three of the studies reviewed elucidated participants' vertical and horizontal approaches. Nelson (2007) briefly discussed how participants "alternated between a vertical method of recording several tracks or parts simultaneously and a horizontal method of adding to or re-positioning at the end of the composition" (p. 239). In Nelson's study, participants composed primarily at the keyboard, not with drawing tools, as in the present study. Mellor (2008) found that all participants worked primarily vertically, completing one section of their composition at a time before moving on. Folkestad, Hargreaves, and Lindström (1998) identified two primary composition strategies employed by participants, horizontal (considering all sections of the piece while composing and revisiting various sections for various purposes), and vertical (completing each section in its entirety before moving on). My observation that novice composers were generally able to negotiate both the vertical and horizontal aspects of composition effectively was consistent with Nelson and Folkestad et al. and inconsistent with Mellor's study. Figure 113 (see Appendix D) summarizes the directional processes used for the eleven compositions produced by the focus composers. An additional direction, curvilinear composition, was unique to the present study because of Hyperscore's free-draw option without regard to traditional horizontal and vertical constructs related to music composition.

Sound and Sight

Thinking in sound or thinking *about* thinking in sound emanated from the processes, strategies, or responses of the four focus composers in this study. My finding of thinking in sound as important in this study confirmed Webster's (2002b) contention that, "Most music teachers agree that student decision-making (perhaps all of 'musicianship') is predicated on the ability to hear musical possibilities without the actual presence of the sound—being able to think in sound" (p. 17). This finding also underscored Reimer's (2003) assertion that "Composers think and do creatively by imagining possibilities of sounds coming into being and by capturing them in some way (notation, computer memory, their own memory) so they can be worked on and made something of" (p. 123).

There were two primary ways in which the focus composers in the present study exhibited thinking in sound, which I described as sound *before* sight or sound *with* sight. Sometimes, these four composers exhibited thinking in sound by humming or vocalizing a melody or rhythm before notating and describing or discussing their intended sonic elements before notating; that is, sound *before* sight. At times, participants exhibited thinking in sound while trying to transcribe a melody they had in mind, sometimes while simultaneously humming the tune or vocalizing the rhythm; that is, sound *with* sight. This strategy was consistent with Smith's (2004) observation that several of her participants sang while composing. However, she noticed this mostly with students working with lyrics, whereas none of the participants in the present study composed with lyrics. In addition to thinking *in* and *with* sound, the focus composers in the present study thought *about* sound possibilities for their compositions by listening to sample music in Hyperscore for inspiration. My observations appeared to parallel DeLorenzo's (1989) finding that participants displayed thinking in sound at different levels and in different ways, including thinking *about* music. Table 25 (see Appendix D) illuminates the various ways and extent to which sound and sight processes manifested themselves as I observed the four focus composers' individual and collaborative processes.

I assumed that participants' processes would primarily comprise thinking in sound first and capturing it with graphic notation second; that is, sound *before* sight. However, I noted instances while observing Chelsea and Emily's processes when sight (notation) came first with a noticeable lack of concern for its sonic implications. Conversely, Draco expressed that the drawing aspect of Hyperscore was not beneficial to him, saying, "My brain isn't wired to think of things in like an artistic drawing way. When I think of music, I automatically go to thinking of my trumpet" (interview, October 10, 2017). I suspect that Ryan, whose compositions often were uniquely visually appealing, also engaged in sound before sight at times. However, I had no data to confirm this suspicion. Kaschub (2009) contended that the goal of composition "is to think in sound and not just create a picture or graphic that one then listens to once the visual aspects are complete" ("Tools for Composing," para. 3). However, it was clear from my observations that at least two focus composers (Chelsea and Emily) used the graphic notation tools to engage in a sight *before* sound approach at least part of the time.

Traditional notation. Although the use of traditional notation was not an intended component of the present study, it arose organically during Emily and Draco's processes. Emily indicated that she intuitively applied conventional note values even though she "wasn't really thinking about [it]," and ultimately expressed that conventional notation would have been easier to use than graphic notation because of her familiarity with standard notation. Draco spent considerable time 'hacking' the software to emulate a traditional staff. For Ryan and Chelsea, the idea of traditional notation did not surface to a significant extent during their processes. Considering that Hyperscore's design integrates graphic notation with the option of applying standard Western notation constructs (e.g., creating measures and standard note values), and two participants' (Draco and Emily's) apparent preference for conventional notation, I found that Hyperscore is a useful mediating tool for bridging traditional and non-traditional notation.

For Draco and Emily, it appeared that traditional notation was preferable to some extent. This finding is contrary to Carlin's (1998) assertion that "traditional notation has the effect of constricting the creative possibilities during the 'making' process" (p. 263), Various other music education scholars have suggested that using non-traditional graphic notation or avoiding notation altogether may be a more effective way of engaging children in composition (Hickey, 2012; Kaschub & Smith, 2009; Wiggins, 2009). Contrastingly, Upitis (1990, 1992) and Bamberger (2013) observed children who invented notation that possessed attributes of traditional Western notation. Two other studies reviewed indicated that utilizing both graphic and standard notation might be advisable, depending on participants' preferences, as I suggested above. Younker (1997) gave participants the option of viewing their piano compositions in standard notation or in piano-roll-style graphic notation as they composed and noted that all participants viewed their compositions in standard notation while some viewed their compositions in both graphic and standard notation.

Graphic notation. Of no surprise was the vast amount of salient data that emerged concerning how the four focus composers in the present study utilized Hyperscore as a graphic notation tool. I noted two types of approaches to graphic notation by the four focus composers, exploratory and intentional. The focus composers used the graphic notation tools at times in exploratory, heuristic ways. At other times, their processes were more intentional and deliberate. The graphic notation tools in Hyperscore strongly supported both exploratory and intentional approaches and seemed to inherently encourage the participants in the present study to compose in both modes.

My finding that participants used both exploratory and intentional approaches resonated strongly with Webster's (2002b) discussion of convergent and divergent thinking as one of five components in creative thinking and with Mellor's (2008) finding that "all the composition responses [in her study] evidenced examples of both convergent and divergent thinking skills" (p. 468). Webster (2002b) asserted, "the ability to generate a number of possible solutions and then arrive at the single best" ((p. 18) is an essential component of creative thinking. Savage (2005) found that technology facilitated time and space for playful exploration and "allowed pupils to generate many sound ideas fairly rapidly" (p. 173), which was vital to participants discussed in his three-study meta-analysis. Similarly, the focus composers in the present study demonstrated that graphic notation supported playful exploration to some extent, either as individual or collaborative composers.

The use of graphic notation in the present study drew attention to its potential to *compromise* intentionality and thinking in sound at times in favor of exploration and extemporaneous drawing (i.e., sight *before* sound). The focus composers, Chelsea, in particular, sometimes used the drawing tools to draw erratically and seemingly randomly with no concern for the sonic implications. In these instances, thinking in sound was noticeably absent. Kratus (2012) asserted that "music compositions are planned [and] all compositions do possess intentionality" (p. 370) and concurred with other scholars' emphases on thinking in sound, saying, "the sounds heard in the performance of a composition generally bear a strong relationship to the sounds imagined by the composer" (p. 371). Based on Kratus's definition of composition, it might be that Hyperscore fostered *exploring* sonic elements more than *composition* at times for the focus composers in the present study.

A particularly intriguing finding was the use of various geometric approaches adopted by the four focus composers, which precipitated contrapuntal composition techniques. Composers often quickly and intuitively drew lines followed by a reflection of that line, thereby creating an inversion. Also, participants frequently translated (transposed) groups of droplets higher or lower on the grid, sometimes copying and pasting a group of droplets above or below another to create bi-tonality. Composers also created exact patterns (sequences) with droplets and drew two or more lines on the sketchpad to create parallel, contrary, and oblique contrapuntal motion.

The geometric approaches used by participants often added an element of sophistication to participants' compositions. I conjectured that composers intuitively drew patterns and lines on the sketchpad as a way to get started. Typically, this strategy seemed to involve a sight before sound strategy in which the composer quickly created an interesting drawing or pattern and might not have been thinking in sound first. However, subsequent manipulation led to immersion *in* sound as the composer listened, reflected, and manipulated these 'objects to think with.' Using geometric shapes as a starting point was akin to the type of 'anchoring' Rosenbaum (2015) observed among novice composers who used familiar tunes as a starting point. In my study, familiar *shapes* sometimes provided an 'anchor' or springboard. Table 26 (see Appendix D) provides a list of compositions that incorporated the geometric approaches I described above.

Another somewhat fascinating finding was the manner in which graphic notation appeared to promote reflection during stimulated recall moments. Participants readily and frequently referred to elements of their graphic notation and pointed to them on the screen while explaining their processes and describing their compositions to me. It was clear that droplets, lines, and grids functioned effectively as 'objects to think with' in the Papertian sense. I found the role of notation in this study consistent with Christensen's (1992) assertion that notation, traditional or non-traditional, promotes reflection during the composition process: "When students notate their compositions...they are not only recording what they think is important, they are engaging in the process of reflection; they are engaged in serious thinking about how their music works, how it is structured, and what makes it sound good" (pp. 68-69).

Considering the wide range of directional approaches to composition observed in the present study (see Figure 113, Appendix D), my findings were consistent with previous researchers' assertions about the benefits of graphic notation. For example, although the products made by the students in the present study were not rated for creativity, the diverse strategies summarized in Tables 26-30 (see Appendix D) appeared to be consistent with Auh and Walker's (1999) and Auh's (2000) findings regarding diverse strategies used in a graphic notation setting. Auh and Walker found that students composing with graphic notation used more diverse strategies and composed more creative pieces than students using traditional notation.

Although I required the students in the present study to use the provided software, Hyperscore's design provided enough flexibility that students with and without interest in notation could notate their compositions in different ways. For example, certain participants used Hyperscore grid lines to compose with traditional beats and measures, while others ignored the grid lines altogether. Similarly, at various times, composers drew on the sketchpad linearly reflecting traditional notation, and on certain occasions, composers applied a curvilinear, distinctly non-traditional approach to music notation. My finding resonated with Parry-Jamieson's (2006) conclusion that it is essential for teachers to "provide opportunities for students to compose and present their ideas in their own preferred ways" (p. 284).

In the present study, Draco talked about the importance of preservation (i.e., notation) for recall purposes, and it was clear that the ease with which participants in the present study preserved their compositions 'in writing' was an advantage. This finding resonated with Upitis (1990, 1992), who asserted that notation should be a simple act of preservation that does not become restrictive or prohibitive to the composition process and Emmons (1998), who contended that preservation plays an equal role in a three-part composition cycle.

The focus composers in the present study created music quickly, easily, and unencumbered by the limitations of traditional notation. Because of Hyperscore's accessibility and user-friendliness as a graphic notation tool, it appeared to function as the type of shared notational system to which Bamberger (2005) referred when she acknowledged the value of the security provided by such systems that allow musicians to communicate. However, Bamberger also warned of "the ever present danger of notational imperialism" (p. 21). It is possible that the graphic notation environment in my study encouraged the perception that notation is an essential aspect of composition.

Participants in the present displayed that they were able to successfully compose music without formal training or knowledge of notation or music theory, and, because of the software's design, were able to "engage with music conceptually as music rather than spend all of their time simply learning to manipulate the parameters of the software" (Louth, 2013, p. 151). Louth contended that using music technology to bypass theory and standard notation remains controversial among educators. While some educators view the use of such technology as "betraying pedagogical obligations," others believe that music technology can be "liberating and even democratizing" (p. 144). Gall and Breeze (2005) contended that technology leads to "the democratisation of music" (p. 430). The user-friendly digital graphic notation tool used by novice composers in the present study perpetuated the tension between democratization of composition and composition as something that "specially talented people do" (Paynter, 2000, p. 25).

Participants' application of traditional composition techniques discussed in the next section exemplifies the tension underscored by Louth (2013). Although participants displayed the ability to apply composition techniques used by professional composers, the opportunity to *instruct* students *about* what they were doing eluded me several times. On the other hand, this particular constructionist environment and use of Hyperscore technology "afforded the students the opportunity to escape the ideology of traditional notation and theoretical assumptions" (p. 151) in favor of intuitive composition.

Traditional Composition Techniques

A particularly impactful finding that emanated from the data in the present study was the composers' intuitive application of relatively sophisticated traditional composition techniques in the absence of direct instruction in composition. Similarly, Younker (1997) found that of the nine participants in her study, two exhibited strategies similar to those of professional composers. Ladanyi (1995) also concluded that participants' composing processes resembled those described by numerous professional composers, and Wise (2016) similarly noted that "students with little or no formal understanding of traditional notation and theory, or with little or no experience of formal instrumental tuition, [were able] to create sophisticated and complex pieces" (p. 291).

Table 27 (see Appendix D) enumerates twenty discrete techniques I observed and deemed 'traditional' due to their frequent use by formally-trained composers. In addition to the six aforementioned geometric approaches (see Table 26, Appendix D), four other 'traditional' approaches were prevalent: contour, motive-making or borrowing, form, and repetition. The focus on motive-making was probably due to Hyperscore's design, which encourages composing short melodic and rhythmic 'loops.' Therefore, the present study *cannot* corroborate other research (e.g., Daignault, 1996; Kratus, 1989; Wiggins, 1994), concluding that novice composers intuitively composed with motives. However, the focus composers' emphasis on contour, form, and repetition in the present study seemed intuitive and unbiased by Hyperscore's design.

Contour, form, and repetition. Participants in this study manipulated contour much more than other aspects of their compositions, which is consistent with Davidson and Scripp (1988), who found certain participants gravitated toward notating contour rather than rhythm. Hickey and Lipscomb (2006) noted that compositions going beyond “the standard template provided by the instructor” (p. 107) were partially different because of undulating contour. Similarly, although I provided no template, the students in the present study distinguished themselves through their focus on contour.

Seven participants, all of whom stated they had *some* previous formal musical training or experience creating original music, demonstrated that incorporating structure and form in their compositions was a relatively innate process. The one participant in the present study (Bri) who claimed she had *no* formal musical training and no previous experience creating original music created music with relatively coherent form. Also, one collaborative pair (Draco and Ryan) created a highly structured and symmetrical piece but never orally articulated such a plan (see Table 20). This finding was consistent with Barrett (1996), who concluded that participants demonstrated a considerable grasp of structure, and children with little musical experience or training were able to create form in their compositions. Similarly, Nilsson and Folkestad (2005) found that “young children without formal musical training are able to create music with form and structure” (p. 25). Other researchers (e.g., Burnard, 2000; Kratus, 1989; Upitis, 1990) have expressed similar observations that novice composers can incorporate form and structure into their compositions.

Repetition as a compositional device surfaced to varying extents among the four focus composers in the present study, similar to Christensen (1992) and Nelson (2007), who identified repetition and revision as an emergent theme in their case studies. The use of repetition by three of the four focus composers in the present study also resonated with Swanwick and Tillman's (1986) Speculative and Vernacular stages in which repetition becomes more prevalent in children's composition processes after age 10.

My finding that four participants used repetition as a compositional device reflected findings in two particular studies I reviewed. Kratus (1989) asked novice composers to complete highly structured tasks suggested, "learning to compose a replicable song requires an understanding of the importance of repetition of musical ideas" (p. 18). Although participants in the present study were not asked to replicate their songs and their tasks were unstructured, they demonstrated to some extent an innate sense of repetition as a valuable compositional device. Daignault (1996) questioned the validity of highly-rated compositions such as those in Kratus's (1989) study when participants displayed compositional strategies such as repetition and development on highly structured tasks that do not "provide the required space for exploration and divergent musical thinking" (p. 28). Conversely, participants in the present study employed repetition as a compositional device on completely *unstructured* tasks in this constructionist-oriented environment, which also revealed evidence of both convergent and divergent strategies, as discussed earlier in this chapter.

Intuition

Although my study did not examine the extent to which participants *learned* formal musical concepts and techniques, evidence showed that the four focus composers in the present study intuitively applied formal techniques while composing without direct instruction. Similarly, Downton (2105) concluded that “giving students, especially those with no formal training or lessons, the opportunity to make music starting out at a mid-level structure allows them to discover and learn formalisms (e.g., pitch) that are important” (p. 158). Likewise, Jennings (2005) found that Hyperscore and its constructionist underpinning appeared to facilitate interaction with complex musical concepts and allowed participants to express their intuitive understanding of these concepts despite their limited musical vocabulary and somewhat early stage of musical development.

The findings described above resonated with Bruner’s (1977) assertion that “any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (p. 33). Although the present participants were not explicitly taught how to compose music, the design of the study appeared to be “an intellectually honest form” through which they could express their intuitive understanding of complex musical concepts.

The ways that the focus composers in the present study intuitively applied a wide range of formal techniques without instruction resonated with Bamberger’s (2003, 2005) research centered on the role of intuitive and formal music ‘knowing’ in music education and music composition. The constructionist-oriented environment in this study fostered intuitive composition while affording me opportunities to scaffold, provide direct instruction as appropriate, and help composers formally understand what they created. This finding also resonated with three other scholars’ assertions about the role of instruction and the instructor during composition activities. Berkley (2004) contended that placing practice before theory and interjecting theoretical knowledge to complement what students discover on their own can be an effective approach to teaching music composition. Similarly, Barrett (2006) contended that "teacher provoked description and explanation and prompted self-analysis" can help novice composers develop their musical intuition. Paynter (2000) asserted, "By listening attentively to the processes in a piece and commenting on what appears to be happening, a teacher can help pupils to understand the nature of what they have created intuitively and to build upon that experience" (p. 9).

Research Question #2: Participants' Displayed or Expressed Responses to the Composition Process and Their Products

During the 10 weeks of the study, the eight participants exhibited various compelling responses to their composition experience and the products they created in this particular environment. Figure 136 (see Appendix E) elucidates the themes, categories, and sub-categories that emerged as I analyzed the eight participants' displayed or expressed responses to their processes and products. The word tables in Tables 33–45 (see Appendix E) and network displays in Figures 145–148 (see Appendix E) include textual examples and various relationships I identified as I analyzed the eight participants' displayed or expresses responses to their processes and products. Also, the time-ordered and crosstab matrices in Tables 31–32 (see Appendix E) illuminate the extent to which each category and sub-category manifested itself in each of the participants' processes. In the following section, I briefly summarize my findings related to the second research question and explicate connections to previous literature both inside and outside the field of music education.

Being A Composer

Composer and composition traits. Participants in this study exhibited a wide range of responses to their experiences being composers and their ideas of what composition and a composer are (see Figure 136). Overall, and contrary to Bolton's (2008), Guthmann's (2013), and Huang and Yeh's (2015) findings, the participants in the present study expressed a lack of confidence in their *qualifications* as composers, and a strong sense of composer identity was generally not the case in my study. The closest I observed to a composer identity flourishing in the present study was Draco's self-ascribed identity as a 'mechanical guy,' which he adopted early on and applied continually to his process over the 10 weeks of the study. Also, participants' preconceived ideas about composers might have influenced some of their responses to being a composer.

Typically, participants qualified their responses by referencing factors such as getting help from Hyperscore as artificial intelligence (Brittany), knowledge of instruments (Ryan and Josh), the quality of the composition (Draco and Chelsea), and one's ability to think in sound (Draco and Ryan). Three participants (Chelsea, Emily, and Jeff) conveyed similar notions of composers as classically-oriented musicians, and two participants (Draco and Emily) each expressed a sense that innate ability affects your success with composition. Seven of the eight participants (all except Jeff) referred to the composition process as "hard" to some extent when I asked them to talk about what they learned, which was inconsistent with Huang and Yeh's (2015) finding that virtually all participants who used graphic notation technology to compose "realized that music composition was simpler than they had imagined" (p. 82).

Participants' preconceived notions of composition and their references to composition as "hard" might have affected participants' concepts of themselves as composers. This finding paralleled Brandes's (1992) study investigating participants' personal construction of their image of science. Brandes concluded that school science tends to promote science as the realm for an elite few and that children increasingly feel more like science outsiders even as their scientific thinking becomes more sophisticated. Considering the dubiousness expressed by participants in the present study about being composers, it is possible several of them left this experience feeling no more like a composer than before. One participant (Bri) was a discrepant case because she equated composition with conducting and described herself as a conductor and ostensibly a composer.

Developing and persisting. All of the participants in the study expressed interest in developing or extending their compositions by creating denser textures or lengthening their pieces. However, participants were minimally successful overall doing so as evidenced by the generally sparse textures applied in most of their final products, and their practically unanimous expression that vertically fitting together multiple discrete sonic elements was challenging. This finding was consistent with Mellor's (2008) finding that the "fit, what is liked, what sounds right, what sounds most idiomatic, what works musically, what sounds good together" (p. 466) were primary concerns for novice composers. Relatedly, one of the four ways in which the participants in Burnard's (2006) study constructed meaning as composers was based on "when it fits together to make a proper piece" (p. 125). Also related was Nelson's (2007) study examining children's composition processes using technology. Nelson concluded that "working with the software allowed children to decide…what they liked and how to develop a composition" (p. 263), as was the case in the present study. However, unlike Burnard and Nelson's participants, those in the present study displayed or expressed much uncertainty about *how* to develop their compositions.

My above finding also corroborated Bolden (2009) and Guthmann (2013) to the extent that participants expressed or displayed a desire to revise their compositions, but participants in the present were only minimally successful in the revision process. Participants in my study often left ideas 'on the table' (e.g., Bri and Ryan) or resorted to sparse textures or minimalism (e.g., Bri, Chelsea, Draco, Josh, Ryan) when it became difficult to develop their compositions. Bolden asserted that participants are naturally inclined to revise their compositions and noted that the "diagnose and fix technique [that] figured prominently as a means of assessing compositions-in-progress and providing feedback" (p. 149) was effective in his study. Guthmann found that students "can work independently of their music teacher to produce a final product and one that reflects revisions" (p. 300). It might be that more teacher intervention, as described by Younker (2003), and peer interaction during the individual composition phase, would have fostered more development and persistence.

My finding that participants struggled with developing their compositions also corroborated Savage (2005) who concluded that "pupils were often quick to produce sound ideas and seek approval for them, but then had to be encouraged to develop these further before moving onto the next stage" (p. 177). Savage conjectured that "an element of uncertainty within the composition process was the cause of this phenomenon" (p. 177). Savage's assertion is consistent with the general lack of confidence in being a composer that I noted among participants in the present study, a finding I discuss further later in this chapter.

Taking or needing time. Seven of the eight participants (all except Bri) expressed or displayed that taking or needing time impacted their processes and products. Three participants (Jeff, Chelsea, Emily) indicated that taking time affected quality, and five participants (Ryan, Brittany, Chelsea, Josh, and Draco) conveyed they needed more time to develop their compositions, not necessarily to improve the quality. Also, one participant (Draco) appeared to occasionally exhibit a state of flow (Csikszentmihalyi, 1991) and expressed he might not have been aware of how much time he was devoting to isolated parts of his compositions.

Allowing time for exploration, and developing compositions is a common theme in the literature on novice composers' processes (e.g., Bamberger, 2003; Carlin, 1998; Hickey, 1997, 2003; Menard, 2015, Nelson, 2007; Stauffer, 2001, 2002; Younker, 1997), and the present study corroborated other researchers' conclusions about the importance of allocating time for composition. Bamberger (2003) emphasized facilitating unconstrained composition without time limits, and also proposed that "a computer can play a special role as a resource for inquiry and invention. But it should be a place where [composers] can work at a pace and within a conceptual space where they feel secure" (Bamberger, 2013, p. 202).

Allowing participants to compose at their own pace was part of the design for the present study. Participants in the present study engaged in approximately four hours of unconstrained individual composition and the same amount of time for collaboration. Nevertheless, seven of the eight participants expressed time as a concern. Similarly, participants in Menard's (2015) study overwhelmingly agreed that there was not enough time to develop musical ideas, and Stauffer (2001) underscored that "children need time to explore and become familiar with the medium, time to find their own strategies and gestures, and time to practice using them" (p. 18). In Nelson's (2007) study, the two target composers demonstrated a need for time *with* composition and, ostensibly, time for exploration, and developing their compositions.

Participants in the present study expressed that they needed or took more time to make their compositions *better* or *longer* or to find ways to make their sonic elements *fit together*. This finding is somewhat different from Nelson's (2007) and Kennedy's (2002) findings that composers focused on time for thinking, procrastinating, and revising. However, the idea of needing time to make things *fit together* also appeared in Stauffer's (2001) study in which the composer developed "an increasing awareness of the qualities of musical sounds and their functions within their compositions" (p. 13). Contrastingly, Guthmann (2015) found that students wanted to spend *less* time revising their compositions and more time moving forward with new ideas, and probably only took the time to revise because they knew their revisions were the main focus of the study.

Thinking in sound. In my above response to the first research question, I discussed how thinking in sound manifested itself as a process among the four focus composers' processes. In terms of their responses to the process, these composers also *talked about* how thinking in sound was either essential or organic. Two participants (Draco and Ryan) expressly articulated the importance of being able to think in sound as a composer, and two (Chelsea and Emily) claimed that they always had a song in their head (Chelsea) or were good at thinking in sound (Emily). One participant (Ryan) expressed that his ability to think in sound improved throughout the project. Conversely, one participant (Draco) commented a few times that thinking in sound was abstract and not a strength for him. However, he unambiguously demonstrated thinking in sound continually in my analysis of his process (see Chapter 4). Similarly, Kaschub's (1999) students described their composition process as "thinking up ideas in their heads" (p. 189), and the composers Wiggins (2003) interviewed talked about knowing the music in their heads before trying to play it on instruments or having an idea and then persisting until they succeeded.

Originality. Originality arose explicitly as a concern for five of the eight composers (Brittany, Chelsea, Draco, Jeff, Ryan). This concern stemmed from whether borrowing sample composition excerpts or loops from the Hyperscore library compromised originality (Jeff, Chelsea, Ryan), and to what extent originality mattered (Brittany and Draco). In the literature reviewed, many scholars have discussed or investigated originality as a component of the creative composition process (e.g., Auh, 2000; Hickey, 1995; Hickey & Lipscomb, 2006; Smith, 2004; Mellor, 2009; Ward, 2008). However, in only one study I reviewed did participants *talk about* originality or its importance. Similar to the five present participants mentioned above, Mellor's (2009) participants were dubious of the originality of music they created using loops.

Prior knowledge and experience. Five of the eight novice composers in the present study (Chelsea, Draco, Emily, Jeff, Josh) talked explicitly about prior experience or knowledge in relation to the composition process at some point. Also, a desire to refer back to previous compositions as a composition strategy surfaced in two cases (Jeff and Josh). Three participants (Chelsea, Draco, and Emily) comparably demonstrated evidence of drawing on previous instrumental experience to generate ideas, and one (Josh) referred to his experience playing in the school band as he formulated his concept of composition as a process and a product.

The composers in the present study used previous instrumental experience or compositions created during the project as a way to *generate ideas*. This differed from Christensen's (1992) composers who wanted to create something unique but not peculiar and therefore had to go about retrieving previous knowledge to *make sense* of their musical ideas. The participants in my study were similar to Kaschub's (1997) and Nelson's (2007) sixth-graders whose compositions were directly influenced by previous experience. Nelson (2007) concluded that the *constructivist* approach in her study allowed "for personal ideas and previous knowledge to be incorporated during composing" (p. 307), which was consistent with the *constructionist* approach in the present study.

Two participants (Chelsea and Emily) responded to their challenge of creating creepy music by recalling familiar melodies (i.e., Beethoven's *Fifth Symphony* motive, *Twilight Zone* theme, *Harry Potter* motive) to enhance their composition. Likewise, one participant (Emily) explicitly articulated how her previous knowledge of piano pieces helped her to persist "When I can't come up with something immediately" (interview, October 20, 2017). Two participants (Jeff and Josh) reached an impasse while collaborating and solved their problem by referring back to their previous individual compositions for ideas that resolved their problem. Similarly, 'anchoring' (i.e., reusing previous knowledge) was one of the ways participants in Rosenbaum's (2015) study moved from the unfamiliar to the familiar. Rosenbaum asserted that anchoring was analogous to Piaget's concept of moving from assimilation to accommodation.

Participants' (Chelsea and Emily) use of familiar melodies was also similar to the way Stauffer's (2002) composers used familiar melodies as starting points for their compositions and Pitts and Kwami's (2015) participants layered pre-existing themes with new sonic elements. Four participants (Draco, Ryan, Chelsea, Emily) expressed or displayed the importance of thinking in sound which, in addition to helping students synthesize earlier learning about musical elements, was consistent with Chen's (2012) finding that a technology-supported composition process "helps [composers] 'think in sound' and feel the expressiveness of their own creative work" (p. 159).

Two participants' (Bri and Josh) stated they had taken no *private* lessons and had not previously experimented with creating music. Like participants in Downton's (2015) study, I found that "even without prior knowledge of a domain (e.g., music) intuitions help[ed] guide thinking during the construction of a meaningful artifact" (p. 105) for Bri and Josh. However, their *responses* to the process contrasted with one another. Bri's individual process was a joyful journey through 'composer land,' whose collaborative process was contrastingly not as rewarding. Inversely, Josh expressed increasing frustration and dissatisfaction as an individual composer. Although Bri and Josh were both able to intuitively create a composition with little or no formal musical training, respectively, and no previous experience creating music, their inclinations toward individual and collaborative composition ultimately differed. The finding here is that individuality and collaboration impacted the two composers with the least prior musical experience differently.

Individuality and Collaboration

Four of the eight participants (Chelsea, Draco, Josh, Ryan) stated a preference for peer collaboration over individual composition explicitly, three (Bri, Emily, Jeff) expressed a preference for working alone, and one discrepant case (Brittany) claimed to enjoy both approaches and commented on the challenges and advantages of each. Three participants (Josh, Chelsea, and Ryan) focused on the advantage of having two people generate ideas, sometimes mentioning quantity (e.g., “You have more ideas between you two”) and sometimes referencing quality (e.g., “Someone else might have a better idea”). One composer (Draco) preferred collaborating but for a different reason than the others emphasizing the benefit of having two different *styles* of thinking more than the benefit of having two people to generate more *ideas*.

My findings about individuality and collaboration were somewhat consistent with Kaschub’s (1999) and Tobias’s (2010) respective findings. Kaschub’s participants indicated a preference for collaborating over working alone regardless of whether the task was prompted or unprompted by the teacher and reported higher general interest levels than individuals. In my study, all tasks were unprompted. Kaschub's participants reported multiple ideas emerging from collaborative processes, which was corroborated by four of the eight composers (Bri, Josh, Chelsea, Ryan) in my study. These four composers all talked about the advantage of having two people to generate more ideas. Also, similar to my observation, Tobias (2010) observed that eight of 11 participants preferred collaborating when given a choice. In my study, one participant (Brittany) was a discrepant case, who articulated the benefits of both individual and collaborative composition. However, when I asked Brittany on the last day if she had to choose one or the other, she chose collaboration, saying, "It's fun to be able to bounce ideas off each other" (interview, November 7, 2007).

In contrast to Kaschub (1999) and Tobias's (2010) findings were two composers' (Emily and Jeff) assertions that working alone was more conducive to generating ideas. Emily cited her tendency to defer to her partner as her reason for preferring individual work, and Jeff felt like he was merely an assistant when working with Josh, especially when he did not have mouse control. Also, one composer (Bri) lamented that the collaborative experience was not favorable because her ideas did not get used. These three composers' preference for working alone was more consistent with Hickey (1997) who asserted that the computer may be "the best tool in which to set optimal creative music making conditions" (p. 65) and that the ability to work alone at one's own pace may be an effective way for novice composers to display their creative potential. My finding that three of the eight composers preferred individual composition corroborated Guthmann (2013), who also concluded that "some students prefer to be left alone to compose" (p. 314).

Planning and 'diving in' surfaced among individual and collaborative processes alike, which contrasts with Kaschub's (1999) conclusion that individuals tended to be planners and groups conversely appeared to have more "courage to dive into the task" (p. 151). As individuals, two composers (Josh and Ryan) were relatively circumspect planners in their approaches, as evidenced by their conservative approaches to composition. One composer (Draco) was immersed primarily in technical music editing and was a distinctly intentional planner as a result. One composer (Bri) tended to be less exploratory, leave ideas 'on the table,' and start over like a planner. The other four individual composers (Brittany, Chelsea, Emily, Jeff) dove in and displayed risk-taking at the outset and throughout, which was possibly nurtured by the accessible software design and the open-ended nature of the project.

As collaborators, two composers (Josh and Jeff) struggled to reconcile their contrasting 'planning' and 'diving in' styles, although Josh evolved into a more adventurous composer and expressed appreciation for Jeff's style. Two other composers' (Draco and Ryan) similar 'planning' styles appeared to benefit their process. Contrastingly, two composers' (Bri and Brittany) contrasting styles may have impeded their collaborative process. Two composers (Chelsea and Emily) exhibited a similar shift from more exploratory as individual composers to planners while collaborating, possibly because of the programmatic nature of their composition. Similar to what I observed in the present study, Burnard and Younker (2004) observed a range of styles from organized planners to those who made few decisions in advance.

As collaborative composers, participants demonstrated relatively little explicit disagreement. Two participants (Ryan and Emily) tended to defer to their respective partners when two opposing ideas surfaced. At one point, two participants' (Josh and Jeff) contrasting styles (planner and bricoleur) created an impasse, which Josh resolved by suggesting they look to their individual compositions for ideas. Kaschub (1997) found that "collaborative efforts allow students to challenge each other's ideas and to experiment with compositional decisions which may be questioned or criticized by their peers" (p. 27). In contrast, I found relatively little evidence of students challenging, questioning, or criticizing others' work. Kaschub also observed collaborative composers in large groups who struggled to reach consensus and sometimes expressed hurt feelings when their ideas were not used. In the present study, one of the four collaborative pairs (Bri and Brittany) exhibited a similar experience when one composer's ideas were not used.

The individual composers in the present study rarely asked peers for suggestions and opinions of their work. Listening to others' compositions usually stemmed from mere curiosity, needing a break, or being asked to listen by another participant; however, suggestions and opinions rarely emerged during these infrequent exchanges. Contrary-wise, in her review of literature on children's compositional processes, Wiggins (2007) asserted, "At the very least, [student composers] invite peers' suggestions and opinions of their work in progress" (p. 462).

Two collaborative pairs (Chelsea and Emily, Draco, and Ryan) effectively dialogued to collaborate on their compositions and extend each other's ideas, although two (Emily and Ryan) were often deferential to their partners. Contrastingly, one pair's (Josh and Jeff) conflicting styles impeded building on each other's ideas, and another's (Bri and Brittany) exhibited no evidence of developing one another's ideas. This finding was somewhat consistent with Hewitt (2008), who concluded that 10- and 11-year-olds were able to develop and extend both their own ideas and those of their partner.

Two of the four collaborative pairs in the present study worked well together despite one person being more deferential, which was only somewhat consistent with Guthmann's (2013) finding that "dominant/subservient student pairing works well in collaborative composing" (p. 314) was my conclusion that, in the present study, Emily and Ryan's deferential nature appeared to complement their partners' (Chelsea and Draco, respectively) assertiveness. However, in the other two collaborative pairs, Jeff and Bri's deference to their partners led to feeling like they were working on their partner's composition or their ideas were not being used, respectively.

Mouse control affected involvement among three of the four collaborative pairs to some extent. Two composers (Jeff and Ryan) sometimes became noticeably disconnected from the process when not controlling the mouse. In another pair, one composer (Emily) tended to let her partner control the mouse, possibly because of her self-ascribed tendency to "just let others do it." Despite Emily's repeated and ignored requests to use loops while not controlling the mouse, she and her partner engaged in reciprocal idea-sharing overall regardless of who controlled the mouse. Hewitt (2008) noted that mouse control seemed not to affect developing one another's ideas, which was the case for two of the four collaborative pairs in my study.

The Hyperscore Experience

Hyperscore, as a mediating tool, manifested itself among participants' processes in three ways. Six of the eight participants (Bri, Brittany, Chelsea, Draco, Emily, Josh) expressed their ideas (either positive or negative) about Hyperscore as a tool to help them learn. Five participants (Emily, Ryan, Draco, Jeff, Josh) related, compared, or contrasted Hyperscore's graphic notation system with traditional notation, sometimes attempting to reconcile Hyperscore's graphic notation approach with traditional notation. All eight participants' responses to their Hyperscore experience impacted agency in some manner, sometimes positively and sometimes negatively.

Learning with Hyperscore. Three participants (Brittany, Emily, Draco) demonstrated regard for or benefit from Hyperscore as a "partner in cognition…flexible and inviting enough to encourage exploration" (Goldman, Black, Maxwell, Plass, & Keitges, 2012, p. 334). These three participants responded favorably to Hyperscore as a type of technological scaffolding. This finding corroborated Ladanyi (1995), who concluded that technology was a useful tool for allowing students to construct individualized methods of learning, with minimal intervention from the teacher. Corroborating Ladanyi's conclusion. These three participants' experience with technological scaffolding also resonated with Savage and Challis's (2001) conclusion that technology empowered students by giving them a way to express ideas that did not rely on traditional instrumental skills. One participant (Brittany) noted that Hyperscore was a form of artificial intelligence and likened it to a musical robot. Two composers' (Brittany and Emily) affect changed noticeably when they discovered that Hyperscore's algorithmic functions could help minimize dissonance in their compositions. One participant's (Draco) 'partnership' with Hyperscore as a mediating tool was exceptionally dynamic. As he continually hummed his musical ideas, he sometimes adjusted Hyperscore graphic notation to emulate his singing and sometimes adjusted his singing voice to match Hyperscore's playback. My finding that three participants benefited from Hyperscore as a type of technological scaffolding corroborated Huang and Yeh (2015), who concluded, "Automated composition can be implemented as scaffolding because students can be guided during exposure to musical concepts that will be formally taught in the near future" (p. 87).

One participant (Bri) displayed a markedly noticeable transformation in her self-assessment about learning with Hyperscore, which started as somewhat skeptical. By the end of the process, however, Bri shared that she gained an understanding of a few musical concepts (i.e., dynamics, rests, patterns, and chords), which she attributed to learning how to use Hyperscore's tools which "help you grow in your knowledge." Although Bri's experience appeared to focus mostly on learning how to use the tools in Hyperscore, her evolution from being skeptical about learning to concluding that she learned a few musical concepts made her a unique case in this regard.

Reconciling graphic and traditional notation. The idea of reconciling traditional notation with Hyperscore's graphic notation system emerged from five of the eight participants' processes (Emily, Ryan, Draco, Jeff, Josh). These five participants either implicitly or explicitly expressed a desire to incorporate knowledge and understanding of traditional notation or reconcile their knowledge with Hyperscore's graphic notation system. At various times, it was evident that attempting to reconcile traditional notation with Hyperscore was time-consuming and unproductive and at others, relating Hyperscore to traditional notation or attempting to ‘hack’ Hyperscore to mimic traditional notation seemed helpful.

One composer (Emily) expressed that it would have been helpful to have the option of using traditional notation at times because she was familiar with it, and another (Josh) expressed that composing with traditional notation would have “been more composer-ish." Four composers (Draco, Ryan, Jeff, and Josh) ‘hacked’ the software to simulate a traditional conductor’s score by circumventing the sketchpad and aligning their melody and percussion windows vertically. My finding that five composers expressed a desire to record their compositions with standard notation somewhat corroborated Menard’s (2015) study in which band participants emphasized notation, displayed concern about putting their ideas on paper and expressed the “need to figure out how to write it down instead of it just being sound” (p. 126).

Although the present study did not compare participants’ use of graphic notation with traditional notation, it was notable that five of the eight participants’ *responses* to the graphic notation process indicated that tenets of traditional notation were useful to them in this setting. A number of other studies also either implied or concluded that traditional notation was useful to novice composers to some extent, even when using standard notation was not necessary. Nelson (2007) found that providing two types of notation programs, one traditional and one graphical, was helpful to participants, and Upitis (1989) observed that students interacted with traditional notation regardless of their understanding of the theoretical components. Smith (2004) observed that, when given a choice, all participants wanted to see traditional notation at some point. Similarly, Pitts and Kwami (2015) found that those who could read standard notation seemed to prefer using it when given a choice. Similarly, in my study, five of the eight composers expressed that having the option of using either traditional notation or graphic notation might have been beneficial.

The five participants who suggested that a traditional notation option would have been desirable brings to light a shortcoming of the approach to composition used in the present study. Requiring all participants to use Hyperscore's graphic notation system, despite its accessibility and ability to democratize the composition experience, might have fallen short of capitalizing on some of the participants' prior experience and training in music. Relatedly, Dammers (2013) asserted, "Technology also frees a teacher from 'one size fits all' instruction" (p. 202), which had implications for the present study. In the present study, five participants' responses indicated that being limited to Hyperscore's graphic notation system (i.e., 'one size fits all') might have undermined their processes and products to some extent.

Notation as preservation. Two composers (Brittany and Draco) each talked about the importance of preservation and the ease with which Hyperscore facilitated remembering what they composed. Brittany once stated, "It's a lot to have a whole piece in your head and then write it down [later], you might forget some parts from the beginning," and Draco commented that without notation, "I wouldn't know what to hum when the time came to hum it." These participants' emphasis on the utility of preserving a composition in writing so the composer can recall it later resonated with Emmons (1998) and Kaschub (1999), whose analyses of novice composers' processes identified preservation as an emergent theme. This finding also resonated with Christensen (1992), who concluded that preservation is essential for reflection and Upitis (1992), who argued for considering notation as merely an act of preservation.

Agency. In the present study, agency surfaced in all participants' responses to their Hyperscore experience in some manner, sometimes positively and sometimes negatively. Three composers (Brittany, Jeff, and Chelsea) focused on personal expression, indicating their appreciation for the opportunity to place their musical ideas into an original composition. Two participants (Josh and Emily) similarly articulated that their Hyperscore experience nurtured reflection *about* self-expression, although they both struggled with being personally expressive while *doing* their compositions. Participants' focus on self-expression (or lack thereof) supported Wiggins' (2007) finding that "When data were collected in contexts in which participants were able to experience personal agency, researchers tended to comment about composers' feelings of personal satisfaction and ownership" (p. 464).

Autonomy was explicitly important to four of the composers (Draco, Jeff, Brittany, and Ryan), each of whom appeared to view their Hyperscore experience as one that allowed for freedom and choice. Draco expressed that "composing is fun because you truly have complete and total control over it," and often when Draco was working alone, and in complete control, he demonstrated something like a state of flow (Csikszentmihalyi, 1991). Two composers (Jeff and Brittany) focused on the appeal of not being given specific instructions from a teacher or someone else. Ryan extolled the benefits and having freedom, but also acknowledged that it is “also kind of a disadvantage” because working without guidelines is more difficult.

For all participants except Brittany and Josh, three specific software constraints impeded their processes to some extent, and comments about these constraints were relatively pervasive. Four participants (Bri, Chelsea, Emily, Ryan) expressed dissatisfaction with the quality of the General MIDI timbres consistent with Airy and Parr’s (2001) findings and committed extended time looking for timbres that met their expectations. Also, Hyperscore’s limit of eight simultaneously sounding timbres diverted much time away from composition for three composers (Chelsea, Draco, and Jeff) as they looked for a workaround. A third limitation was the inability to create internal tempo changes, which prompted four composers (Chelsea, Emily, Draco, and Ryan) to spend time altering note values and spacing in their compositions to create a de facto tempo change.

I inferred that the limitations discuss above prompted creative thinking, yet compromised productivity and possibly agency to some extent for six of the eight participants. This finding also corroborated Kirkman (2011), who concluded that technological resources need to support and interact with existing musical skills. For six of the eight participants, there were indications that the software available to them in the present study might not have strongly supported “their existing approaches to musical ways of working” (p. 120).

Similar to the findings in the present study, previous researchers also observed novice composers who expressed or displayed the effect of autonomy, freedom, and constraint on agency and their composition processes. Airy and Parr's (2001) participants expressed valuing the ability to explore their own ideas independently of both the teacher and other students. Carroll (2007) found that participants "became increasingly involved emotionally and intellectually in their own learning" (p. 173) partly due to allowing as much freedom as possible combined with as much structure as necessary. Van Ernst's (1993) conclusions included participants' clear preference for having a choice about independent or collaborative work and having choices in the nature of the task to be completed. Kaschub's (1999) sixth-grade participants indicated that composing alone gave them the "freedom to create products which reflected their interests without the need to compromise with their peers" (p. 249), which closely resembled comments by two participants (Emily and Jeff) in the present study. Ruthmann (2006) found that learner agency was fostered when the teacher valued and connected to the students' prior understanding and experience, and when students were allowed and encouraged to serve as peer-teachers. Both of these conditions surfaced to some extent in my study.

The mixed positive and negative responses to the autonomous nature of this project described above indicated that unconstrained autonomy was not necessarily a benefit in all cases, with the possible exception of three composers (Brittany, Draco, Jeff) who commented explicitly on their value of autonomy. Ryan noted there were pros and cons to having freedom, and three participants (Chelsea, Emily, Josh) indicated that more guidance might have been beneficial to some extent. Also, Bri's initial skepticism of whether she was learning about composition indicated that she might have benefited from more teacher intervention, at least in the beginning of the process.

Value of the Process

Implicit, and sometimes explicit, in the data were various indicators of how participants valued the composition process and their products. For example, two participants (Bri and Chelsea) displayed an outwardly positive response to the *individual* composition process through their demeanor. Bri was markedly playful in her approach, and Chelsea orally expressed a carefree, adventurous, process-oriented spirit. Contrastingly, Bri exuded a much less satisfactory *collaborative* experience ostensibly because her ideas did not get used to a great extent, and Chelsea was also less outwardly excited while collaborating with her partner. However, unlike Bri, Chelsea did not display a severe change of affect after moving from the individual to the collaborative process.

For two other composers (Emily and Josh), it was their occasionally reflective stance about the purpose of music composition that stood out. Emily and Josh were unique in the way they *talked about* the affective aspects of composition, although they did not demonstrate that their own composition experience was particularly affective. DeLorenzo (1989) concluded that students need as much experience in *thinking about* music as in *making* music, which resonated with Emily and Josh's responses in the present study. When encouraged to think about what a composer does, Emily and Josh focused on the ability of composition to facilitate personal expression, unlike the other six composers who focused more on the technical and mechanical aspects of composition. Consequently, I concluded that more time for students to think deeply about a composer's purpose would have been valuable for the participants in the present study.

Five participants (Brittany, Chelsea, Draco, Jeff, Emily) expressed or demonstrated the importance of perseverance or the benefit of committing time. For two composers (Jeff and Brittany), perseverance was associated with quality. One composer (Jeff) intimated that "messing around" produced lower quality than the piece to which he committed more time and effort. The other composer (Brittany) beamed when she shared her individual composition with me and described how her "long process" of two weeks paid off, obviously satisfied with the quality of her work.

Emily was unique in her view of perseverance and intimated that perseverance was a generally beneficial habit. Chelsea's response was also unique because she claimed that coming up with ideas was easy, but *combining* them into a piece that sounded good required perseverance. Draco outwardly declared his decision to perseverate on with developing one composition over time. One of the four types of problem-solving processes (i.e., committing to the task) identified in DeLorenzo's (1989) study resonated with the findings described above.

My finding that participants valued perseverance and taking time is consistent with Kennedy (2002), whose participants emphasized the importance of taking time to think about the process. This finding also resonates with Papert (1999b), who emphasized, "taking time—the proper time for the job" (p. 1). Taking time or giving participants sufficient time to think, reflect, or revise was also a theme in numerous other studies reviewed for the present study (Bamberger, 2003; Hickey, 1997; Kafai, 1996; Kennedy, 2000; Kosak, 2014; Menard; 2009; Smith, 2004; Van Ernst, 1993; Younker, 1997).

Four participants (Ryan, Draco, Emily, and Chelsea) either explicitly or implicitly conveyed the importance of thinking in sound. Two participants (Ryan and Draco) articulated thinking in sound as an essential skill for a composer. Two other participants (Emily and Chelsea) implicitly expressed their value of thinking in sound when they talked about imitating previous pieces they had played on piano or drums, respectively, or attempted to emulate television or movie themes with which they were familiar. These four participants' implicit or explicit understanding of this elemental aspect of composition corroborated Younker (1997), who asserted that participants had a clearer understanding of what composers do and how they do it after experiencing it themselves. For two composers (Draco and Ryan) in particular, thinking in sound is something they realized as something composers do. Two other composers (Chelsea and Emily) implicitly displayed this understanding by emulating music with which they were familiar.

Two participants (Draco and Jeff) displayed an obvious need for a mediated learning experience; that is, an integrated hands-on, heads-in, playback experience similar to that described by Ackermann (1993) and Bamberger (2013). For these two participants, the computer played a "special role as a resource for inquiry and invention" (Bamberger, 2013, p. 4). Jeff thrived when he worked individually and had control over all three components of the mediated learning process and admitted he felt less involved in the process when working with a partner. Similarly, Draco commented that it was difficult for him when he did not have control of the drawing process, and often displayed a flow-like (Csikszentmihalyi, 1991) state when working alone and in complete control.

Control, choice or both were important to five of the eight composers in the present study, similar to Van Ernst's (1993) participants for whom "the possibility of having choices in the nature of the task and the way of working seemed to get almost unanimous support" (p. 28). Two participants (Draco and Jeff) valued mouse control, and one participant (Bri) equated conducting and composing, saying, "A composer controls everyone." Three composers (Bri, Emily, and Ryan) commented overtly on how they valued being able to make choices about instruments, tempo, and dynamics.

When participants encountered limitations or challenges such as: (a) the low quality of General MIDI sounds, (b) the limited number of simultaneously sounding timbres, (c) a desire to apply tenets of standard notation, or (d) lack of control over internal tempo and gradual dynamic changes, participants sometimes 'hacked' the software to gain more control. Hacking was only mildly successful and distracted participants from the composition process to some extent. Berkeley (2004) found, "In case studies of school students composing, many writers note the significance of authority and autonomy as an indicator of success, competence and confidence in composing" (p. 252). The emphasis on control, choice, or both by five out of eight participants in the present study corroborated Berkley's finding. Emphasis on timbre control by participants in the present study also corroborated Airy and Parr (2001), whose participants expressed that unrealistic MIDI timbres compromised their "ability to achieve production at the desired level" (p. 48).

Articulating responses to the process. The second research question in the present study focused on participants' responses to the composition process, both verbal and non-verbal. Although most participants in the present study lacked command of musical terminology that would have allowed them to describe their processes and products more sophisticatedly, their responses demonstrated they intuitively understood complex concepts and could meaningfully display or express their understanding in lay terms or through their actions while using Hyperscore. According to Kratus (1989), children are unable to meaningfully discuss their compositional processes because the rules underlying their methods of production are mostly unconscious to them. This particular assertion is inconsistent with findings of the present study and studies by other music education researchers who have used children's verbal reports as data (Burnard & Younker, 2002; Carlin, 1998; Kosak, 2014; Richardson & Whitaker, 1996; Younker, 1997; Younker & Smith, 1996). My relative success using verbal reports as data has implications for future researchers considering the validity of such data. Later in this chapter, I will further underscore the benefits of *immediately retrospective* verbal reports.

My finding that participants expressed understanding through actions and lay terms corroborated Ward (2009), who found that "children who had produced excellent work were frequently unable to describe their methods in detail" (p. 163) but demonstrated creative thinking to get their results. My finding also corroborated Major (2007), who concluded that "children's capacity to talk about what they understand is far more limited than the understandings which are demonstrated in their music" (p. 176). Consistent with Kratus (1989) was how overt musical behaviors children display while composing, (i.e., the sounds they produce on an instrument) can be considered "an audible analogue of their internal thought processes" (p. 7). However, the added advantage I had over Kratus was the multiple sources of data accompanying participants' audible analogue of their internal thought processes," including screen-captured videos, videoed think-aloud data, stimulated recalls, and interview responses.

Bruner (1977) once asserted, "any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (p. 33). Although I was not *teaching* composition, and participants were often not able to describe their processes and products using sophisticated musical terminology, most of the participants intuitively applied their understanding of music and composition to some extent. In some cases, participants exhibited intuitive understanding resembling that of professional composers, which corroborated studies by Kennedy (1999), Ladanyi (1995), and Younker (1997). Although participants might not have been able to articulate their understanding in sophisticated musical terms, the multiple sources of data in the present study showed that participants applied a wide range of complex composition processes (see Figure 94, Appendix D) and created relatively coherent compositions.

Value of Individual and Collaborative Products

Although several studies have included evaluating novice composers' products by adults or professionals, few researchers in the literature reviewed for the present study asked novice composers themselves about their impressions of the products they created. To a lesser degree than the composition *process*, participants in the present study expressed or displayed how or to what extent they valued their *products*. Because of time constraints, it turned out that it was difficult to engage with participants and promote deep thinking about *why* they were satisfied or dissatisfied with their compositions. Despite time limitations and participants' limited musical vocabulary, I was able to gather enough data through multiple sources to make lower level inferences about participants' responses to their products. Screen recordings of the participants' final products are available online at https://www.youtube.com/playlist?list=PLTLPLSaYn2ssCtiX5oaS_YMK1xVp1JlvD

Three participants (Josh, Ryan, Draco) expressed more dissatisfaction than satisfaction with their individual compositions. Two participants' (Josh and Ryan) dissatisfaction appeared to stem from frustration about not knowing how to develop a composition and not being technically savvy, respectively. One composer (Draco) expressed dissatisfaction with his results only near the end of the individual composition process, apparently unaware of the quality of his emerging product earlier in the process. However, he usually reacted understatedly with comments such as, "I don't love the ending."

Two participants (Chelsea and Bri) continually expressed overall dissatisfaction with their individual products until near the end of the process. Chelsea's comments exuded a great deal of dissatisfaction throughout most of her individual process, but often countered her dissatisfaction with comments such as "it's all about the process." She ultimately attributed satisfaction with her final piece to her persistence. Similarly, despite her joyful journey through 'composer land,' Bri regularly expressed dissatisfaction with the sound of her composition. However, on the last day of individual composition, Bri discovered how to make patterns and use the droplet tool, which led to cohesiveness and a dramatic ending of which she was proud. Three participants (Jeff, Emily, and Brittany) expressed overall satisfaction with their individual results regularly throughout the process. Unlike the other participants, they rarely expressed dissatisfaction with their results during the process or at the end.

Concerning collaborative compositions, composers' value-oriented responses varied widely. Two composers (Brittany and Bri) had contrasting opinions about their collaborative piece. Brittany was satisfied with the outcome but thought it could have been more original. Bri was not at all satisfied with the outcome, ostensibly because her ideas "did not get used a lot." Two other composers (Josh and Jeff) never expressed satisfaction with the product until the last few minutes of the process when they drew quickly and randomly on the sketchpad and launched Hyperscore's 'general harmony' algorithm, which created a satisfactory, quasi-modern jazz result.

Although they never commented explicitly on the quality of their finished product, I inferred Emily and Chelsea were satisfied with the results based on their overall affect. They regularly reacted enthusiastically to the results as they developed their creepy composition and grew more excited about the outcome throughout the process. Draco and Ryan explicitly expressed satisfaction with the outcome of their collaborative composition. However, when I asked Draco and Ryan about their final product, each focused more on their effectual partnership, mutual focus on thinking in sound, and high level of productivity than the composition itself. Apparently, for Draco and Ryan, their *productive process* was the key to producing a satisfying composition.

This finding supported my sense that, in a constructionist-oriented setting, process and product are inextricably linked.

Social concerns in my study included feeling unable to express one's individuality when working collaboratively (Emily), feeling excluded when one's ideas were not used (Bri), and feeling like collaborating was like helping someone *else* make their composition (Jeff). Performance limitations (i.e., Hyperscore's limits on timbres, simultaneously sounding timbres, and internal tempo and dynamic changes) were a common concern among composers in the present study. Also, the practically unanimous sentiment that vertically fitting together multiple discrete sonic elements was challenging was consistent with Kaschub's finding concerning combining multiple ideas. Three of Kaschub's (1999) four findings relative to how individual and collaborative composers responded to their products and processes were consistent with the present study. Kaschub concluded that individuals and collaborators described their final products differently, with individuals focused on single elements and performance limitations while collaborators focused on social concerns and combining multiple ideas. Although my data did not show a clear distinction between perceptions of individual and collaborative compositions, my findings discussed above were similar to Kaschub's.

Four of the eight participants (Chelsea, Emily, Jeff, Draco) in the present study exhibited that their compositions were personally meaningful or that their individual or collaborative composition was "in a sense an object of involvement that was defined as an artifact of their musical biography or past experience" (Burnard, 2006, p. 126). Chelsea drew extensively on her drumming experience to help her compose and talked about how she tried to impersonate her drumming with Hyperscore. Similarly, Emily explicitly expressed how previous piano pieces she had played, and her knowledge of music theory influenced her compositions. Collaboratively, Emily and Chelsea thrived as they gained inspiration from familiar classical, television, and movie themes for their ‘creepy’ composition. These findings corroborated Burnard (2006), who found that "children played out a range of relations with compositions in ways that demonstrated a strong correlation between the degree of structuring of a composition and the identity attributed to it” (p. 126).

As an individual composer, Jeff expressed almost immediate satisfaction with each of his products, which he attributed to his ability to create simple textures. Draco, the self-ascribed “mechanical kind of guy,” created products that capitalized on his predilection for technical music editing and processing, as well as his idea that melody was the most critical element of a composition. My finding that four participants created personally meaningful products corroborated Bolden (2009), who found that students created personally relevant music “by drawing from an area of personal interest or by invoking a personal experience” (p. 150). culture that has produced the composer, and the emerging work. (2003, p. 6)

Although the other four participants (Bri, Brittany, Josh, and Ryan) expressed satisfaction with some of their products, they did not display or express that their products were particularly personally meaningful to them during the 10-weeks of the project. For these four participants, the process appeared to be more a composing ‘exercise’ than a meaning-making activity. Nilsson and Folkestad (2005) found, “when the children had difficulties in creating meaning on their own in their composing, they turned the task itself into the meaningful context" (p. 35). However, there was not a specific task in the present study that might have encouraged these four composers to turn the task itself into a meaningful context.

Previous music education scholars have examined how prompted and unprompted tasks affected novice composers' processes or products. In my study, there was some evidence that a prompted task might have led to more personally meaningful compositions for four participants (Chelsea, Emily, Draco, and Josh). These four composers explicitly expressed a desire for more guidelines to some extent. Presumably, a prompted task would have included guidelines, yet there were no prompted tasks assigned. Smith (2004) found that her twelve participants split evenly on whether they preferred prompted or unprompted tasks, which is similar to my finding that half of my participants expressed a desired for more guidelines.

Other literature reviewed for the present study underscored the importance of balancing freedoms and constraints. For example, Daignault (1993) asserted, "too much openness and freedom in the task may be detrimental to the creative process because there are no positive constraints to direct and focus the creative effort. On the other hand, the compositional task should not be excessively constrained" (p. 25). Hickey and Lipscomb (2006) advised, "Composition assignments should be balanced between structure and freedom in order to facilitate creative thinking" (p. 106). In my study, freedom abounded. However, there was some indication that more structured tasks and guidelines (i.e., constraints) might have benefited at least some of these novice composers.

Research Question #3: Application of the Theoretical Framework

While examining participants' strategies, processes, and their responses to their products and processes, the three theoretical concept dyads I presented in Chapter 1 (i.e., constructionism-instructionism, concrete-abstract, and affect-cognition) emerged from the data regularly along with their related variables of interest (Miles, Huberman, & Saldaña, 2013; Yin, 2009). I derived the concept dyads and related variables of interest from the theoretical framework for the present study, which blended tenets of Papertian, Piagetian, and Vygotskian constructionist, constructivist, and social constructivist perspectives, respectively, and inspired my third research question: To what extent and in what ways do the constructionism-instructionism, concrete-abstract, and affect-cognition concept dyads manifest themselves within participants' composition processes? The following discussion elaborates on the a priori theoretical variables of interest I adopted based on the literature reviewed for the present study. Appendix F contains word tables with textual references to the most salient examples of how the variables of interest revealed themselves.

Figure 149 is a hierarchical chart created with NVivo that represents the extent to which each of the theoretical concept dyads discussed in Chapter 1 and their related variables of interest and sub-categories surfaced as I examined the data through three discrete lenses: (a) affect-cognition, (b) constructionism-instructionism, and (c) concrete-abstract. The relative sizes of various sectors reflect the number of data sources labeled with that code. I found that approximately half of the data provided evidence reflecting the affect-cognition dyad, approximately one-third of the data provided support for my analysis of the constructionism-instructionism dyad, and approximately one-fifth of the data were pertinent to the concrete-abstract dyad.

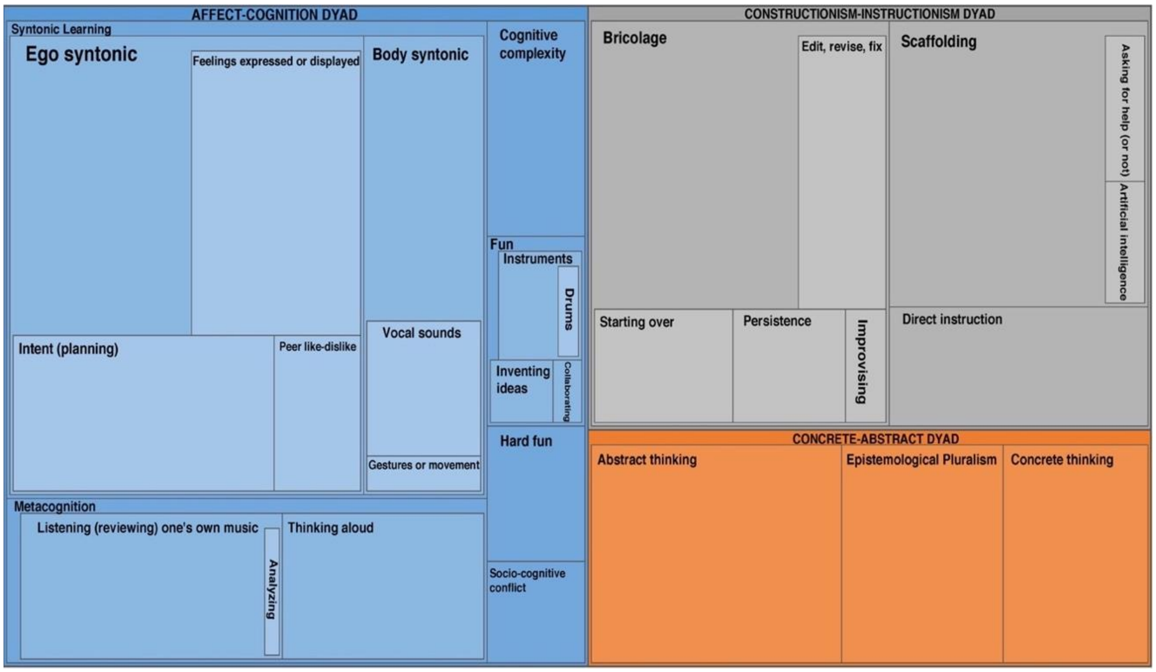


Figure 149. Illustration of the three concept dyads, related variables of interest and prominent related categories, and the extent to which each manifested itself in the present study. The relative sizes of various sectors reflect the number of data sources labeled with that code.

In the following sections, I present a summary of the most impactful examples of how the concept dyads, related variables of interest, and prominent related categories manifested themselves in the present study. Also, I include the results of my search for discrepant evidence and negative cases in my effort to avoid "the proclivity to find confirming rather than disconfirming evidence" (Creswell & Miller, 2000, p. 127). As stated in my third research question, I was interested in the extent to which and the ways these concept dyads revealed themselves in the present study. While examining the data through the three concept dyad lenses, I assumed that the 'ways' could possess negative and positive qualities alike and the extent to which these concept dyads and related variables of interest could range widely.

The Affect-Cognition Dyad

A recurring theme in the literature I reviewed on constructionism is its relation to learner affect and cognition. Constructionism scholars often emphasized the importance of affect within the context of this learning approach and underscored the tendency of psychologists to set up a dialectical relationship between cognitive functions and "considerations of affect, of feeling, of sense of beauty" (Papert, 1980a, p. 194). Consequently, Papert developed the concept of *affective computing* as an expansion of Piaget's theory of cognitive constructivism. Table 46 synthesizes the textual data described in the following sections related to the affect-cognition dyad (link to Table 46, Appendix F).

Ego syntonicity. Papert defined ego syntonicity as "that which is coherent with children's sense of themselves as people with intentions, goals, desires, likes, and dislikes" (1980a, p. 63). I concluded that ego-syntonic behavior was the most prevalent variable of interest when I examined the data through an affect-cognition lens. To some extent, all eight composers expressed definite feelings of like and dislike, goals, and intentions as well as other personal responses.

Personal feelings expressed and displayed during the process were mostly positive but occasionally conveyed frustration, dissatisfaction, or lack of confidence. Generally speaking, and probably because of the 'low stakes' environment in which there were no constraints and no formal evaluative components, participants in this study exhibited enjoyment of the process and a carefree demeanor. They appreciated having autonomy, and even when they were not satisfied with their products, it did not appear to affect their overall demeanor, with a few notable exceptions.

One composer (Ryan) was conspicuously dissatisfied with his final individual composition and doubted if he wanted to share it publicly; however, he expressed more comfort in the collaborative process and pride in the final product he created with Draco. Another composer (Josh) became observably overwhelmed at times, which affected his productivity, although, like Ryan, he expressed feeling more successful when collaborating. A third composer (Bri) was a nonchalant, joyful individual composer who felt *less* successful after the collaborative phase because her ideas "did not get used a lot."

For four composers (Draco, Emily, Josh, and Ryan), this experience prompted feelings about their ability to express themselves through music composition, and each of these four expressed self-doubt to some extent about their ability to compose music. Their dubious impressions of themselves seemed to emanate from three ideas they held about composers. Two participants (Draco and Ryan) felt strongly that composers must be able to think in sound, an ability they believed was lacking in their skill set. Although, by the end, Ryan claimed his ability to think in sound improved.

According to two other participants (Emily and Josh), composers need to create personally meaningful pieces, and neither felt they succeeded in doing so as individual composers. Emily articulated that self-expression is a challenge for her and that the software was not particularly helpful to her in this regard. Later in the process, she expressed that standard notation would have supported her self-expression better. Although Emily expressed that making personally meaningful music was difficult for her, her individual composition process demonstrated that she created personally *relevant* music to some extent by integrating past experience.

Two participants' (Josh and Emily) references to composers who create personally meaningful pieces appeared to resonate with Swanwick and Tillman's (1986) "symbolic level [in which] there is a growing sense of music's affective power and a tendency to become articulate about this experience" (p. 93). Two other composers (Draco and Emily) each expressed their belief that innate ability affects success with composition to some extent. These two composers' position corroborated numerous scholars who asserted that music composition is sometimes perceived as an activity for an elite group (e.g., Cage, 1961; Kennedy, 2002; Paynter, 2000; Wiggins, 2002). The perception in the present study of composers being innately capable also resonated with Brandes (1992), who concluded that school science tends to promote science as the realm for an elite few.

Two individual composers (Draco and Jeff) and two collaborative pairs (Chelsea and Emily, Draco, and Ryan) were emphatically intentional in their approaches, as evidenced in their think-aloud data, interviews, and my observation of their processes. Near the end of the study, Ryan shared his developing strategy of thinking in sound before coming to class. The forethought about the sound of compositions displayed by five of the eight participants was consistent with Tobias's (2010) participants who displayed "planning and discourse as they discussed various options for generating, developing and editing their music" (p. 444). Conversely, one participant (Jeff) was adamantly opposed to planning and discourse, and another (Emily) asserted that, as an individual composer, planning in her head was not helpful because she often felt unable to transfer her sonic ideas to the software.

Body syntonicity. Papert (1980a), defined body syntonicity as “that which is firmly related to children’s sense and knowledge about their own bodies” (p. 63). For example, Papert observed children using bodily motion and gestures to reflect actions they aimed to program for a robotic turtle using the LOGO computer language. Relatedly, five of the eight novice composers (Draco, Ryan, Chelsea, Emily, Brittany) in the present study used their singing voices and physical gesturing spontaneously and organically to reflect what they intended to create with Hyperscore. Draco hummed and sang almost continuously and appeared to inspire this behavior in Ryan. Ryan only hummed or sang occasionally while composing individually but joined in with Draco regularly while collaborating. Chelsea used body syntonicity to a greater extent than all participants, combining ‘air drums’ with vocal percussion when she thought “of a drumbeat and [tried] to impersonate it.” As collaborative composers, Chelsea and Emily relied heavily on their singing voices while transcribing their quasi-*Twilight Zone*, *Harry Potter*, and Beethoven’s *Fifth Symphony* themes.

Metacognition. For the present study, I defined metacognition as a process, during which learners “become their own observers, narrators, and critics” (Ackermann, 1996, p. 9). In the present study, composers had the opportunity to practice metacognition by thinking aloud, listening to and reflecting on their compositions while engaged in dialogue with peers, and engaging in stimulated recall and semi-structured interviews with the present researcher. Video-stimulated recalls and semi-structured interviews proved to be effective tools for promoting metacognition among participants and provided valuable insight into participants' processes and strategies and their responses to the process.

There was one discrepant case (Jeff) in the present category because metacognition appeared to be absent from his individual composition process much of the time. Jeff prided himself on not planning and thinking too much, citing his success with trial-and-error as an individual composer. In his final interview, I asked Jeff if he thought planning was important, to which he responded, "It depends on whether you want to think about your piece or just try it."

More significant than the success of planned strategies for promoting metacognition were the instances of reflection that surfaced organically during the process. These unprompted metacognitive experiences took place within the context of critical listening and think-aloud moments that occasionally precipitated reflexivity.

Reflexivity. One of the most impactful instances of *reflexivity* (Duffy & Cunningham, 1996) in the present study came from Josh, who experienced an impasse in his collaborative process with Jeff. Josh demonstrated reflexivity by ostensibly thinking critically about the impasse. Ultimately, Josh suggested drawing on their previously composed individual compositions for ideas, which restored the pair's enthusiasm and resolved the impasse.

Listening, discussing, and planning, followed by reflexive revision by two participants (Draco and Ryan) resulted in a highly-structured, cohesive composition.

Similarly, two others (Chelsea and Emily) often engaged deeply in a sound *with* sight process by iteratively singing, notating, and listening while they emulated well-known themes, and engaging in discussion of how to create ‘creepy music.’ These four composers also proved to be reflexive in the context of critical listening described later in this section. The reflexive processes demonstrated by these four composers in the present study were similar to regulated pathway composers described by Younker and Smith (2004), during which the composer “tested, recorded, revised, and refined evolving drafts of a piece” (p. 69).

Critical listening and reviewing. At times, listening critically and reviewing one’s music as a metacognitive experience equated to a strategy among each of the four focus composers. I observed numerous instances of an iterative sing-notate-playback (SNP) cycle among the four focus composers as individuals and in collaborative pairs. The playback portion of the SNP cycle sometimes included thinking aloud and was often followed by intentional revision. Chelsea once confirmed my observation, explaining, “I’d listen to one [sonic element], then I would listen to the other, then I would listen to them together and like, tweak it.”

The SNP cycle I observed resonated with Papert’s (1980a, 2005) model of constructionism that included an emphasis on metacognition. The SNP cycle also reflected the verification stage identified by Burnard and Younker (2002), during which the composer engages in “evaluation of the piece, when notation or recorded play-backs, fixing ideas and play-throughs verify decisions made” (p. 248). Similarly, Guthmann (2013) noted that participants “listened to their compositions over and over again” and concluded that “sound was a motivating factor to make a change” (p. 315) as much as, and sometimes more than, advice from the teacher or the professional composer mentor.

In addition to the SNP cycle, the four focus composers as collaborators frequently engaged in *unprompted* reflective dialogue *about* their pieces, during which they discussed what they had accomplished and what they intended to create going forward. Two studies I reviewed paralleled the type of reflective dialogue I observed. Huang and Yeh (2105) also concluded that visualization, automation, and immediate sound feedback improved learning effectiveness, and Stauffer (2001) concluded that “time, tool, and technique are interactive in the composition process.” Huang and Yeh and Stauffer’s conclusions each parallel the SNP cycle I noted while observing the four focus composers’ processes. The SNP cycle also resonated with Ackermann’s (1993) idea of a mediated experience, during which the learner has the ability to “play-back, or recast an event, either in one’s head or better, on some external symbolic substrate” (p. 4).

Thinking aloud. The present study was consistent with previous studies in which conversation among participants yielded compelling think-aloud data (e.g., Burnard & Younker, 2002; Carlin, 1998; Christensen, 1992; Collins 2007; Younker, 1997; Younker & Smith, 1996). In addition to providing me with data related to their processes and strategies, thinking aloud in the present study integrated time for participants to “step out and reconsider what has happened to them from a distance” (Ackermann, 1996, p. 5).

Unsurprisingly, when composing individually, participants needed regular reminders to think aloud about their processes, but collaborative composers generated think-aloud data more extemporaneously, which was consistent with Carlin’s (1998) study. In the present study, think-aloud data combined with data from stimulated recalls and semi-structured interviews provided sufficient data for making inferences about participants' responses to their processes and products. However, thinking aloud was also *partly* successful as an impetus for metacognition, as described herein.

As individual composers, four participants (Chelsea, Draco, Emily, and Ryan) seemed more comfortable talking aloud than others during the composition process. Consequently, I selected these four participants as focus composers. At times, while thinking aloud, focus composers expressed not only their processes and strategies but also the thinking surrounding their processes, which provided useful data for answering my first research question. There were also impactful moments when each of the eight participants' conveyed their *responses* to their processes and products while thinking aloud, which helped with answering the second research question. My observations appeared to resonate with Christensen (1992), who concluded that her participants' think-aloud data "exhibited an increased metacognitive awareness of the compositional processes" (p. 212).

At times, I noted that the think-aloud process appeared to go beyond mere reporting and led to deeper reflection about the composition process that informed participants' decisions about their compositions. This observation resembled Ackermann's (1996) description of metacognition as a metaphorical dance of diving in and stepping out as a way to negotiate the transition from Piagetian assimilation to accommodation. However, at as many other times, participants merely provided 'play-by-play' descriptions of what they were doing as they continued to work, especially when I *reminded* them to talk about what they were doing. However, my explicit prompts such as, “Please stop, talk, point [with the mouse], and play [your composition]” appeared to result in more thoughtful responses and sometimes led to metacognition instead of mere ‘play-by-play’ reports.

Think-aloud data in the present study exhibited evidence of participants sometimes going beyond concurrent verbal reporting (Ericsson & Simon, 1993) and revealed organic, unprompted metacognition as a component of participants’ processes. Five participants’ (Chelsea, Draco, Emily, Josh, and Ryan) think-aloud data sometimes included evaluative comments about their processes and products followed by acting on their thoughts; that is, they exhibited reflexivity as described by Ackermann (1996) and Duffy and Cunningham (1996). One participant (Ryan) once described how he would sometimes think about his composition before coming to class and invent new ideas in advance. Two composers (Draco and Ryan) overtly aimed to think of melodies before notating and engaged in conversations about what they had created and wanted to create. Although their success in connecting thinking *about* their composition to *doing* their composition was limited, their think-aloud data demonstrated their respective metacognitive inclinations. Similarly, two composers (Chelsea and Emily) spent much time reflecting on their desired ‘creepy’ effects, continuously discussing their desired outcome, evaluating the actual outcome, and engaging in dialogue about how they might achieve their desired effect.

My observations of the think-aloud process in the present study corroborated Collins (2007), who found that *immediately retrospective reporting* (Ericsson and Simon,

1993) is useful as one of the multiple sources of data. Findings from the present study also appeared to corroborate studies by numerous other researchers (e.g., Burnard & Younker, 2002, 2004; Carlin, 1998; Downton, 2015; Parry-Jamieson, 2006; Younker, 1997; Younker & Smith, 1996) who found verbal reports useful data for examining novice composers processes and strategies. In the present study, the use of concurrent verbal reporting seemed to be effective and support Ericsson and Simon's (1993) assertion that participants "will still retain in their short-term memory the necessary retrieval cues" (p. 19) to report what they can remember about their thoughts from the immediately preceding problem-solving situation.

Overall, thinking aloud only occasionally led to thinking *about* the process, thereby qualifying as metacognition. Perkins (1981) claimed that simply asking subjects to express their thoughts and not asking them to 'think about their thinking' is unlikely to prevent accurate reporting, and further asserted that various experiments have shown "disruption is not a serious problem" ("A Voice for the Mind," para. 17). Perkins argued that if thinking about something "just means observing, that need not be disruptive at all" (para. 14). My observation that thinking aloud in the present study was useful for reporting an immediately preceding situation, and *somewhat* useful as a metacognitive strategy, was consistent with Perkins's assertions.

Fun vs. hard fun. Although seven of the eight participants articulated that "composing is hard" at some point in the study, and all participants indicated they had fun in a variety of ways (see Figure 149), evidence of Papert's (1999) 'big idea' of *hard fun* was relatively slight in comparison with other variables of interest within the affect-cognition dyad. Jeff was a distinct negative case who commented, “I like using Hyperscore [because] it’s really easy and fun.” Jeff consistently articulated that he enjoyed the process, and a few times asked if he could skip band practice to continue composing because he ostensibly enjoyed composing. However, he also made a point to communicate how *easy* it was for him to create successful compositions while working individually.

Other participants *approached* the idea of hard fun with their comments but fell short of Papert’s idea of something that is fun *because* it’s hard. Remarks such as, “It’s easy to make something, but hard to make it sound like the books in music class” (Josh) and, “It’s easy to come up with ideas, but hard to execute them” (Chelsea) expressed a process that was occasionally fun and somewhat hard. Similarly, another participant (Ryan) intimated that having freedom was enjoyable, but that it was difficult “to make all the notes and…make them sound the way you want them to.” There was one discrepant case in this category (Emily), who three times explicitly conveyed a sense of *hard* fun. Emily’s comments included, “The harder part is when you’re trying to figure out what will fit and what will co-exist together nicely. The great part is when you finally get that right combination, “It’s good to experience how hard and time consuming it (composition) is” and, “It’s hard to figure out what will fit and co-exist, [but] when you finally get that right combination you’re impressed with yourself, and you feel good.”

Cognitive complexity. Perkins (1992) asserted, “A constructivist pedagogy often imposes sharp demands on learners— cognitive complexity” (p. 19). Similarly, Kirschner, Sweller, and Clark (2006) claimed that a constructivist environment could be “highly complex [and] may generate a heavy working memory load that is detrimental to learning” (p. 80). Dick (1992) contended that constructivists are apparently "not concerned that the gap will be too great between the schema of some students and the tools and information that they are provided” (p. 96). Webster (2006) cautioned music educators, asking, “How much do we know how children with diverse learning styles and modalities deal with the challenges of a constructed knowledge acquisition?” (p. 93). With these scholars’ cautions in mind, I found little evidence that composing music in this particular environment was a cognitively complex experience overall for the eight participants. It is possible that the absence of constraints and requirements, and the ‘low stakes’ environment led to a generally enjoyable and relatively cognitively undemanding experience for most of the participants.

Although seven of the eight participants anecdotally referred to composition as “hard,” they was little evidence of this experience being cognitively demanding for most participants. However, in two cases (Ryan and Josh), the composer’s affect, demeanor, thinking aloud, or interview comments conspicuously displayed that the process might have been cognitively overwhelming at times while working alone. One participant (Ryan) was markedly discouraged near the end of his individual composition process and was dubious about showing his piece in public, which ostensibly led to his lack of productivity and affected the quality of his final product. Another composer (Josh) was forthcoming about being overwhelmed, saying, “Sometimes it gets so confusing and hard, and you just lose yourself,” and, “I’m trying to use everything, and it’s so overwhelming.” Josh’s disinclination to explore the Hyperscore software and his overall conservative approach evidently emanated from feeling overwhelmed. For these two participants, it appeared that this constructionist-oriented environment negatively impacted their productivity and engagement during the individual composition process. For the other six individual composers and all of the collaborative pairs, overwhelming moments were fleeting and did not appear to affect their productivity or engagement overall.

It is important to note that cognitive complexity appeared to affect *productivity* and *engagement* for two participants working along and did not seem to affect productivity and engagement for six of the eight individual composers or any of the four collaborative pairs. However, there was no attempt in the present study to evaluate *learning* formally. Although most participants successfully completed at least one individual and one collaborative composition without displaying or expressing significant difficulties, and I regularly scaffolded composition processes and sometimes provided direct instruction in my role as observer as participant, it is possible that participants completed this study learning little about the composition process. There were no assessments to measure what participants learned *about* composition.

Conversely, considering that a modicum of direct instruction and regular scaffolding took place throughout the 10 weeks of the present study, it is possible that participants learned about music composition to some extent. It is also possible that the *mathetic* (Papert, 1980a, 1993) environment fostered learning *how* to learn. Papert (1972a) described his Mathland as a place where students learn to be mathematicians rather than being taught how to do math: “Being a mathematician, again like being a poet, or a composer or an engineer means doing, rather than knowing or understanding" (p. 1). Similarly, participants in the present study experimented, played, reflected, and experienced *doing* composition and might have learned something about *how* they learn in this context.

Socio-cognitive conflict. Socio-cognitive conflict, as derived from Piaget's work, refers specifically to discussion between peers who bring different perspectives to the task (Applefield, Huber, & Moallem, 2000; Lourenço, 2012; Tudge & Rogoff, 1989; Tudge & Winterhoff, 1993). Kaschub (1999) asserted that, based on Piaget (1976), children are more likely to interact as equals and are comfortable in experimenting with new ideas and questioning each other. My observations of the four collaborative pairs in my study corroborated Kaschub to some extent, but not wholly. Five of the eight composers (Brittany, Chelsea, Draco, Josh, and Ryan) expressed or demonstrated being comfortable collaborating on new ideas or questioning each other, and preferred collaboration over individual work. Typically, in these cases, one composer would make a suggestion, the pair would notate it and listen, and would agree to keep, alter, or discard it. I found that extended discussion of different perspectives on musical ideas or choices was minimal.

One composer (Jeff) felt like "We're kind of making his [composition]" and was much less enthusiastic working with a partner than he was working individually, ostensibly because he did not sense ownership and agency. I inferred that Jeff's outlook diminished his interest in regularly dialoguing with Josh. Similarly, (Bri) tended to defer to her partner, possibly because her partner had significantly more musical experience or was frustrated that her ideas “did not get used a lot.” Another composer (Emily) expressed her tendency to be deferential to her partner, saying, “I always think like, what are they thinking, and so then I kind of let them take the lead,” apparently feeling self-conscious about sharing her ideas. Although Emily’s deferential nature was noticeable during her collaboration with Chelsea, she did not outwardly appear uncomfortable.

Balancing affect and cognition. Reimer (1989) asserted that humans experience music with “an intermingling of perceptual and affective cognitive processes, [and] it is becoming clearer that in art, affect functions cognitively” (p. 32). Meyer (1956) noted that affective experience is not the polar opposite to conscious cognition, and Webster (2002b) pointed out that constructionists view affect as an essential aid to learning. Similarly, Wiggins (2009) described certain meta-dimensions of music that provide young composers with “doorways in” (p. 40) to affective musical experiences, rather than focusing on discrete, abstract elements of music. In the present study, six of the eight individual composers (Bri, Brittany, Chelsea, Draco, Emily, Jeff) demonstrated that affect appeared to play positive a role as a ‘doorway in’ to being a composer. For two individual composers (Josh and Ryan), it seemed that the cognitive demands of the activity were somewhat of an obstacle, regardless of how positive the affective aspect of their experience was.

Among the four collaborative pairs, two appeared to experience a well-balanced affective-cognitive experience. Emily and Chelsea demonstrated that their enjoyment of creating a ‘creepy’ soundscape combined with their compatible bricoleur styles, which seamless transitioned to a planner style as needed, led to success. Draco and Ryan, Draco probably more than Ryan, thrived on the linear, ‘planner’s approach’ to composition. Draco sometimes exhibited a flow-like experience (Csikszentmihalyi, 1991), especially when engaged in composition as a technical process, and Ryan seemed occasionally inspired by Draco as a “more capable peer” (Vygotsky, 1978, p. 86). The other two collaborative pairs (Bri and Brittany, Jeff, and Josh) each included one person who displayed or expressed being somewhat detached from the process. In these two cases, it was difficult to draw a conclusion about the quality of their collaborative experience, except to say that Bri and Jeff explicitly articulated a feeling of being excluded or disconnected from the collaborative experience. It is likely that their feelings adversely affected the affective aspect of their collaborative composition experience.

The Constructionism-Instructionism Dyad

Papert (1993) defined *instructionism* as “belief that the route to better learning must be the improvement of instruction” (p. 139). Educators who embrace the principles of the constructionist learning model argue that a constructionist environment accommodates authentic learning (solving real-world problems) more effectively than an instructionist environment. This is not to say that instruction is unnecessary or inconsequential, but constructionists aim for a balance between direct instruction and *bricolage* (self-making, -fixing, and -improving mental constructions). In the present study, I perceived a continuum underpinned by the constructionism-instructionism concept dyad, with bricolage and direct instruction at opposite ends, and scaffolding in-between. Table 47 synthesizes the textual data described in the following sections related to the constructionism-instructionism dyad (link to Table 47, Appendix F).

Bricolage and planning. Papert (1993) viewed bricolage as analogous to the student who solves problems in a heuristic manner and improves mental constructions along the way, without relying on direct instruction. The bricoleur is "guided by the work as it proceeds rather than staying with a pre-established plan" (Papert, 1991). Analysis of the data coded through the constructionism-instructionism lens revealed that I labeled slightly more than half of the data for evidence of bricolage or its antithesis, 'planning.' There was a clear distinction between heuristic, bricoleur-oriented processes, and planning processes, and both styles emerged from the data to relative equally.

It is important to note that, in my study, I applied the concept of *bricolage* in a narrow sense, relating it only to its use by (Papert, 1980, 1987, 1996), whose idea of bricolage was based on Lévi-Strauss (1962). I applied this term to describe how participants displayed a process of tinkering, adding things, pushing elements around, and remolding something to grow it into something more complex (Papert, 1996). Other applications of bricolage have surfaced, such as the process of mixing various theoretical perspectives and methods as necessary in qualitative research (Kincheloe & Berry, 2004; Lincoln & Denzin, 2008). In my study, bricolage refers to the participants' processes and not my research methods. However, to some extent, the amalgamated Papertian, Piagetian, Vygotskian I applied in this study could be considered somewhat of a bricolage, or a "pieced-together set of representations that is fitted to the specifics of a complicated situation" (Lincoln & Denzin, 2008, p. 5).

My analysis of the data through the constructionism-instructionism dyad lens revealed that four of the eight individual composers (Brittany, Chelsea, Emily, and Jeff) worked more as bricoleurs, exhibiting “a desire to play with the elements of the program, to move them around almost as though they were material elements” (Turkle & Papert, 1990, p. 136) than planners. Conversely, four of the eight individual composers (Bri, Draco, Josh, and Ryan) worked primarily as planners (see Table 47 for specific textual evidence). However, all participants engaged in bricolage and planning at some point, either as individuals or in their collaborative pairs.

Similarly, Burnard and Younker (2004) observed a range of attention to form and structure, from organized planners to those who made few decisions in advance, and Kafai (1996) observed discrete planners and bricoleurs in her study. Kaschub (1999) found that individuals, more than groups, tended to be planners, which was somewhat inconsistent with the present study in which four of the eight individuals were predominantly planners, and bricoleur and planner styles among collaborative pairs were also relatively balanced.

In the present study, the four bricoleurs all were able to complete at least one composition successfully. The bricoleurs displayed and expressed an overall positive response to the individual composition process and were noticeably satisfied with their final (but not always earlier) individual products. Four composers in my study (Bri, Draco, Josh, and Ryan) demonstrated that planning was preferable to them rather than bricolage. Similar to my findings, Johnson (2014) also concluded that participants worked both as bricoleurs and planners. Also similar was Johnson’s assertion that “bricolage is not an effective way of working for some pupils and some tasks” (p. 102).

Jeff was a discrepant case within this theme by exhibiting the ‘classic’ attributes of a bricoleur even more prominently than the other participants. Jeff epitomized the notion of a bricoleur who worked persistently with the material at hand rather than frequently discarding and starting over. At one point in the process, rather than creating a new composition, Jeff epitomized the bricoleur’s approach by creating multiple versions (i.e., variations) of the same composition using the same sonic elements for each variation.

Regarding the four planners (Bri, Draco, Josh, and Ryan), two appeared to be somewhat hindered by their planning tendency. Josh and Ryan’s planning tendency appeared to be somewhat of an obstacle for them and led to lower productivity levels. As individual composers, Ryan and Josh seemed to lack the typical characteristic of bricoleurs who have goals and intentions, “but set out to realize them in the spirit of a collaborative venture with the machine” (Turkle & Papert, p. 136). Contrastingly, Draco thrived as a planner for whom the software seemed like “an instrument for premeditated control” (Turkle & Papert, 1990, p. 136). Bri started over many times and left many ideas ‘on the table.’ However, she ultimately created a composition about which she was proud and expressed that composing individually was generally a positive experience.

Concerning the four focus composers whose collaborative processes I examined closely in Chapter 4, one pair coincidentally consisted of two planners (Draco and Ryan), and the other consisted of two bricoleurs (Chelsea and Emily). Their planner and bricoleur tendencies, respectively, appeared to nurture their generally successful and productive experiences. Notably, Chelsea and Emily seamlessly and mutually evolved from their individual bricoleur styles to being more planners as collaborators. Their transition to planners appeared to stem from the programmatic, sequential nature of the piece they decided to compose.

Contrastingly, the other two collaborative pairs (Jeff and Josh, Bri and Brittany) were less successful at negotiating their contrasting bricoleur and planner styles. Jeff sometimes felt like he was working on Josh's composition rather than collaborating and didn't appear to appreciate planning. Bri and Brittany were also a contrasting planner and bricoleur pair, respectively. Bri and Brittany concurred that it was challenging to agree, and my observations showed that Bri tended to defer to Brittany's planner style, possibly because Brittany was a more confident composer.

Scaffolding. A great deal of literature addresses the role of scaffolding in learning. Although Vygotsky (1978) himself did not use the term *scaffolding* in his discussion of *Zone of Proximal Development* (ZPD), educators sometimes connect scaffolding with ZPD. For example, Bruner and Haste (1987) associated scaffolding with ZPD when they described it as "the gap between what the child can currently do…and what she can achieve with intercession and scaffolding of adults or peers" (p. 6). According to Tobias and Duffy (2009), scaffolding refers to guidance "provided only when learners are unable to proceed" (p. 5). According to Duffy and Cunningham (1996), scaffolding is an unfortunate metaphor because it "implies guiding…of the learner toward some well-defined (structural) end" (p. 15). They, instead, believed scaffolding "must be viewed as a learning environment—as supporting the growth of the learner" (p. 15) without determining a predefined structural end. Similarly, Wiggins and Medvinsky

(2013) discussed collaborative learning and scaffolding within the context of music composition and advocated for approaching learning as "something the learner does rather than…something the teacher does *to* the learner" (p. 111), which aligned directly with the present study.

For the present study, I viewed scaffolding as Duffy and Cunningham (1996), and Wiggins and Medvinsky (2013) suggested, whose ideas of scaffolding resonate strongly with Papert's concept of a *mathetic* environment. This concept of scaffolding also parallels Bruner and colleagues' (Wood, Bruner, & Ross, 1976) description of scaffolding as a process in which a more knowledgeable other (Ruthmann, 2006; Webster, 2011; Wiggins, 1994) *guides* a learner toward a personal objective rather than directly *instructs* a learner toward a well-defined end.

Based on my concept of a constructionism-instructionism continuum, with bricolage (and its antithesis 'planning') and direct instruction at opposite ends, and scaffolding in the middle, the extent to which I observed scaffolding occurred slightly *less* than bricolage and planning, and much *more* than direct instruction (see Figure 149). This finding implies that, in this particular environment, participants engaged mostly in self-directed activities, engaged in slightly less scaffolded learning, and experienced minimal direct instruction.

Teacher scaffolding. In my role as observer as participant, I provided the majority of the scaffolding during the individual composition phase and less so during the collaborative composition phase. Although I occasionally encouraged participants when composing individually to engage with one another, they rarely did so. At times, participants would *listen* to one another's compositions, but rarely offered feedback beyond expressing satisfaction or mild dissatisfaction. Occasionally, one participant would ask another a technology-related question, but such interactions were minimal and rarely involved composition-related scaffolding. An exception to my observation was the way Draco organically took on the role of the expert technician or 'hacker' by explaining to others how to navigate the software and work around some of its musical and technical limitations.

Also notable, and particularly relevant to Tobias and Duffy's (2009) concept of scaffolding as guidance "provided only when learners are unable to proceed" ("Introduction," para. 9), I found that I *initiated* a preponderance of the scaffolding provided, and not necessarily at moments when participants expressed inability to proceed. At times, participants asked for or demonstrated a need for help when unable to proceed. However, and far more often, scaffolding took the form of me asking questions about participants' objectives and processes and offering unsolicited advice and sometimes no specific solutions.

My predominant type of scaffolding (i.e., asking questions about participants' objectives and processes without offering solutions) aligned closely with the type of scaffolding Downton (2015) observed in which questioning "prompted learners to go beyond what they already intuitively knew" (p. 150). My questions occasionally led to a suggested solution and sometimes led to direct instruction discussed further below, but usually left students to their own devices. My questioning approach resonated with Kaschub & Smith (2009), who asserted, "As composers attempt to explain their work to an ‘outsider,’ their own perceptions are strengthened and refined. This process of questioning and listening often coaxes a solution to the current challenge” (“The Teacher’s Role in Implementing Instruction,” para. 5). My role also resonated with Van Ernst (1993), who suggested, “a facilitating role where the teacher intervenes at strategic points during the compositional process and offers technical or imaginative suggestions” (p. 38).

Peer scaffolding. Unsurprisingly, after analyzing Draco and Ryan’s individual and collaborative processes, I noted that Draco often took the lead and functioned as the “more capable peer.” Ryan confirmed my perception in his final interview, saying, “I think what really helped me was actually like, Draco learned a lot of things, and he said them to a lot of people.” Contrastingly, although I noticed one incident during which Emily took on the role of “more capable peer,” Chelsea and Emily worked predominantly as equals.

Probably due to the dynamics of their relationship described earlier, Bri’s perception that Brittany did not value her ideas likely explained the lack of peer scaffolding observed during their collaborative process. Similarly, Jeff and Josh’s contrasting bricoleur (Jeff) and planner (Josh) tendencies appeared to work against a potentially dynamic relationship in which peer scaffolding might have otherwise thrived. These two collaborative pairs composed with each other more in a conciliatory manner than collaborative, which undoubtedly undermined the tendency for peer scaffolding to emerge.

My findings of peer scaffolding partially corroborated Tobias (2010), who found that "when provided with an open environment and informal learning situations to create and produce original music, students draw upon…their peers to scaffold their own learning and engagement" (p. 541). In the present study, only one of the four collaborative pairs exhibited explicit peer scaffolding. Scaffolding was much more often researcher-initiated or provided than peer-initiated or provided. I can only conjecture that my occasional prompts encouraging participants to interact were not enough to promote peer scaffolding. An alternative explanation might be that participants were disinclined to ask me for help or give or receive assistance to or from their peers based on prior experience. If these 7th-graders had not experienced similar learning environments beforehand, they might have been less inclined to interact with others and ask for help.

Technological scaffolding. For two participants (Brittany and Draco), Hyperscore functioned dynamically as a "partner in cognition…flexible and inviting enough to encourage exploration" (Goldman, Black, Maxwell, Plass, & Keitges, 2012, p. 334). Brittany overtly referred to Hyperscore as a form of artificial intelligence and expressed that this form of scaffolding undermined her credibility as a composer, saying, "I'm still using something else to help me compose. That kind of makes me feel like I am not exactly a composer." Draco did not explicitly refer to Hyperscore as a form of artificial intelligence. However, my interpretation of Draco's relationship with Hyperscore was one of close reciprocity. Draco often engaged in an intensive sing (or hum)-notate-playback cycle (SNP), during which he sometimes adjusted the *notation* to emulate his singing and sometimes adjusted his *singing* to match what Hyperscore played back. In these instances, it appeared as if Hyperscore were tutoring Draco while they created a melody in tandem.

Papert (1980a) asserted, “The aim of AI is to give concrete form to ideas about thinking that previously might have seemed abstract” (p. 157). In Draco’s case, he was able to quickly transform his abstract musical ideas to concrete ‘notation’ with Hyperscore’s assistance, probably more rapidly than using pencil and paper. However, from Brittany’s viewpoint, Hyperscore’s influence and support made her, and presumably Draco, *not* real composers.

Although some aspects of Hyperscore’s technology are outdated (e.g., General MIDI sounds and lack of control over internal tempo and dynamic changes), two types of technological scaffolding provided by Hyperscore are quite sophisticated and benefited all participants at some point. Algorithms interpret curves in lines drawn by the composer that “impose a pitch envelope on the motive’s repetitions but do not alter the melodic contour to the point that the new material is unrecognizable from the original motive” (Farbood, Kaufman, & Jennings, 2007, p. 51). These algorithms maintain the general contour of the composer’s melodies while altering pitches as needed to ensure their success in context. Algorithms also provide automated harmonization that reduces dissonance at two progressive levels. The effect of automated harmonization noticeably impacted two participants’ (Brittany and Emily) perceptions of themselves as composers at two points in the study. Emily once remarked, “I’m very proud of myself right now,” and Brittany, exclaimed, “I’m such a genius!” shortly after launching the harmonization algorithm and listening to the result.

Direct instruction and guidance. The metaphorical 'dance' in which I engaged throughout the 10 weeks vacillated among observing, responding to requests for help, intervening when I *perceived* assistance might be needed, and providing direct instruction when it felt appropriate. At one point, reflecting on my role as observer as participant, I noted, "I am feeling like I need to give more specifics about how to develop compositions." Whether to provide more direct instruction led to an ever-present source of tension for me.

Evident in the data was the participants' desire to develop their compositions. At times, they were able to find ways to develop their compositions on their own, and at other times they succeeded with some assistance. There were also some instances of participants who appeared at a loss for how to develop their compositions, did not ask for assistance, and I was unaware of their dilemma until later when reviewing video data. In these cases, compositions remained mostly in a stage of infancy. In these instances, in my effort to "provide help only when it is needed and stay out of the way when it is not" (Wiggins, 1999, p. 32), opportunities to develop compositions were lost because students did not ask for help, and I did not sense or notice the need when it arose.

Based on my experience, the challenge of providing help when needed and staying out of the way otherwise supports various scholars' assertions about the potential pitfalls of constructionism as an approach to learning (e.g., Perkins, 1992; Webster, 2006). Although all participants in the present study exhibited or displayed product- or process-oriented success to some extent without direct instruction and only occasional guidance, three participants (Chelsea, Emily, Josh) expressly stated that more direct instruction might have been beneficial. One participant (Chelsea) thought instruction would have been helpful in the beginning but appreciated autonomy in the end. Another composer (Emily) mentioned her occasional need for direction to help her "get in touch with her creative side," and a third participant (Josh) seemed slightly conflicted about the value of instruction. Josh indicated that having better software tutorials might have helped, but also said that too much instruction might have discouraged exploration. The lack of direct instruction was noticeable, and possibly somewhat detrimental, to these three participants.

Two participants' (Josh and Ryan) less successful individual composition experiences appeared to corroborate the aforementioned researchers who cautioned educators about constructivism. In Josh's and Ryan's cases, the limited amount of direct instruction and type of guidance (i.e., predominantly teacher-initiated) they received did not seem to sufficiently support their individual processes, and their productivity and personal affect appeared to decline to some extent when composing individually.
Josh and Ryan's apparent need for closer guidance, initial direct instruction, and gradual removal of scaffolding also corroborated Strand's (2003) finding that a more deliberate approach to scaffolding which included explicit direct instruction was effective for certain students rather than providing guidance "only when learners are unable to proceed" (Tobias & Duffy, 2009, p. 5). Kaschub and Smith (2009) asserted, "Young composers work best when they feel safe, and their safety often lies in knowing that an expert is nearby to help them should they run into problems." In the present study, however, students who ran into problems and needed guidance or direct instruction

sometimes went unnoticed.

Evidenced by Josh and Ryan's relatively unproductive individual composition processes, I suspect that my role as a guide who posed questions and functioned primarily as a resource was insufficient for them to thrive as novice individual composers. Relatedly, Boardman (2002) asserted, "Students accustomed to traditional instructional approaches may need extensive guidance at first until they realize that learning, and thus creating meaning, is their responsibility, not the teacher's. The teacher is there as a guide, as a problem poser, as a resource, but not as an all-knowing authority" (p. 11).

In addition to my observations about Josh and Ryan's implicitly displayed need for more direct instruction and closer guidance, four participants (Chelsea, Draco, Emily, and Josh) *explicitly* expressed that more direct instruction, if only at the beginning, might have been helpful to some extent. Chelsea and Josh expressed that the tutorial on the first day could have been more helpful. Emily once shared, "[Sometimes], I need someone else to tell me [what to do]," when describing how she sometimes struggled with self-expression. Draco once stated, "People like me…may be helped by some training," ostensibly referring to his 'mechanical' tendencies, which he once intimated were mutually exclusive of creativity. Jeff was a discrepant case, who explicitly denounced instruction, saying, "In most classes they make you follow certain rules; in this, you can just test and have fun. I don't like how teachers lecture you about how to use the tools. I don't like instructions."

The five composers discussed above (Chelsea, Draco, Emily, Josh, and Ryan) displayed or expressed, to varying degrees, a need or desire at some point for more instruction or guidance. These five participants corroborated Hickey (1995) because they *could* "compose music with little guidance and/or limited rules" (p. 202); however, they also expressed that more instruction would have been helpful to some extent. The participants in the present study further corroborated Hickey, who found that certain participants "did not seem to have ideas of what to do beyond [creating] short, nondescript groups of notes. While some children not only need a musical idea to begin with, but some suggestions for playing with it, and guidance for using it in a whole composition. Other children may be able to begin from a blank manuscript." (p. 203). Similarly, the blank Hyperscore sketchpad in the present study was not intimidating to some participants, some could only create short, nondescript motives, and others needed more guidance or direct instruction.

Navigating the constructionism-instructionism continuum. Based on examination of myself in the observer as participant role, and the minimal amount of direct instruction I observed taking place relative to the amount of scaffolding (see Figure 149 and Table 47), I am confident I kept direct instruction "in check" as Papert advised. However, the data showed that in two cases (Josh and Ryan), more direct instruction would have been advisable and that I probably offered too little guidance.

In the present study, the data showed that bricolage or its antithesis, planning, was much more prevalent than direct instruction and somewhat more prevalent than scaffolding (see Figure 149 and Table 47). Berkley (2001) emphasized the importance of "creating a balance between the promotion of objective knowledge of theory, technique, rules, and conventions transmitted by the teacher and the promotion of the student's subjective creativity, authority and ownership" (p. 258). In the present study, perhaps a more evenly distributed balance among bricolage, planning, scaffolding, and direct instruction in music theory and composition conventions would have led to a more impactful composition experience, particularly for Josh and Ryan, who, in retrospect, appeared to need more assistance.

In this study, students were, by design, *highly* independent bricoleurs and planners from the outset, and certain participants commented on how much they appreciated the autonomy. However, as Berkley (2001) intimated, it might have been better for participants like Josh and Ryan to compose in a setting in which their independence emerged gradually rather than practically immediately. Berkley asserted, "Understanding, identifying, and predicting how independence emerges whilst the student is still relying on teacherly instruction and guidance is the key to effective teaching" (p. 125).

In the present study, one participant (Emily) demonstrated that prior theoretical knowledge was directly useful in her composition process. Contrastingly, I observed frustration, albeit not debilitating, in two cases (Josh and Ryan). Therefore, engaging in some instruction that provided students with "shortcuts to reach compositional goals" (p. 148) might have been helpful to at least two participants in the present study. Relatedly, Bolden (2009) concluded that "theoretical music knowledge can provide students with shortcuts to reach compositional goals. Without knowledge of music theory, students risk debilitating frustration as they fumble in the dark to create the music they want to hear" (p. 148).

The Concrete-Abstract Dyad

Ackermann (2001) described Piaget's theory of learning as a gradual transformation from concrete to abstract thinking and pointed out that in contrast, Papertian constructionism views concrete and abstract thinking as equal partners in a dynamic relationship: "Papert's approach reminds us that…concrete thinking is no less important than figuring out things 'in the head'" (p. 7). Ackermann (1996) called for a redefinition of Piaget's general stages of cognitive development. Built on Piaget's concept of genetic epistemology or *epistemologie genetique*, epistemological pluralism (Turkle and Papert, 1990, 1991) holds that concrete and abstract thinking, and all gradations in between, are equally valid ways of knowing.

It is important to note that, in my study, I applied the concept of epistemological pluralism as described by Turkle and Papert (1990, 1991). I applied this lens while examining data in relation to the concrete-abstract dyad to help me identify the extent to which and how participants encountered, wrestled with, or bridged abstract musical thinking (i.e., thinking in sound) and concretizing (notating) their thinking using the composition tool provided. More recently, scholars such as Horst (2016) and Ruitenberg and Phillips (2012) have elucidated *epistemological pluralism* as a more complex and relevant construct in their respective discussions of cognitive pluralism and epistemological diversity. An extensive discussion of cognitive pluralism and epistemological diversity is outside the scope of this dissertation. However, these scholars bring to light the idea that the mind employs many special-purpose models for understanding the world that cannot be represented comprehensively or monolithically.

Such scholars challenge researchers to consider how these various special-purpose models can be used in conjunction with one another to produce understanding.

Epistemological pluralism. As I examined participants' processes through the concrete-abstract theoretical lens, some powerful manifestations of epistemological pluralism, as defined by Turkle and Papert (1990, 1991), emerged. Draco once stated, "I have an idea that's hard to explain in my words; it's much easier to explain in my actions," as he took over the mouse from Ryan to begin creating in graphic notation the inverted melody of which he was thinking abstractly. Draco's statement epitomized what I observed among these participants on many occasions; that is, abstract thinking and concrete action working in tandem to help participants realize their musical ideas. In other words, logical thinking was sometimes evidently "on tap, not on top" (Turkle & Papert, 1990, p. 168) for the composers in this study.

Other examples of epistemological pluralism included (but were not limited to) adjusting droplet sizes to create a desired augmentation or diminution effect, making lines fatter or skinnier to incorporate dynamics, thinking of a drumbeat and "impersonating it" with graphic notation, and using the graphic notation tools to apply the abstract concept of bi-tonality. Although the occasional negative case surfaced, such as Josh's admission that graphic notation does not help and Emily's ultimately stated preference for using traditional notation over less abstract graphic notation, many more impactful revelations of epistemological pluralism surfaced than discrepant evidence.

The incidents of epistemological pluralism I described in Chapters 4 and 5 and summarized in Table 48 elucidate novice composers "in relationships with their material that are more reminiscent of a painter than a logician," (Turkle & Papert, 1990, p. 128) (link to Table 48, Appendix F). As espoused by Turkle and Papert three decades ago and demonstrated by the young composers in the present study, "The computer, with its graphics, its sounds, its text, and its animation, can provide a port of entry for people whose chief ways of relating to the world are through movement, intuition, and visual impression" (p. 131).

Sound and sight. Overwhelmingly, epistemological pluralism revealed itself in the present study through a close relationship between sound and sight. Participants in the present study demonstrated three sound and sight relationships: (a) sound before sight (i.e., thinking in sound before notating), (b) sight before sound (notating before thinking in sound), and (c) sound *with* sight (i.e., notating and singing or humming practically simultaneously).

In some cases, Hyperscore facilitated a dynamic process in which participants thought in sound, drew (notated), listened and reflected, and repeated the cycle (i.e., sound before sight). At other times, I observed a powerful sound *with* sight process in which the composer and Hyperscore appeared to work in tandem to realize the composers' intended sonic elements. In these instances, Hyperscore's graphic notation icons and drawing tools functioned impactfully as "objects to think with" rather than preservation objects used solely to create visual representations of sonic elements *after* thinking in sound.

Contrastingly, it was evident that the Hyperscore graphic notation environment undermined thinking in sound at various points. At times, I observed participants engaged in an apparent sight *before* sound strategy, during which thinking in sound was evidently absent in favor of drawing impetuously. In these instances, epistemological pluralism consisted of *beginning* with the concrete, and in some cases *proceeding* to make do with 'whatever is at hand' (Lévi-Strauss, 1962, p. 11) to develop a viable sonic element. In other cases, in the spirit of planners, who "find this ['making do' approach] intolerable" (Turkle and Papert, 1990, p. 140), participants discarded impromptu drawings quickly or "left them on the table" after listening momentarily to the result. In these instances, I concluded that thinking in sound was minimal or possibly non-existent.

Turkle and Papert and advocates of revaluing the concrete might argue that, as equal partners in learning, it ultimately does not matter that participants in the present study sometimes *began* with the concrete object (graphic notation) that *led* to abstract thinking in sound while manipulating objects within Hyperscore. Turkle and Papert would likely equate thinking in sound with "hard thinking [that] has been given a privileged status," and argued that such thinking "can be challenged only by developing a respectful understanding of other styles where logic is seen as a powerful instrument of thought but not as the 'law of thought'" (1991, p. 168).

On the other hand, music educators might argue that young composers should typically be encouraged to think in sound first and that creating notation first and thinking about the sound it represents second undermines a fundamental objective of music education. Music educators should keep in mind that using notation software of any type for composition in the classroom could undermine thinking in sound by encouraging students to create notation first and think in sound later. The data in this study showed that, although there was evidence of thinking in sound before notating, the user-friendly graphic notation approach also facilitated a sight (i.e., notation) before sound approach.

The present study and Hyperscore's user-friendly drawing system for notating music compositions conjured up the classic 'chicken and egg' dilemma. The concern is that software such as Hyperscore might subvert developing musicianship by encouraging a sight *before* sound approach. For me, the critical difference is whether the novice composer uses the sonic elements represented by graphic notation as "objects to think with" or, to coin a music-oriented term, *objects to think in sound with.* If a novice composer notates first and then works as a bricoleur, the concrete and abstract become intellectual partners while thinking in sound is "on tap, not on top."

Concluding Thoughts about the Theoretical Framework

Based on the data discussed in the preceding sections, which I synthesized in Tables 46-48 (see Appendix F) and Figure 149, I concluded that constructs of Papertian, Piagetian, and Vygotskian learning approaches complemented one another to a great extent and provided a strong theoretical foundation for the present study of 7th-grade novice composers processes, products, and their responses to their processes and products. As Tudge and Winterhoff (1993) pointed out, constructivist theorists all share a basic aim—to understand development. Tudge and Winterhoff also asserted that, despite their interest in relations between social factors and cognitive development, scholars tend to categorize and isolate theories. This is where Papertian constructionism breaks down such isolationism. As I showed in the answer to my third research question, tenets of Papertian constructionism help to integrate constructs of cognitive and social constructivism (e.g., *metacognition* and *scaffolding,* respectively*)* to create a powerfully blended theoretical framework.

Papert and Harel (1991) distinguished constructionism from Piagetian constructivism by explaining:

> Constructionism…shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sandcastle on the beach or a theory of the universe. (p. 1)

For participants in the present study, their 'sandcastles' were musical compositions. The data and my answer to research question #1 showed they completed their 'sandcastles' using a wide range of relatively sophisticated composition strategies and processes with relatively little guidance and minimal direct instruction.

Findings presented in this chapter underscored numerous strengths as well as several shortcomings that surfaced as I examined this constructionist approach to composition with novice composers. Although the conceptual framework for this study blended tenets of Papertian constructionism, Piagetian cognitive constructivism, and Vygotskian social constructionism, ultimately, this study primarily reflected Papert's idea of constructionism. For the present study, I conceived of constructionism as a *learning approach* underpinned by theoretical constructs. However, particularly outside the field of music education, scholars and researchers continue to examine Papert's ideas of constructionism, and some argue that constructionism has been represented narrowly as a learning approach or a pedagogical theory. These scholars contend that constructionism "is as much a theory of epistemology as one of pedagogy" (Noss & Clayson, 2015, p. 285) and that Papertian constructionism goes well-beyond an emphasis on 'making things' in a Logo-type laboratory setting. Rather, constructionism is a way for children to learn how they learn and needs to be embraced more as an epistemological stance if it is going to have a lasting impact on education (Noss & Hoyles, 2017).

Also, my examination of novice composers' processes applied a relatively narrow range of related lenses that included constructionist-oriented ideas set forth by Papert, Piaget, and Vygotsky. Examining the same data through additional lenses could shed light on the relationship between constructionism and other theoretical perspectives. For example, in Turkle and Papert's (1990, 1991) discussion of epistemological pluralism, they suggested a link between epistemological pluralism and feminism. According to Turkle and Papert, feminist scholars contribute to the revaluation of the concrete and challenge the notion that "human reason best expresses itself within terms of Western male gender norms" p. 141. This study could have examined how gender manifested itself by asking students to compose in mixed gender groups, unlike the present study in which collaborators were same gender pairs.

From a critical perspective, for example, examining the composition activities of students using technology to compose compared with those using more accessible and affordable materials would be valuable insight. Almost thirty years after Turkle's collaboration with Papert, Turkle (2017) warned us that technology has the power to foster a " "new state of the self…split between the screen and the physical real, wired into existence through technology" (p. 16). This study shows music educators that composition with technology in a constructionist-oriented classroom has distinct advantages; however, music educators also need to continually consider the implications of technological influence on their students' lives.

Implications for Music Education

In the following sections, I discuss implications for music education in relation to the strategies and processes I observed among the four focus composers (research question one), all eight participants' responses to the process and their products (research question two), the application of the theoretical framework to the present study (research question three), and methodological implications.

Composition Strategies and Processes

Considering the wide range and relatively sophisticated use of traditional composition techniques by the relatively untrained and inexperienced composers in the present study (see Table 27, Appendix D), I concluded that these participants as a group successfully composed intuitively, and ostensibly learned what works in composition, and what does not to some extent. This finding implies that, as previous researchers have found intuitive thinking can be a useful "doorway in" (Wiggins, 2009, p. 40) for novice composers and set the stage for direct instruction that supports the acquisition of formal knowledge. There were several instances of this dynamic at work in the present study in which participants implemented a traditional compositional technique about which they had no formal understanding. This study shows music educators skeptical of including composition in the classroom that a constructionist-oriented approach to learning composition can be an effective doorway into formal understanding before students acquire music theory knowledge or skills with standard notation.

Music educators may have the tendency to overemphasize reading and writing standard music notation. This study supports the importance of emphasizing sound before sight (notation) and encourages music educators to question assumptions they might have about the need for students to fully grasp standard notation before engaging with composition. The findings in this study showed that novice composers with minimal or no knowledge of traditional notation can create compositions using sophisticated techniques resembling those employed by formally-trained composers. The graphic notation tools in this study facilitated the intuitive act of “making up music” (Paynter, 2002, p. 224) unencumbered by abstract standard notation. The implication of this finding is that knowledge of standard notation is not essential for learning how to compose, which corroborates many previous scholars’ assertions about novice composers’ processes. For example, Kaschub and Smith (2009) contended that novice composers can create music “that far exceeds their notational skills” (p. 109), which was evident in the present study.

Previous researchers have asserted that music educators often lack experience with composition and consequently do not have enough confidence in their ability to include composition in the music curriculum (e.g., Barret, 2006; Kaschub and Smith, 2009, Kennedy, 2002; Hickey, 2012.) The present study demonstrates for music educators that novice composers can succeed as intuitive composers without relying heavily on direct instruction in music composition. This does *not* imply that students learn composition best using technology alone, thereby eliminating the need for human interaction and instruction. Participants in this study expressed that they would have appreciated more direct instruction from me *or* the software. However, the type of constructionist-oriented environment described in this study indicates that students can 'jump right in' to composition without instruction from a formally-trained composer. An advantage of a constructionist approach is that a teacher without formal training in composition can learn *with* students.

Two participants demonstrated that lack of direct instruction adversely affected their success as *individual* composers but not as collaborative composers. Therefore, especially in cases where music educators might lack confidence in teaching composition, collaborative work might be the preferable or initial approach to learning composition for novice composers. Two participants expressly preferred individual composition, which implies that both scenarios could hold value for novice composers.

Overwhelmingly, participants in the present study focused on instruments (i.e., timbre) as the essential sonic element in their compositions. Participants in the present study devoted inordinate amounts of time exploring instrument sounds, and often displayed or expressed that instruments (i.e., timbre) were the basis of composition as opposed to other elements of music. Although six of the eight participants had previous musical experience and training, it appeared they also had a limited idea of possible springboards for their compositions. Music educators might consider how novice composers could benefit from preliminary instruction about the basic elements of music (i.e., rhythm, melody, harmony, timbre, form, dynamics, texture) to expand their 'toolkit' beyond timbre. However, this does *not* suggest that providing instruction in music theory and notation are advisable or necessary. Rather, it suggests that novice composers might need more guidance toward creating melodic and rhythmic ideas *before* assigning timbres as a means for expanding their ability to think in sound in diverse ways. Possibly, listening to music (Kaschub & Smith, 2009) might encourage novice composers to think in sound and help them consider a wider range of starting points for composition beyond timbre.

Responses to the Process and Products

Being a composer. If music composition is to become more prevalent in music classrooms, music educators might consider how to counteract the sentiment that composition is something that "other, specially talented, people do" (Paynter, 2000, p. 25). Music educators might consider how a constructionist approach can help dispel stereotypes of composition as something that highly-trained musicians do. Overall, participants in this study expressed a lack of confidence in their *qualifications* as composers and held fast to their pre-conceived ideas of a composer as someone classically-oriented, innately capable, or specially trained. A few participants eventually referred to themselves as composers in-training, a finding indicating that these participants' experience affected their perceptions of composition to some extent.

Taking or needing time. The novice composers in the present study indicated they needed or intentionally took more time to develop and improve their compositions, which is consistent with several findings by several other researchers. Consistent with implications of previous studies I reviewed, music educators might allot more time to fewer composition activities to allow time for bricolage and planning alike. In this study, participants expended considerable time while in ‘planner’ mode, which often led to starting over and less productivity. Had the planners worked more as bricoleurs by persisting with a given set of material over time or drawing from multiple sources for ideas, they might not have felt the need for more time.

Music educators might find it challenging to embrace the ‘messiness’ inherent in bricolage and encourage students to explore this modality. Particularly in a standards-based culture, music educators might be uncomfortable with the open-ended nature of bricolage, which might affect a novice composer’s ability to meet pre-determined standards. However, constructionism places emphasize on creating personally meaningful products and learning how to learn rather than meeting pre-defined standards. Negotiating this tension will likely be a challenge for music educators applying a constructionist approach to a standards-based classroom.

Originality. Music educators might encourage novice composers to reflect on the extent to which originality is important and consider how to foster originality, particularly when using loops-oriented software. I found that five of the eight composers demonstrated a sense of pride and ownership in their work and expressed distinct concern about originality. Although I suggested the idea of creating a personally meaningful product to participants at the outset of the study, I subsequently provided no explicit reminders about this idea. My finding that participants expressed the importance of originality without being prompted to do so was relatively unique in comparison with the studies I reviewed.

Agency, freedoms, constraints. Agency was important to several of the composers in this study. Contrastingly, there were indicators that more guidance would have been beneficial to at least two participants, and three participants commented on the potential benefit of more direct instruction. This finding implies that, although novice composers may express appreciation for freedom as some did in the present study, continually assess whether there is balance between freedoms and constraints is advisable. My finding resonated with those by previous music education researchers who have considered the dialectical relationship between freedoms and constraints. The need for balance between freedoms and constraints underscores the ongoing constructionism-instructionism tension that the present study perpetuated. There were indicators throughout this study that the emphasis on freedom with few constraints beyond those inherent in the software might have contributed to some of the dissatisfaction or frustration expressed by these participants. Music educators considering applying a constructionist approach to composition might want to anticipate how they will provide enough of a foundation and structure (i.e., constraints) for students to be successful as composers without imposing too many rules.

In my role as observer as participant, I had a tendency to stay out of the way, that is, observe more than participate. However, I ultimately determined that most participants would have benefited from more guidance or instruction. My dual role as observer as participant was difficult to balance, and my ongoing concern about being more of a 'guide on the side' was pervasive and likely affected the outcome. Music educators interested in designing a similar study might want to consider the pros and cons of the observer as participant role and possibly consider focusing on observation while another music educator functions as the 'guide on the side.'

Individuality and collaboration. Participants were evenly divided about their preference for collaborative work over independent composition. In two cases, the *individual* composition process (but not the collaborative process) appeared to result in frustration, and possibly *cognitive complexity* (Perkins, 1992). I found that a constructionist approach to composition requires fine-tuned scaffolding and extensive time to think and reflect to avoid learner frustration, particularly for individual novice composers. The two individuals who appeared to experience cognitive complexity and frustration were much more successful as collaborative composers. This finding indicates that collaborative composition rather than individual work *might* be more conducive to learning music composition in a constructionist-oriented environment.

For two students, collaboration was somewhat problematic, though not due to cognitive complexity. These two participants overtly stated that they worked better when they were physically in control of the drawing process with the mouse. This finding indicates that a wholly collaborative composition experience for novice composers using technology might *not* be effective when just one of the composers has physical control of the technology. When a learner is not physically making their composition, a critical component of constructionism is absent. Even though the learner might still be cognitively and affectively involved through discussion and listening to playback of their composition, not being hands-on might detract from their sense of 'doing' and ownership. Music educators might consider using technology that facilitates more uniform hands-on learning. For example, certain ‘cloud-based’ digital music software allows all collaborators to be hands-on. Also, a collaborative composition using instruments first and notation later (if at all) might be preferable. Inversely, “hands-on is not enough without heads-in and play-back” (Ackermann, 1993, p. 2). The challenge for constructionist-oriented music educators is to facilitate composition activities that ensure the integrity of this complex three-part learning model.

For different reasons, two composers were adamant that composing alone was better for them. One felt like they tended to be overly deferential and not assertive about expressing ideas, and one felt like they were making the other person’s composition. Although 21st-century learning often emphasizes collaboration, music educators might consider that certain students might thrive more when composing alone. However, it might be important to consider the implications for such students’ ability to learn how to learn if they work strictly individually.

Previous knowledge or experience. Five of the eight composers implicitly or explicitly displayed or expressed that previous knowledge was useful to them as composers, which they drew on intuitively without being prompted to do so. Several previous studies have examined the influence of previous musical experience, particularly instrumental music lessons, on novice composers’ processes (e.g., Burnard & Younker, 2002; Seddon and O’Neill 2001, 2003, 2004; Stauffer 2002). Although I did not examine the data explicitly through the lens of instrumental music training, there was evidence in this study that resonates with implications of previous studies in which participant’s instrumental music training benefited novice composers to some extent.

Conversely, this study also found that two composers with minimal and no previous musical experience, respectively, were successful to some extent.

Part of my rationale for pursuing this study was to shed light on an approach to composition that might help support the idea that, although children might not be ready to compose a symphony, “they certainly can engage in the process of creating original musical ideas” (Wiggins, 2002, p. 103). Hopefully, this study encourages music educators to consider the act of creating original musical ideas or “making up music” (Paynter, 2002) as synonymous with composition, and that all children can compose regardless of prior knowledge or experience.

Responses to compositions. In this study, it appeared there might have been a relationship between participants’ compatible (or incompatible) working styles and their impression of their products. Because of the relatively small amount of data related to participants’ responses to their products in this study, further research would be needed to determine if there were relationships among participants’ working styles, perceptions of the process, and opinions of their resulting products. However, considering the inextricable link between process and product in a Papertian constructionist environment, future music educators considering a constructionist approach to composition might want to consider the importance of providing ample time for novice composers to reflect on process and product alike.

I found that participants’ dissatisfaction often appeared to stem from their lack of success with fitting sonic elements together. Part of this challenge was likely related to the disassociation between discrete sonic elements and their context within their composition as a whole. Hyperscore's design inherently creates this disassociation. In Hyperscore, composers create sonic elements in separate 'windows' first and transfer them to the sketchpad (score) later. This finding indicates that more direct instruction on how to approach combining sonic elements might have increased these composers' level of satisfaction with their compositions. This finding also alerts music educators to the importance of evaluating the inherent shortcomings of music composition technology in advance—anticipating the type of direct instruction or scaffolding that students will need to be successful.

Constructionism-Instructionism

My attempt to "provide help only when it is needed and stay out of the way when it is not" (Wiggins, 1999, p. 32) appeared ineffective to some degree in the present study and has significant implications for music educators. My analysis revealed that, despite participants' appreciation for the freedom and autonomy, at least two of the eight participants in the present study would have benefited from additional close guidance and direct instruction. Other participants *suggested* that more guidance, at least at the beginning, would have been helpful This finding alerts future music educators to the potential pitfalls of minimal guidance and the idea of scaffolding as guidance "provided only when learners are unable to proceed" ("Introduction," para. 9). I found that student success in a constructionist-environment such as the one applied in my study depends heavily on the instructor's ability to provide guidance that is highly "situated, flexible, and responsive" (Wise & O'Neill, 2009, p. 101).

Considering the practically unanimous consensus among participants that fitting multiple sonic elements together vertically was difficult, participants in this study would probably have felt more successful if given more direct instruction about how to approach combining multiple sonic elements vertically to create harmony and polyrhythms. Despite Hyperscore's algorithms that assisted with making multiple sonic elements complement one another, participants frequently remarked about how difficult it was to combine several discrete musical ideas vertically. This finding suggests to music educators that direct instruction in a constructionist environment can be as valuable as allowing students to learn how they learn through bricolage and scaffolding.

The value of direct instruction might be underestimated when constructionist-oriented music educators focus on helping students learn *how* to learn more through scaffolding and bricolage and less through direct instruction. Furthermore, constructionism might be misunderstood as a 'discovery' approach to learning that provides minimal guidance. Overemphasis on self-directed learning and guidance provided "only when a learner is unable to proceed" (Tobias and Duffy, 2009, p.5) could undermine the value of and need for direct instruction in a constructionist environment.

Although I noted evidence of the need for more direct instruction and closer guidance by me at times, I also found that Hyperscore's design and algorithms provided impactful scaffolding several times during this project. Future music educators might find that sophisticated music composition software will become increasingly capable of scaffolding the composition process, thereby enabling novice composers to learn composition without the need for direct instruction. Therefore, music educators might consider how such intelligent technology might *lessen* the perceived importance of including composition in the music classroom, and what the role of a music educator might be in a composition class that *includes* highly intelligent software. Considering the often-limited amount of time available for music instruction in schools, highly intelligent music composition software could contribute to the rationale for not including composition in the curriculum.

Affect-Cognition

Ego- and *body-syntonicity* (Papert, 1980a) were the variables of interest that surfaced to the greatest extent within the affect-cognition dyad. Participants' displayed or expressed that their likes, dislikes, goals, and intentions played a significant part in their processes. Also, body-syntonicity in the form of humming, singing, air drumming, and drawing contour in the air played a role in participants' processes. This aspect of a constructionist environment might easily be overlooked within composition activities or thought of as merely enrichment for cognitive processes. However, this study implies that music educators might need to be reminded that the affective aspects of the composition experience in a constructionist setting function as equal partners with cognitive processes.

This study indicates that hard fun might not surface organically in a constructionist-oriented composition environment, and music educators may need to purposefully orchestrate such learning. *Hard fun,* which Papert described as a process that is fun *because* it is hard, only surfaced occasionally. Future music educators interested in constructionism as a framework for composition activities might give special consideration to designing experiences that resonate with Papert's idea of hard fun. Implicitly related to Papert's idea of hard fun is Vygotsky's (1978) *Zone of Proximal*

Development. 'Hard' and 'fun' meet when the challenge at hand is "in advance of development" (p. 89) but achievable. Designing such experiences is the challenge for future music educators implementing constructionism as a framework.

Music educators unaccustomed to allowing time for students to reflect and act on their reflection might easily overlook this critical aspect of constructionism. To some extent, for each participant in the present study, this environment and learning approach fostered thinking about their processes. This setting was also conducive to participants reflecting on their composition processes and learning how to learn. A constructionist approach to composition relies partly on time for composers to dive in, step out and observe what they have done, think about their thinking, and dive back in. It is through such processes that learners learn how to learn.

The present study corroborated others' finding that use of think-aloud data can provide useful information when attempting to discern participants' strategies and processes and their response to their processes and products. Although *concurrent* verbal reporting would likely have been difficult for the 7th-grader composers in the present study, I found that asking them to "stop, talk, point (to the screen), and play (i.e., listen to their compositions) corroborated Ericsson and Simon who found that participants who were asked to engage in *immediately retrospective reporting* can retrieve valid information when a general instruction is given "to report everything you can remember about your thoughts during the last problem" (p. 19). Keeping in mind that think-aloud data cannot be claimed as insight into the human mind, music education researchers who take time to *ask* students to describe their processes and products in the context of *immediately retrospective reporting* could gain valuable insight into novice composers' processes.

Epistemological Pluralism

One of the most significant findings in this study emerged from the processes of four participants who explicitly articulated or implicitly demonstrated that thinking in sound is a vital composer attribute and one composer who claimed his ability to think in sound improved during the 10 weeks. For these composers, Hyperscore's graphic notation icons and drawing tools functioned impactfully as concrete objects to think *with* rather than merely preservation objects for notating sonic elements *after* thinking in sound. This finding implied that a constructionist-oriented environment "in which the mind can think with objects" and technology provides "a physical path of access to the world of formal systems" (Turkle & Papert, 1990, p. 143) can promote thinking in sound and a dynamic interplay between the abstract and concrete. This finding alerts music educators to the potential of a constructionist-oriented experience such as the one described in this study to foster a cognitive process many consider fundamental to music education; that is, teaching students to think in sound.

Despite the dynamic interplay between the abstract and concrete that was evident in the present study, it was also apparent that this constructionist environment, with its accessible concrete graphic notation tools, has the potential to undermine thinking in sound. At times, I observed participants engaged in an apparent sight *before* sound strategy, during which thinking in sound was likely absent in favor of drawing impetuously or creating an interesting picture. Future music educators using technology with composition activities need to consider how the use of technology and digital graphic notation might compromise thinking in sound. In this situation, it is advisable to regularly prompt novice composers to consider and imagine the sounds they intend to create before notating it with a digital notation or recording tool.

Music educators have argued that young composers should always be taught to think in sound first. The present study, and Hyperscore's uniquely user-friendly drawing system for notating music compositions, conjured up the classic chicken and egg' dilemma. Wiggins (2007) asked, "Must a musical composition be notated?" (p. 455). Two participants in the present study explicitly stated that notation is essential for preservation purposes. However, other than brief references to preservation by two participants, there was no data in the present study to indicate that graphic notation was particularly necessary or beneficial for these participants.

Music educators might consider that a constructionist approach using 'objects to think with' other than digital graphic notation could be as beneficial as the graphic notation approach to composition used in this study. It might be that composition without involving *any* notation might be best for some novice composers. For example, "physically enacting sound…allows the composer to acquire and represent physical or bodily-based understanding of musical gestures and intents" (Kaschub & Smith, "A Rationale for Composition," para. 13) and could substitute for notation. Novice composers might also find that composing music by performing and recording yields similar or better results than composition with notation (Tobias, 2010). Nevertheless, the dynamic interplay between graphic notation ('the concrete') and thinking in sound ('the abstract') was powerful in the present study.

Methodological Implications

I applied maximum variation sampling to potentially enhance transferability. I purposefully chose participants with varied musical backgrounds and different genders, which "allowed for the possibility of a greater range of application by readers or consumers of the research" (Merriam, 2014, p. 227). However, variations among participants' characteristics in my study were not particularly wide-ranging due to the small and homogenous pool of potential participants.

Although maximum variation sampling allowed me to establish a *somewhat* diverse group of participants, it is unlikely that diversity was enhanced to a great extent with the three demographic criteria I considered: gender, private music lessons, and previous experience creating original music. These criteria were chosen out of convenience and not out of my interest in explicitly examining the data through these lenses. These appeared to be the only criteria for establishing a somewhat diverse group of participants within the population being sampled. Future music educators encountering a similarly homogenous pool of potential participants might consider the extent to which purposeful sampling could enhance transferability. Despite the likelihood that maximum variation sampling did not enhance transferability, the descriptive data provided in this study as well as my application of the theoretical framework as both a *lens* and a *filter* likely enhanced transferability (Lincoln & Guba, 1985; Miles, Huberman, & Saldaña, 2013) and *analytic generalization* (Yin, 2012).

Regarding participants' *responses* to their processes and products and research question #2, there was limited time to interview participants about their responses to their processes and products. Consequently, the amount and quality of data for answering research question #2 were slightly compromised in comparison to the other two research questions. Future music educators interested in examining novice composers' *responses* to their process and product might consider that 40-minute composition periods once or twice weekly in this study was somewhat insufficient for collecting interview data.

The embedded case study design resulted in collecting data from 12 cases, eight individual composers, and four collaborative pairs. Qualitative research scholars warn novice researchers of data overload, which was my experience. I was able to engage in some fundamental analysis while collecting data, as well as between data collection activities, and NVivo software helped facilitate simultaneous, preliminary analysis during the 10-week data collection period. However, much more time for concurrent data collection and analysis is advisable for future novice researchers planning to embed multiple case studies.

Suggestions for Further Research

Numerous studies within the field of music education have examined novice composers' processes and strategies through a *constructivist* lens; however, relatively few have examined novice composers' processes through an overtly Papertian *constructionist* lens. Although the present study was not underpinned exclusively by Papert's idea of constructionism and was instead an amalgam of Papertian constructionism, Piagetian cognitive constructivism, and Vygotskian social constructivism, it was relatively unique in its intentional inclusion of Papertian constructionism as part of the theoretical framework. Seven prior studies I reviewed within the field of music education explicitly examined Papertian constructionism as an approach to learning. Evidently, further research about the viability of Papertian constructionism as an approach to learning music composition is needed.

The data showed that at least two theoretical variables of interest (*hard fun* and *socio-cognitive conflict*) situated within the affect-cognition theoretical dyad might have been affected by the 'low stakes' environment of the present study in which there were few constraints and no formal evaluative components. Further research is needed in a constructionist-oriented environment that is more balanced between constraints and freedoms and also includes assessment as described by scholars such as Hickey and Lipscomb (2006), and Kaschub and Smith (2009) to determine the impact of the constructionism approach on affect and cognition. The present study integrated more freedoms than constraints and included no assessment.

This study did not explicitly aim to examine whether learning *about* composition took place. I inferred from the generally positive affect displayed by most of the participants most of the time that they were *open* to learning and probably learned something about composition in the process. I also inferred from the somewhat regular occurrence of scaffolding, and occasional direct instruction that some amount of learning *about* music composition took place. However, future studies might explicitly assess learning about composition in a constructionist-oriented environment.

Considering that the four focus composers either talked explicitly about the importance of being able to think in sound or commented about their ability to think in sound, more research is recommended about novice composers' cognizance of and ability to apply this critical skill in a constructionist-oriented environment. Also, considering that sight *before* sound (notating before thinking in sound) was evident on a few occasions, more research about whether graphic notation programs such as Hyperscore either support or undermine thinking in sound is needed.

Numerous music education scholars have written about the potential perils of requiring notation as part of a novice composer's process. Because of Hyperscore's accessibility and user-friendliness as a graphic notation tool, it appeared to function well as the type of shared notational system to which Bamberger (2005) referred. However, it is possible that this constructionist-oriented environment, paired with Hyperscore as a composition tool encouraged the perception that notation is an essential aspect of composition. Further research is needed to confirm or disconfirm this possibility.

Considering that Hyperscore's design integrates graphic notation with the option of applying conventional Western notation constructs (e.g., observing measures and creating traditional note values), and two participants' stated preference for standard notation, it might be that Hyperscore or other software are useful tools for integrating non-traditional and standard notation. However, the present study was not explicitly designed to explore this relationship, and further research is needed to examine this relationship.

This study appeared to corroborate other studies in which participants preferred collaboration over individual composition to some extent. However, three of the eight composers articulated a preference for individual composition over collaborative composition, and one seemed ambivalent, two findings that indicate a need for further research. Considering that 21st-century learners are often expected to collaborate in educational settings, future music educators need to continue comparing collaborative and individual processes. In the present study, participants composed alone first and collaboratively second. Future researchers might reverse this sequence and consider whether novice composers should start in a collaborative setting or should have agency over whether they compose alone or with others altogether.

Conclusion

The problem addressed in the present study is one sometimes perpetuated by well-intentioned music educators who, already accustomed to working with traditional notation, might expect students to understand this arguably abstract system before learning to compose music. The present study grew out of my desire to address this problem by including more composition activities in my music classroom using progressive approaches that do not hinge on understanding abstract standard music notation. My search for solutions led me to a 2015 professional development workshop led by several of Papert's contemporaries, a visit to the MIT Media Lab, and my first encounter with Hyperscore composition software developed by aficionados of Papert's constructionist-oriented approach to learning.

The three research questions in the present study guided my examination of the participants' strategies and processes, their *responses* to their processes and products, and the three concept dyads that emerged from my deep dive into constructionism, respectively. The present study revealed that novice composers with relatively little to no formal musical training and relatively little to no previous experience creating original music could produce compositions emulating strategies and processes used by professional composers. The present study also showed that participants relied on inspiration as do professional composers and were able to intuitively and successfully manipulate, but not necessarily combine vertically, multiple sonic elements with minimal guidance and practically no instruction.

Participants exhibited evidence of thinking in sound and thinking *about* thinking in sound. However, findings also alert future music educators and researchers to the potential of such an environment to *threaten* thinking in sound by its emphasis on graphic notation, which could place ‘the cart before the horse’ (i.e., symbol before sound). Also, the participants in the present study reinforced Bruner’s (1977) assertion that “any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (p. 33). Although I did not explicitly *teach* composition to the participants in the present study, there was some evidence of *learning* about composition by several of the novice composers in the present study.

Participants in the present study were generally skeptical of themselves as bona fide composers. However, this did not dissuade them from responding to the process with perseverance. Participants pursued their desire to develop their compositions, expressed and displayed appreciation for the time it takes to create a composition and demonstrated that they valued agency, autonomy, originality, and prior experience. Although this study cannot conclusively state that either individual or collaborative composition was the most efficacious, participants in the present study overall expressed a preference for collaboration. This study helped illuminate the benefits and drawbacks of independent work and collaboration, respectively, for future music educators.

The novice composers in the present study demonstrated or expressed benefiting from technological scaffolding provided by Hyperscore. Although technological scaffolding was particularly impactful for two of the eight participants in the present study, it was evident that more inquisitive teacher intervention and more responsive and situated guidance was needed for at least two other participants.

The present study underscored that agency and autonomy are valuable to novice composers, which was consistent with findings by other researchers. Relatedly, participants in the present study demonstrated that a balance between freedoms and constraints is essential to a novice composer's success. The present study emphasized freedoms more than constraints, and the data showed this emphasis adversely affected at least two composers' individual processes.

At times, participants in the present study demonstrated that this experience resembled Papert's description of *affective computing*. *Ego syntonicity* and *body syntonicity* abounded, although little evidence of *hard fun* surfaced. The novice composers in the present study engaged fluidly in researcher-prompted as well as self-imposed metacognition, and four participants notably exhibited evidence of *reflexivity* by turning their 'thinking about thinking' into explicit actions to develop their compositions.

The novice composers in the present study worked as bricoleurs and planners and sometimes transitioned from one to the other as needed. Participants were able to compose successfully with some guidance and very little direct instruction. However, these novice composers' processes and resulting products also confirmed that minimal guidance within this constructionist environment is as much the 'slippery slope' intimated by various scholars who caution about the potential pitfalls of constructionism.

Impactful examples of epistemological pluralism, as defined by Turkle and Papert (1990, 1991), surfaced regularly in the present study, indicating that this constructionist environment fostered both abstract and concrete thinking, each equally valid in their own ways. The technology-based approach to composition in the present study accommodated abstract, formal processing as an equal partner with concrete ways of thinking for people whose preferred modality for composing music might be body-syntonic, tactile, visual, intuitive, or various combinations of these modalities.

APPENDIX A: PAPERT'S EIGHT BIG IDEAS BEHIND THE CONSTRUCTIONIST LABORATORY

(Return to document)

Retrieved June 9, 2014 from http://stager.org/articles/8bigideas.pdf

The first big idea is learning by doing. We all learn better when learning is part of doing something we find really interesting. We learn best of all when we use what we learn to make something we really want.

The second big idea is technology as building material. If you can use technology to make things you can make a lot more interesting things. And you can learn a lot more by making them. This is especially true of digital technology: computers of all sorts including the computer-controlled Lego in our Lab.

The third big idea is hard fun. We learn best and we work best if we enjoy what we are doing. But fun and enjoying doesn't mean "easy." The best fun is hard fun. Our sports heroes work very hard at getting better at their sports. The most successful carpenter enjoys doing carpentry. The successful businessman enjoys working hard at making deals.

The fourth big idea is learning to learn. Many students get the idea that "the only way to learn is by being taught." This is what makes them fail in school and in life. Nobody can teach you everything you need to know. You have to take charge of your own learning.

The fifth big idea is taking time – the proper time for the job. Many students at school get used to being told every five minutes or every hour: do this, then do that, now do the next thing. If someone isn't telling them what to do they get bored. Life is not like that. To do anything important you have to learn to manage time for yourself. This is the hardest lesson for many of our students.

The sixth big idea is the biggest of all: you can't get it right without getting it wrong. Nothing important works the first time. The only way to get it right is to look carefully at what happened when it went wrong. To succeed you need the freedom to goof on the way.

The seventh big idea is do unto ourselves what we do unto our students. We are learning all the time. We have a lot of experience of other similar projects but each one is different. We do not have a preconceived idea of exactly how this will work out. We enjoy what we are doing but we expect it to be hard. We expect to take the time we need to get this right. Every difficulty we run into is an opportunity to learn. The best lesson we can give our students is to let them see us struggle to learn.

The eighth big idea is we are entering a digital world where knowing about digital technology is as important as reading and writing. So, learning about computers is essential for our students' futures BUT the most important purpose is using them NOW to learn about everything else.

APPENDIX B: PARTICIPANT DATA FORM

(Return to document)

* 1. Student's first name

* 2. Student's last name

* 3. Please indicate whether or not you are interested in participating in this research study.

○ **I wish to participate in this study**

○ **I do not wish to participate in this study**

Pacific Ridge School 7th grade music research study

This page is for those interested in participating in this study...

* 4. Please select a gender

○ Female

○ Male

* 5. Please describe any experience you have had with creating original music. If you have never created original music, please write "none."

* 6. Have you ever taken private music lessons?

○ No

○ Yes

Pacific Ridge School 7th grade music research study

This page is for those who have taken private music lessons at some point...

* 7. For approximately how long did you, or have you taken private music lessons?

○ 1 year or less

○ More than 1 year

APPENDIX C: SEMI-STRUCTURED INTERVIEW GUIDE

(Return to document)

The purpose of semi-structured interviews in this study was to generate data for examining participants' displayed or expressed responses to the composition process and products they created within this environment. The pre-determined questions I used for semi-structured interviews were:

- Did you make a plan for your composition today? If so, what was it? If not, how did you get started?
- Did you enjoy composing music today? Why or why not?
- Was Hyperscore a helpful tool while composing music today? Why or why not?
- Was there anything you wish you could do with Hyperscore that was not possible?
- Did your partner or I help you while composing today? If so, in what way(s)?
- Were you satisfied with your composition today? Why or why not?
- Next time, do you think you will build on what you did today or start over? Why?
- *Do you prefer composing music individually or with your partner? Why?
- *Do you think your ability to compose music has improved over the past 10 weeks? Why or why not?
- *What advice would you give to a someone else composing with Hyperscore in the future?

Merriam (2014) suggested that wording of questions may vary, and new questions might surface in a semi-structured interview. The semi-structured interview format allows the researcher to "respond to the situation at hand, to the emerging worldview of the respondent, and to new ideas on the topic" (p. 90.) Many variations of my pre-determined questions as well as new questions emerged throughout the 10-week data collection period. Variations on pre-determined questions and emerging new questions included:

SEMI-STRUCTURED INTERVIEW GUIDE CONTINUED

(Return to document)

- What are some fun things about composing music?
- What aspects of composing are you good at?
- What aspects of composing have been difficult for you?
- What have you learned about composing since we started this project?
- Would you call yourself a composer? Please be specific about why or why not.
- Talk about your successes and challenges as a composer.
- Talk about what makes composing fun.
- Talk about what makes composing hard.
- Talk about what you have enjoyed or not enjoyed.
- Talk about Hyperscore as a tool for composing music.
- Please talk about what you think a composer does.
- Please talk about what makes a good composition.
- Please describe anything that was *fun* or successful while you were composing today.
- Please describe anything that was *hard* or unsuccessful while you were composing today.
- Please talk about your experience using Hyperscore for composing today. Did you learn how to do anything new?
- What have you learned about composing since we started this project?
- Please show and play the composition that you have been working on today and describe how you feel about it. What do you like or not like about it? Do you think you could change it in any way to improve it?
- Now that you have been composing for a few weeks, what do you think of composing?
- Do you think of yourself as a composer? Why or why not?
- How are you feeling about your progress as a composer so far?
- Please describe as many of the strategies you can think of that have or have not worked so far.
- What are some specific things you have learned about composing music so far?
- Please show a composition that has been most successful for you and explain why.
- Please show a composition that has not been the least successful for you and explain why.

*I asked these questions on the final day only.

APPENDIX D: FIGURES AND TABLES RELATED TO RESEARCH QUESTION #1

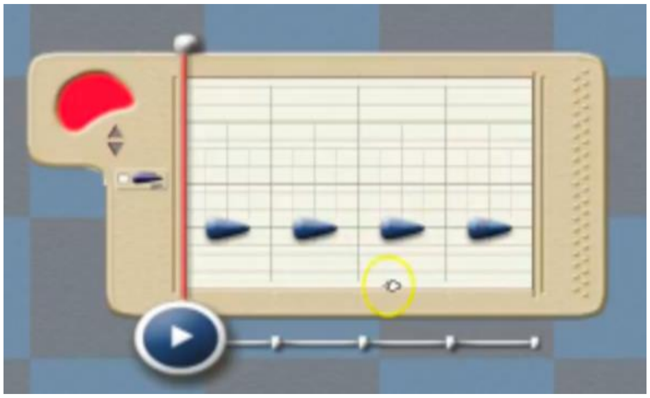


Figure 3. Hyperscore screenshot illustrating Emily's strategy of using repeated note durations and even spacing.
(Return to document)

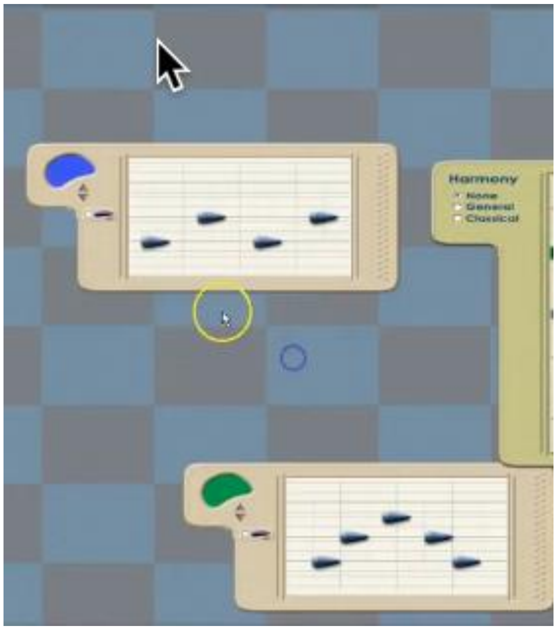


Figure 4. Hyperscore screenshot of Emily's strategy of aligning notes to the grid.
(Return to document)

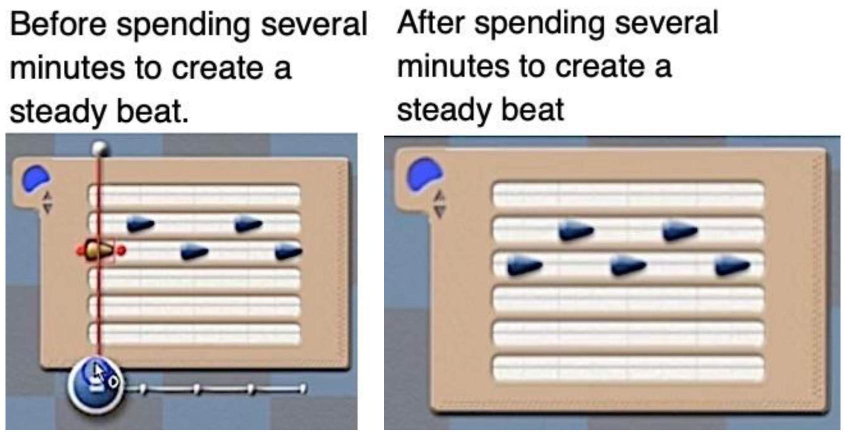


Figure 5. Hyperscore screenshot illustrating Emily's strategy of using repeated note durations and even spacing. The vertical grid lines represent beats.
(Return to document)

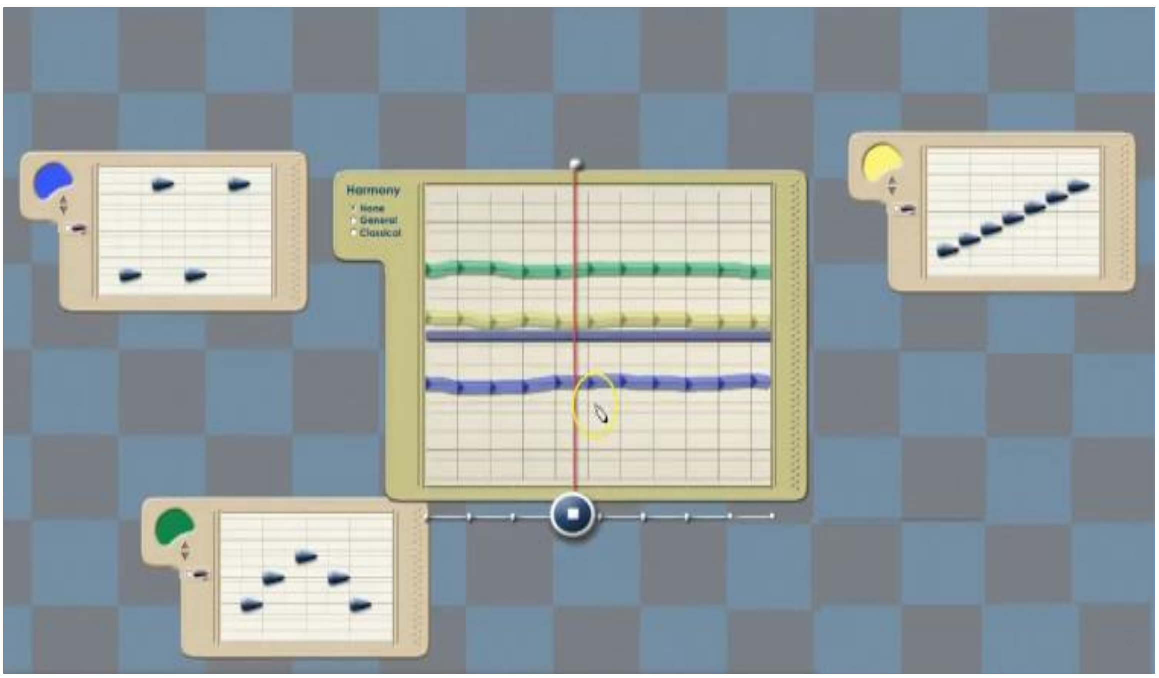


Figure 6. Hyperscore screenshot illustrating Emily's organized, linear approach to melodic and phrase contour. In Hyperscore, the composer uses the melody windows to create melodies by drawing droplets (notes). The larger window in the center is the Hyperscore sketch window in which the composer draws lines to combine melodies and create phrases.
(Return to document)

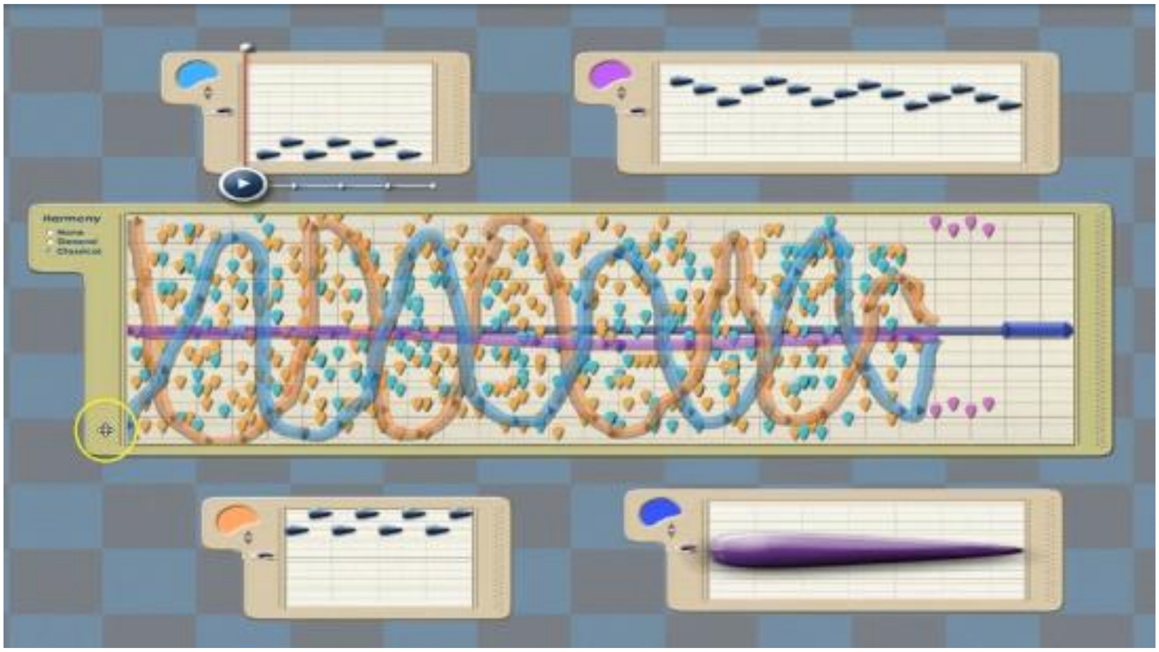


Figure 7. Emily’s final individual composition combining linear and organized melodies (smaller windows) with curvilinear style phrases and random droplets in the sketch window (larger window in the center). Droplets in the sketch window are used to create chords.
(Return to document)

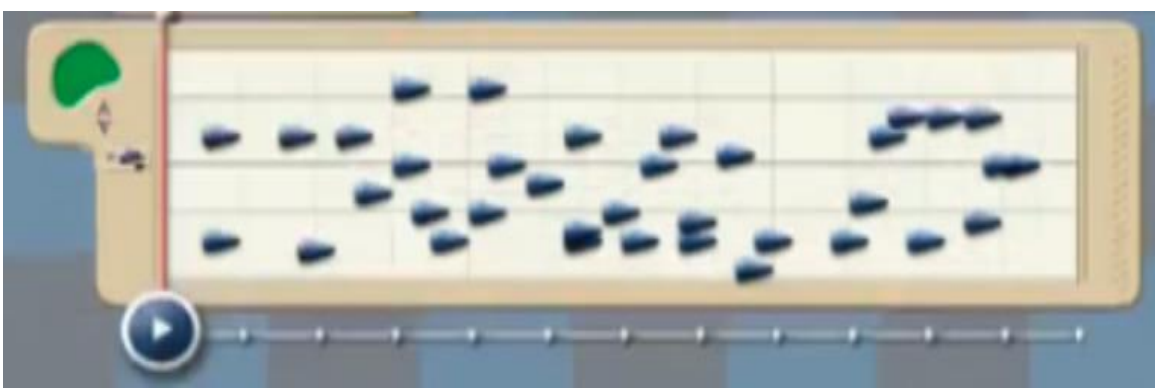


Figure 8. Hyperscore screenshot illustrating Emily’s only attempt to compose a motive using unpredictable intervals, which she immediately deleted from her composition.
(Return to document)

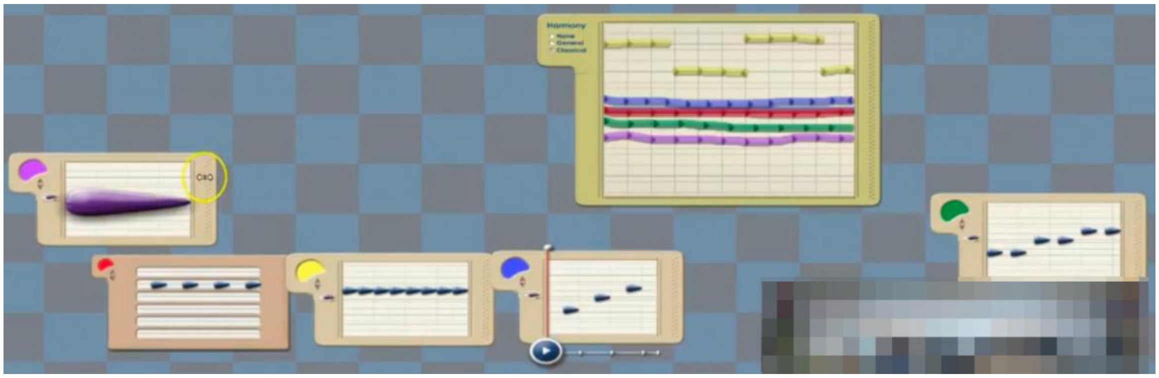


Figure 9. Hyperscore screenshot illustrating Emily's first composition, which she titled *Lines.*
(Return to document)

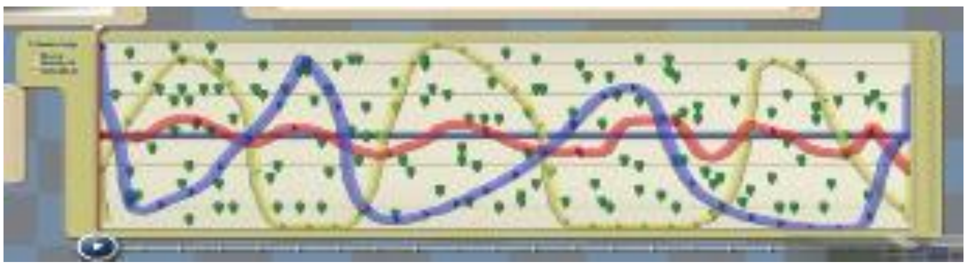


Figure 10. Emily's use of contrary motion in combination with reflection (inversion) between her blue and yellow melodies.
(Return to document)

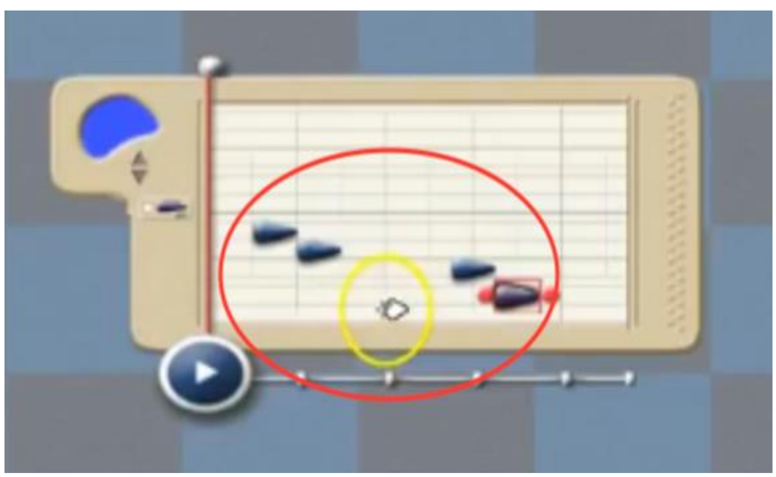


Figure 11. Example of Emily's transposition strategy.
(Return to document)

Figure 12. Chelsea copying and pasting fragments of a phrase onto itself to create varying levels of intensity and a quasi-Baroque terraced dynamics effect.
(Return to document)

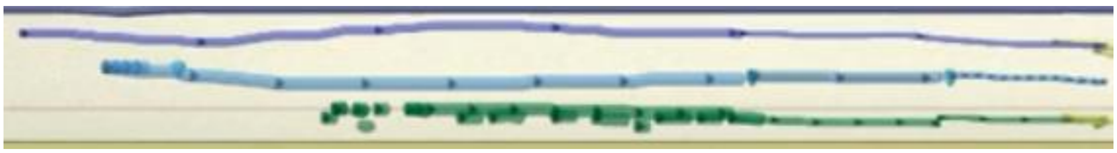


Figure 13. Chelsea creating dynamic changes by adjusting the relative thickness of her phrases.
(Return to document)

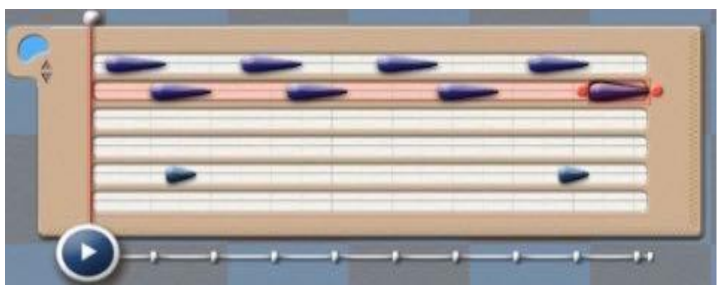


Figure 14. Chelsea's percussion pattern before adjusting spacing.
(Return to document)

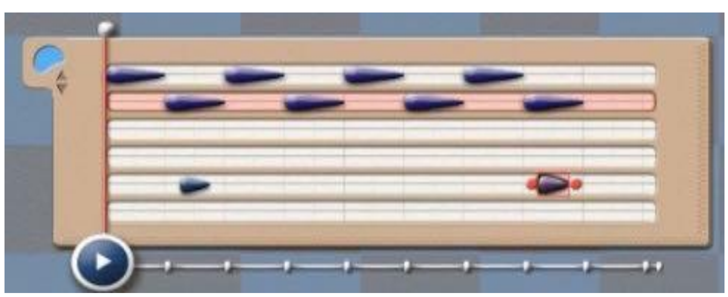


Figure 15. Chelsea's percussion pattern after adjusting spacing to create the effect of a faster tempo.
(Return to document)

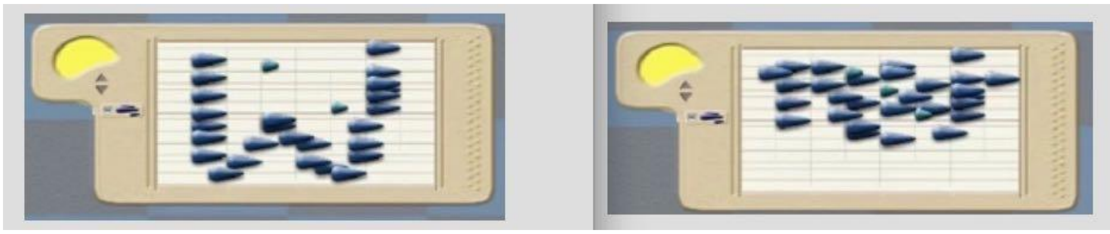


Figure 16. Chelsea's strategy of dragging individual notes higher to create low-high contrast. The image on the left is the "before" screenshot, and the image on the right is the result after Chelsea dragged certain notes higher.
(Return to document)

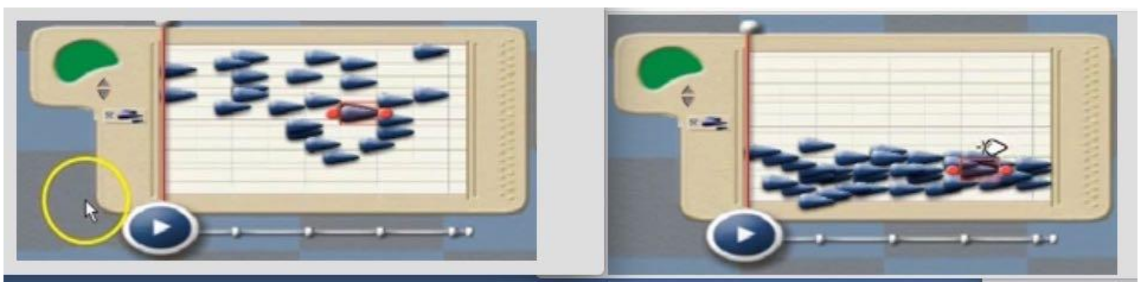


Figure 17. Chelsea's strategy of dragging individual notes lower to create obvious high-low contrast. The image on the left is the "before" screenshot, and the image on the right is the result after she drags all notes lower.
(Return to document)

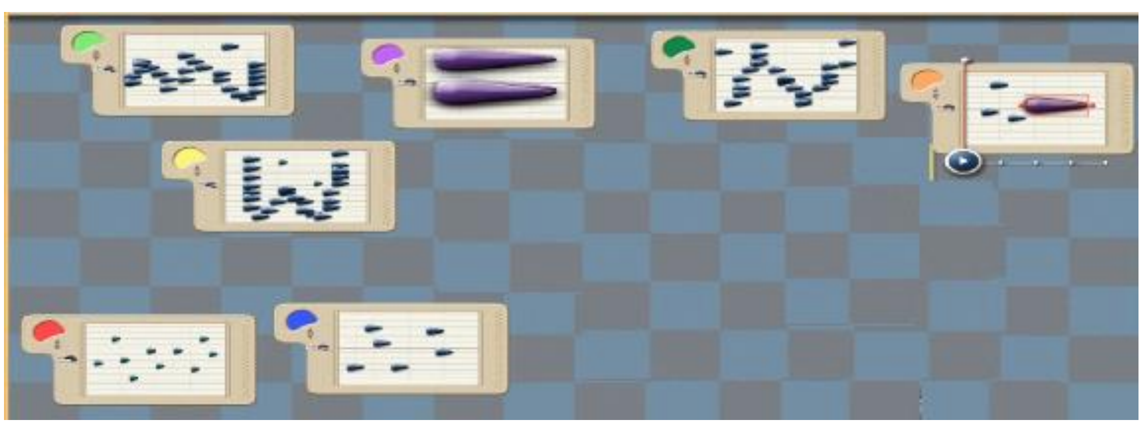


Figure 18. Example of how Chelsea experimented with various droplet sizes (note durations) during her first individual composition session.
(Return to document)

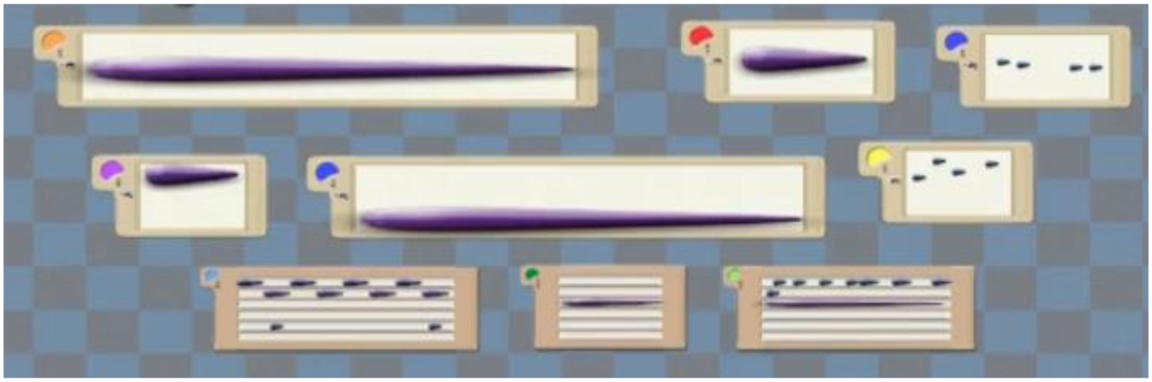


Figure 19. Chelsea's process came to a standstill when she appeared to equate the number of available colors (timbres) in Hyperscore with the number of possible musical ideas.
(Return to document)

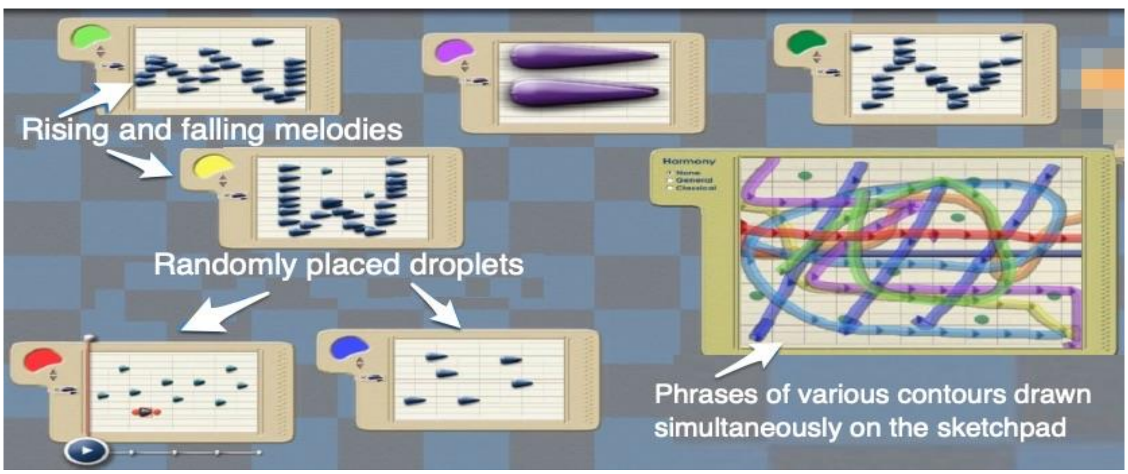


Figure 20. Example of how Chelsea applied various melodic and phrase contours.
(Return to document)

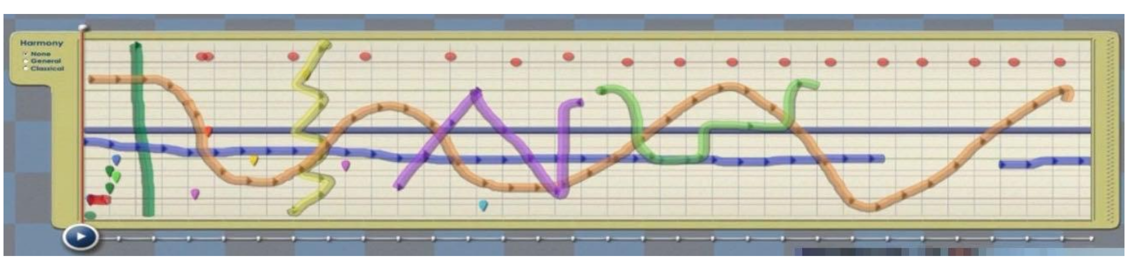


Figure 21. Chelsea continued drawing a wide variety of contours but gradually created less dense textures.
(Return to document)

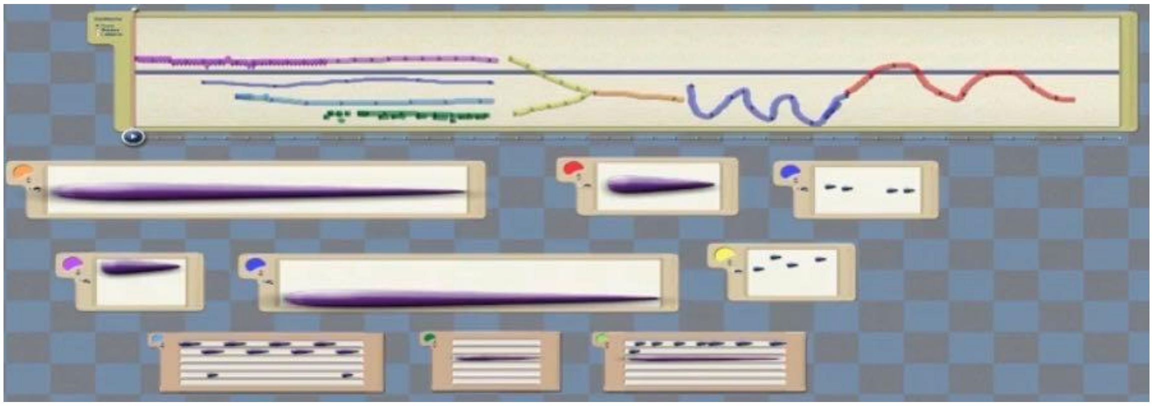


Figure 22. Example of how Chelsea adapted her previous approach in favor of relatively linear melodies and fewer phrases and contour variations happening simultaneously on the sketchpad.
(Return to document)

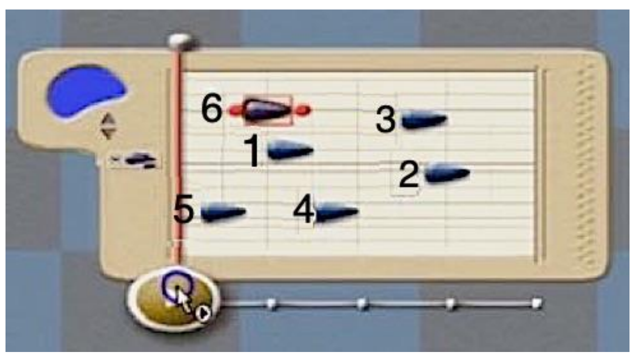


Figure 23. Example of how Chelsea sometimes drew melody notes in a random order rather than how they unfolded over time.
(Return to document)

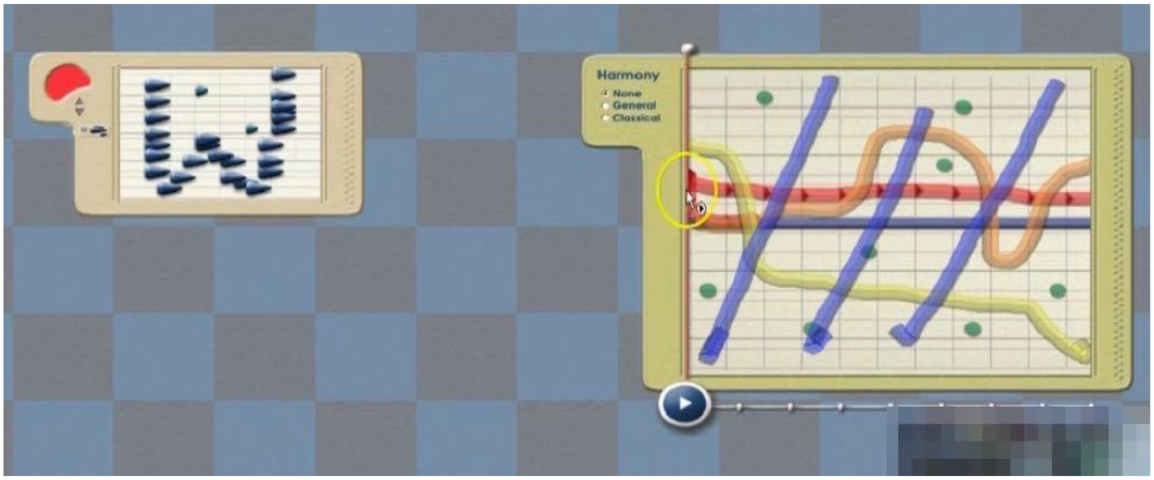


Figure 24. Example of how Chelsea initially appeared focused more on drawing randomly on the sketchpad than on creating melodic or rhythmic material.
(Return to document)

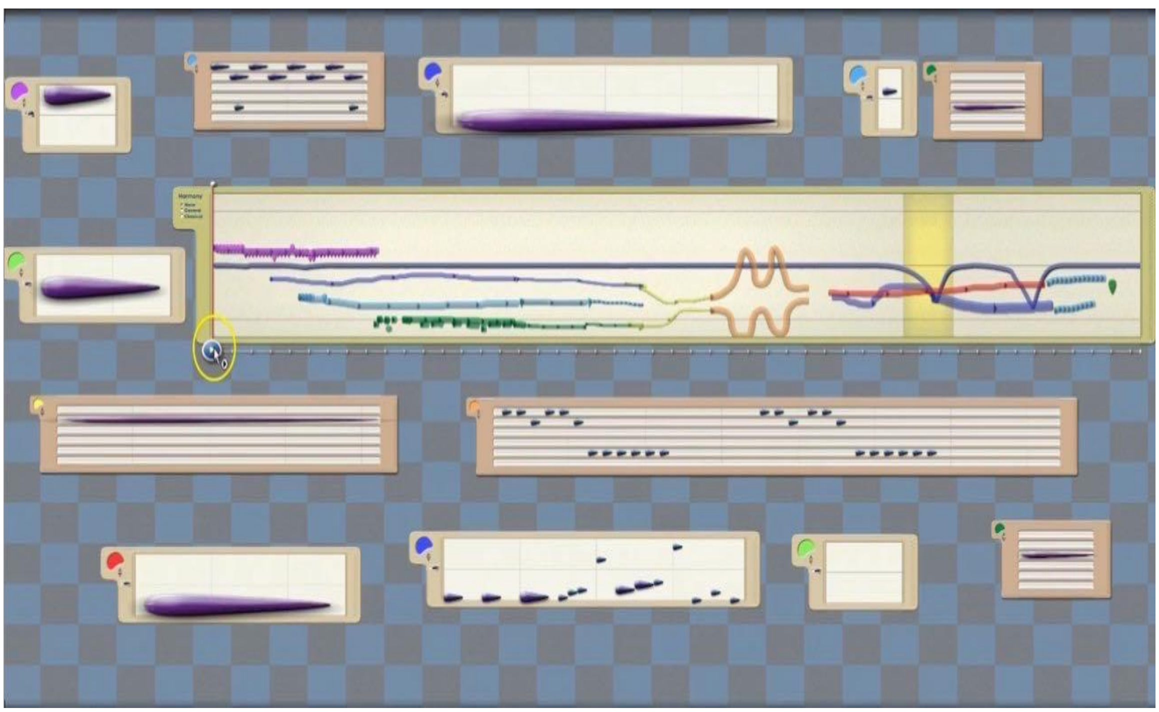


Figure 25. Chelsea's final individual composition illustrating her use of graphic notation to create structure, dynamic changes, and variations in timbre and texture.
(Return to document)

Figure 26. Draco's initial central "green" theme, which repeats three times after its initial appearance. Arrows indicate the beginning of a new iteration of the theme.
(Return to document)

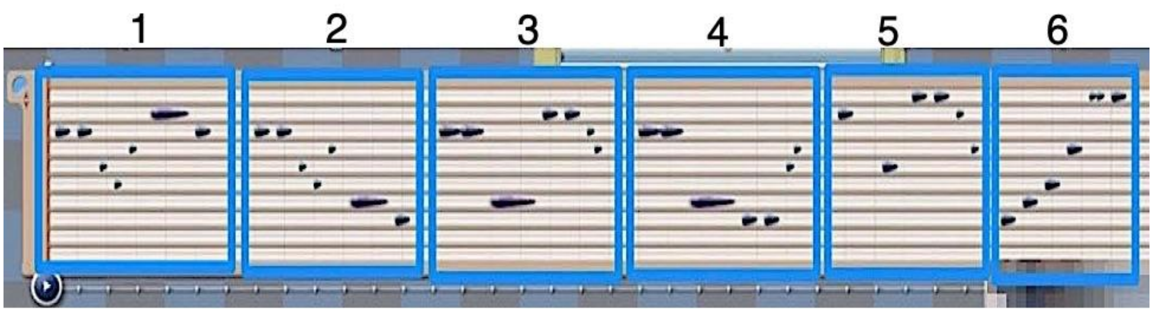


Figure 27. The main theme of Draco's final individual composition. Motives 1-2 and 3-4 incorporate an antecedent-consequent strategy. Motive 2 is an almost exact repetition of Motive 1 with the last two notes transposed down. Motive 4 imitates Motive 3 but inverts the last four notes. Motives 5 and 6 are new material that brings the phrase to a close.
(Return to document)

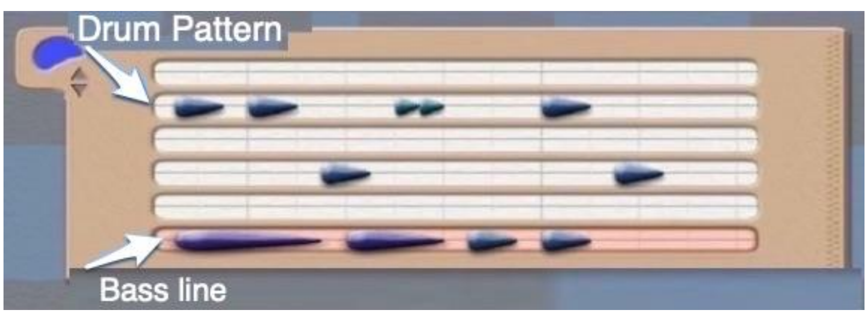


Figure 28. Example of how Draco 'hacked' the software by assigning the bottom line of the percussion window to a bass timbre, which enabled him to compose with two timbres simultaneously.
(Return to document)

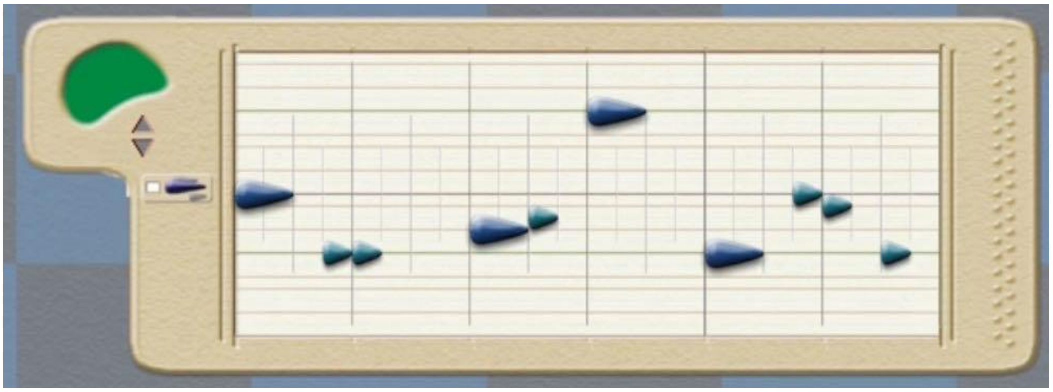


Figure 29. Example of how Draco incorporated specific rhythms and rests on the first individual composition day.
(Return to document)

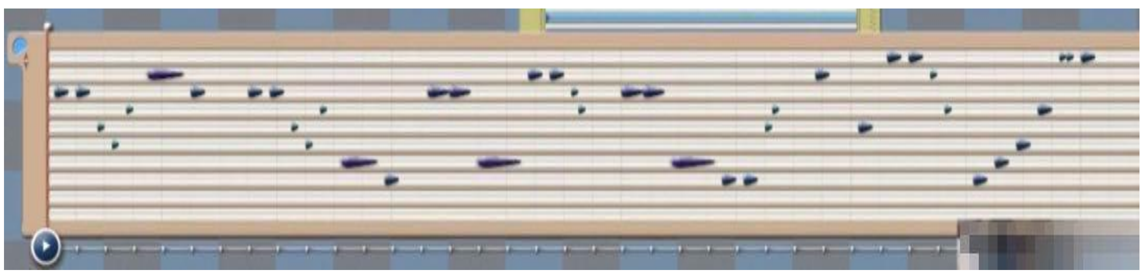


Figure 30. Example of how Draco dedicated time editing musical ideas to represent his desired rhythms accurately. The note values and specific rests between notes illustrated resulted from several minutes of persistent editing. This melody also exemplifies how Draco 'hacked' a percussion window for his melody by assigning each of the 10 percussion lines to a guitar timbre and definite pitches. Draco also pointed out how each of the ten lines could be assigned to any of the 129 General MIDI timbres, if desired.
(Return to document)

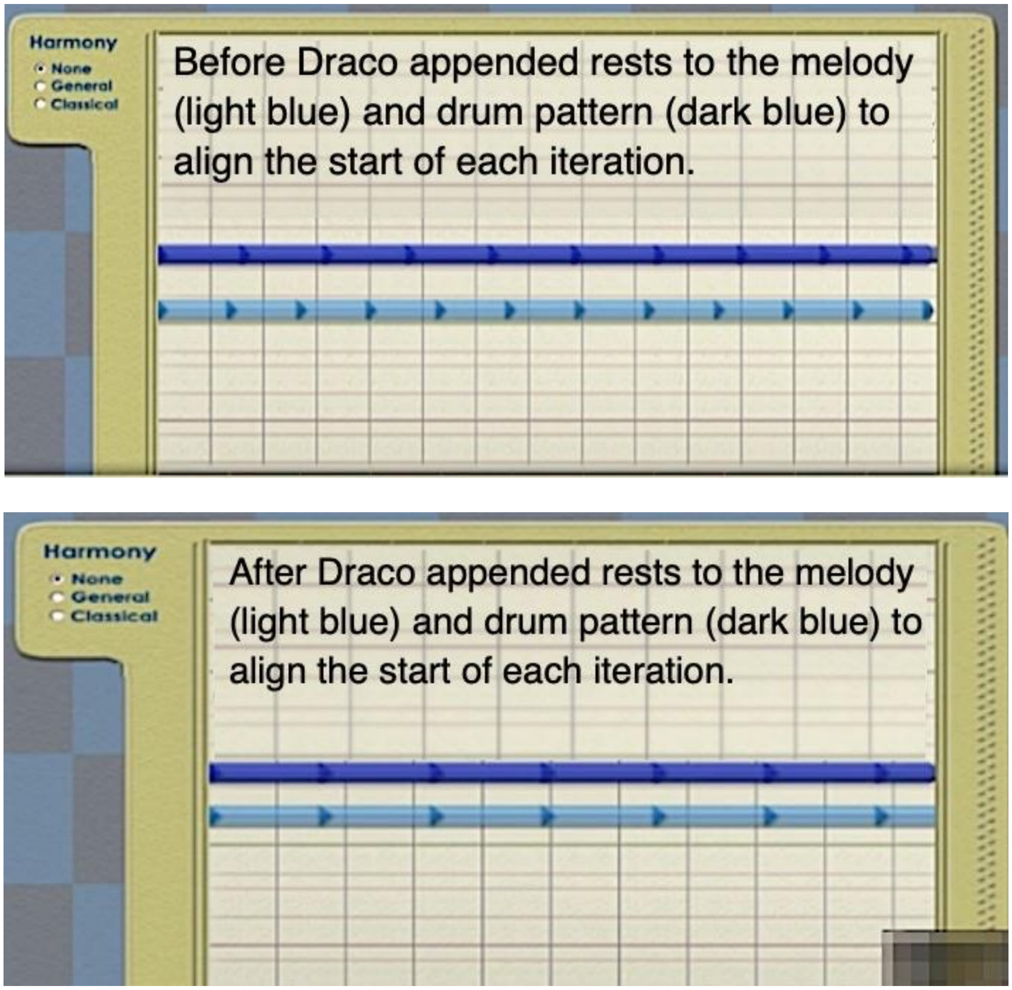


Figure 31. Before and after example of how Draco increased space between iterations of the melody (light blue line) to align better with iterations of the percussion pattern (dark blue line).

(Return to document)

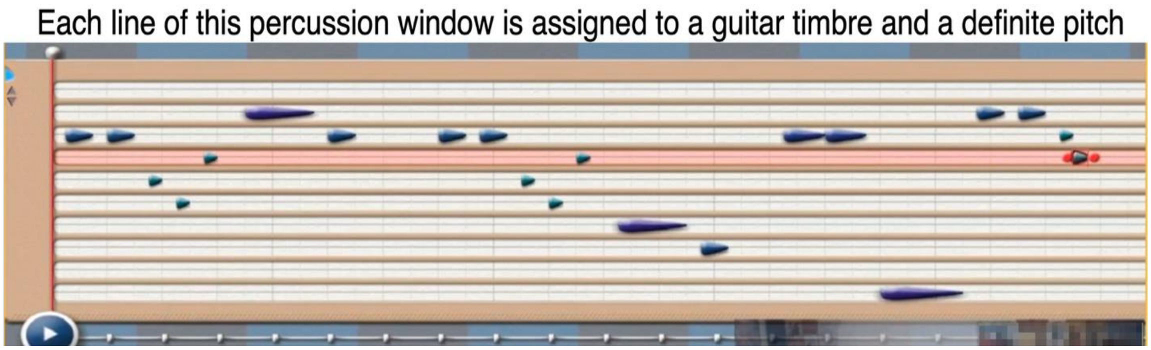


Figure 32. Example of how Draco 'hacked' the percussion window and used it as a melody window.
(Return to document)

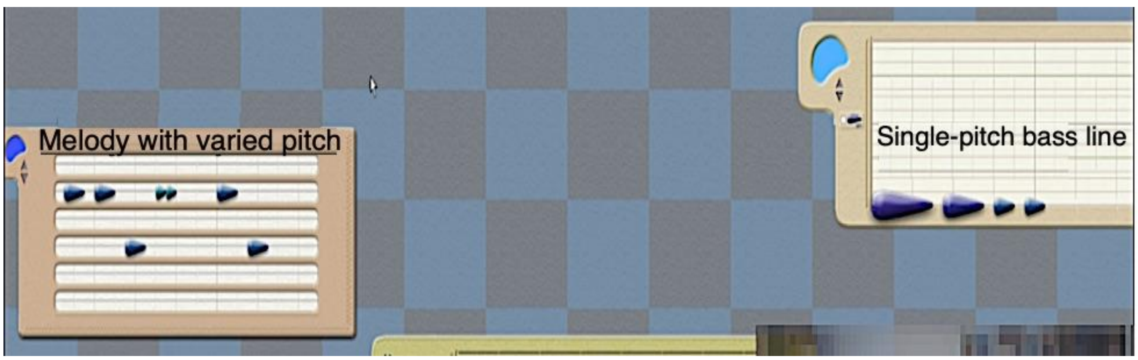


Figure 33. Example of contrasting contours between Draco's melody and bass lines.
(Return to document)

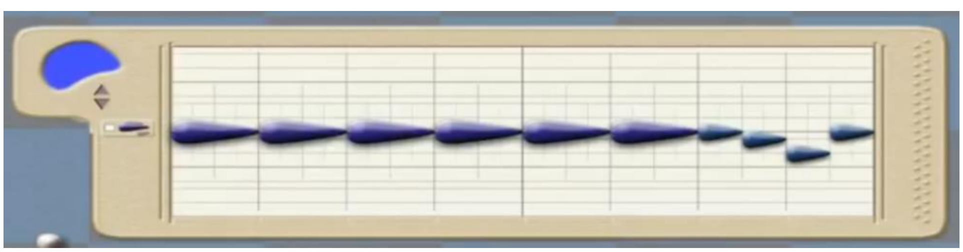


Figure 34. Draco's final bass line consisted mostly of repeated notes but included two varying pitches at the end.
(Return to document)

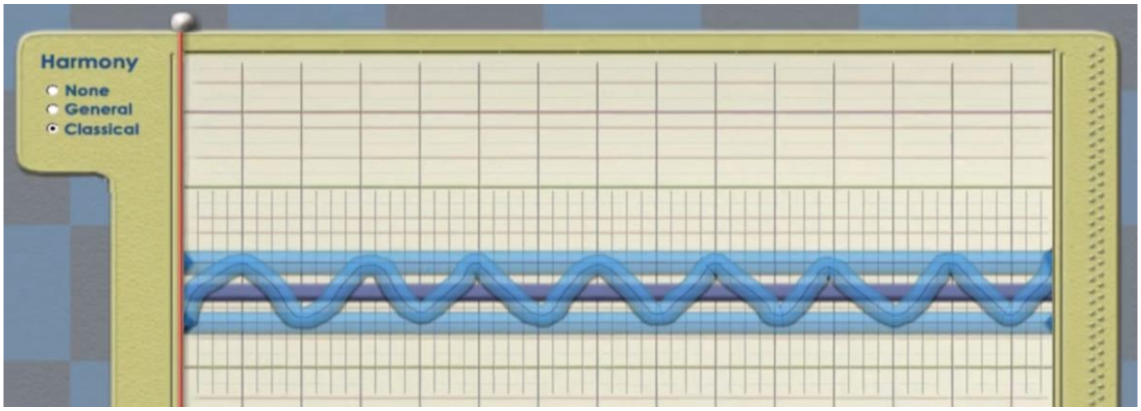


Figure 35. The only time Draco drew a curvy line on his sketchpad, which he deleted because he was dissatisfied with the pitch fluctuations caused by the curvy line.
(Return to document)

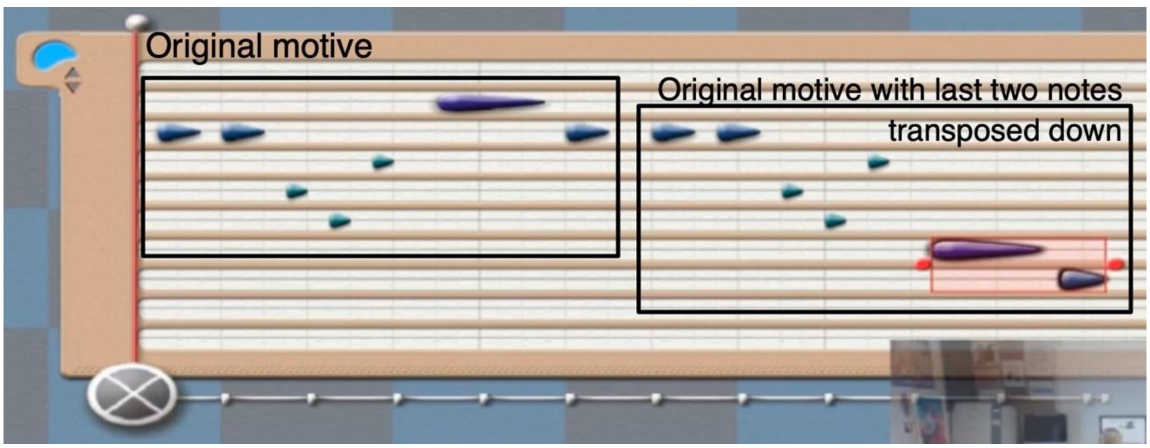


Figure 36. Draco's antecedent-consequent relationship between two melodic fragments.
(Return to document)

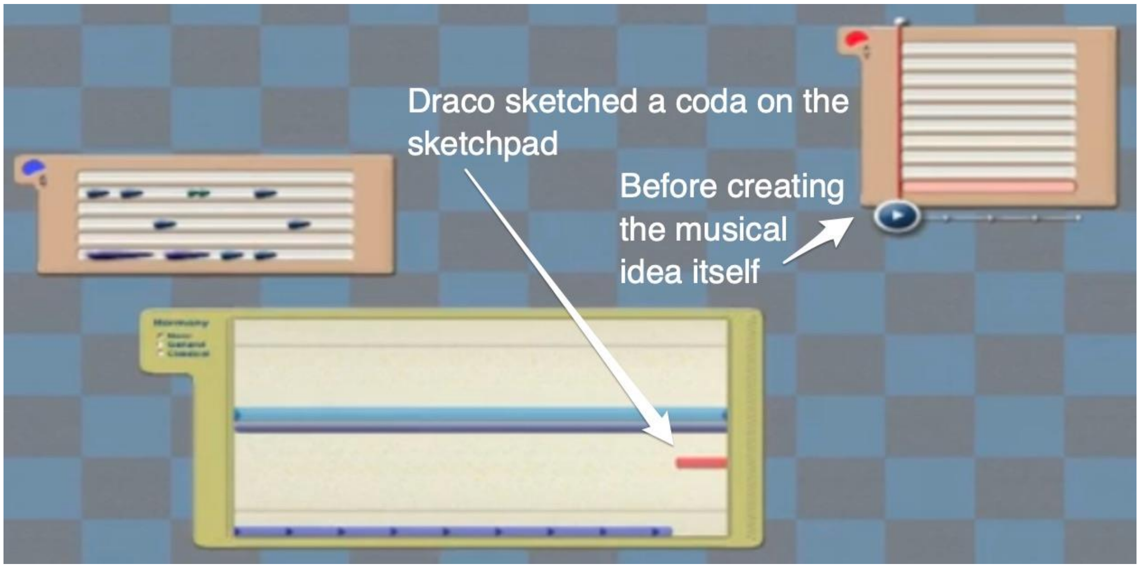


Figure 37. Draco sketched a red line representing his coda before creating the musical material itself (red window).
(Return to document)

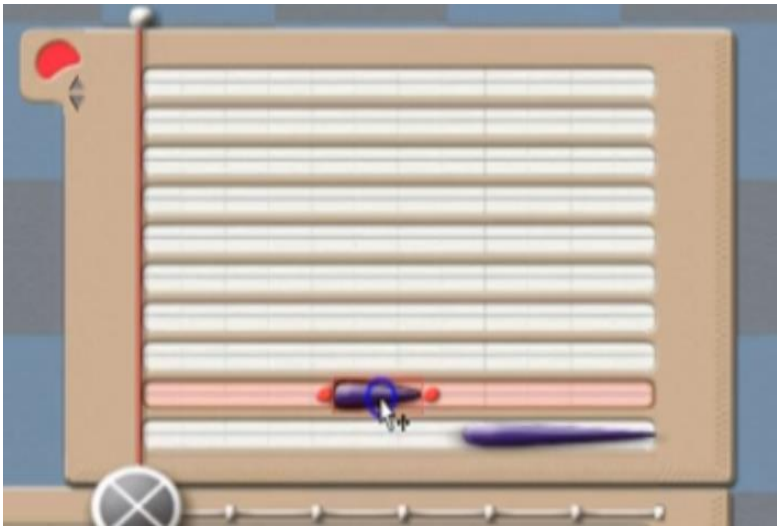


Figure 38. Draco's two-note coda for his final individual composition.
(Return to document)

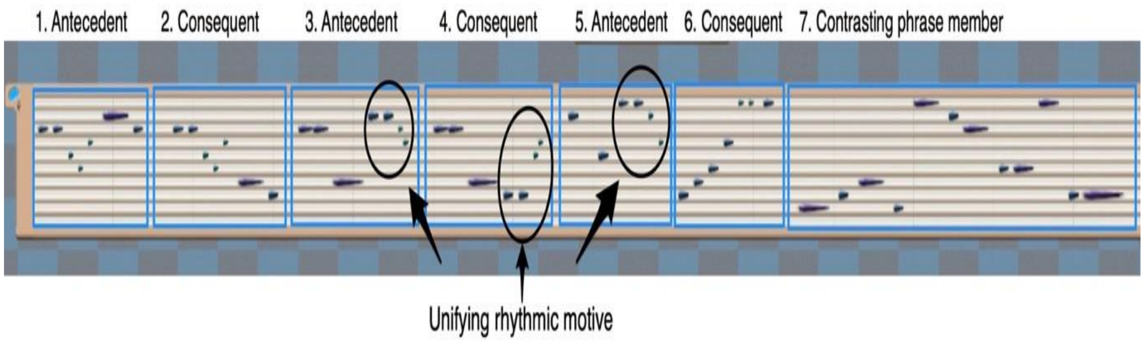


Figure 39. Unity and variety in the main theme of Draco's final individual composition. (Return to document)

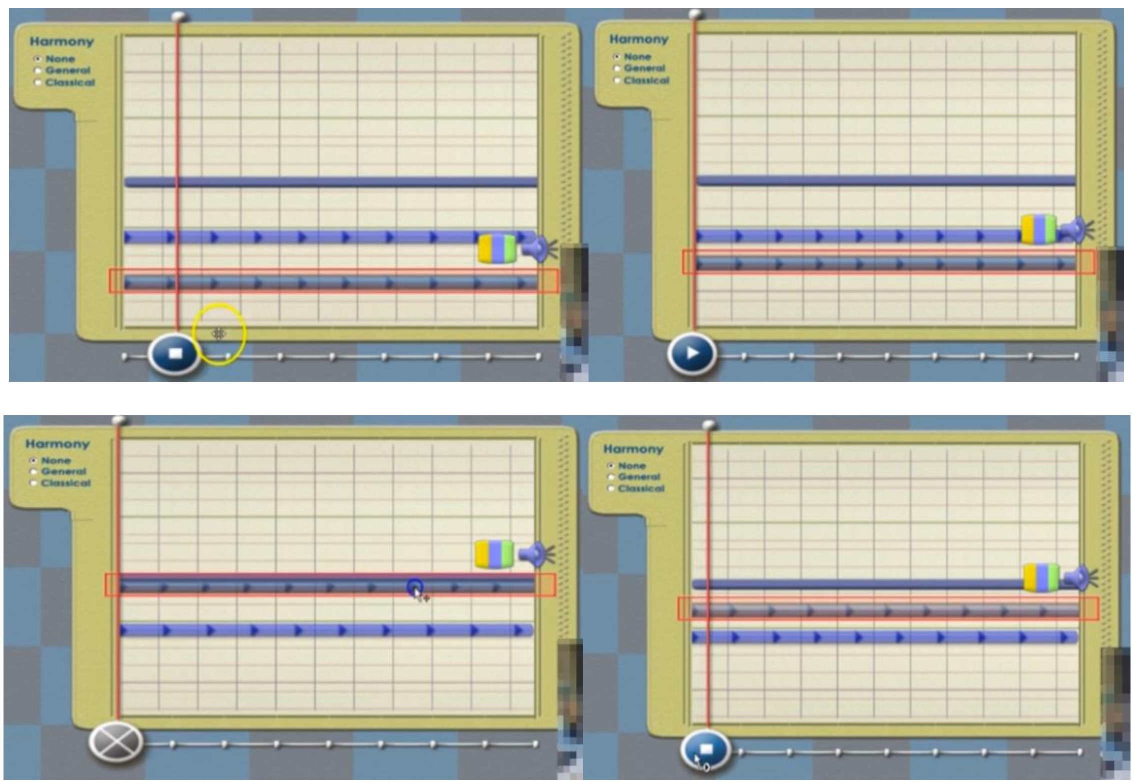


Figure 40. Example of Draco's translation strategy. From top left to bottom right, Draco adjusts the pitch level of the bass line (outlined in red) several times.
(Return to document)

Figure 41. Draco transposed the last two notes of his second phrase member to create an antecedent-consequent effect.
(Return to document)

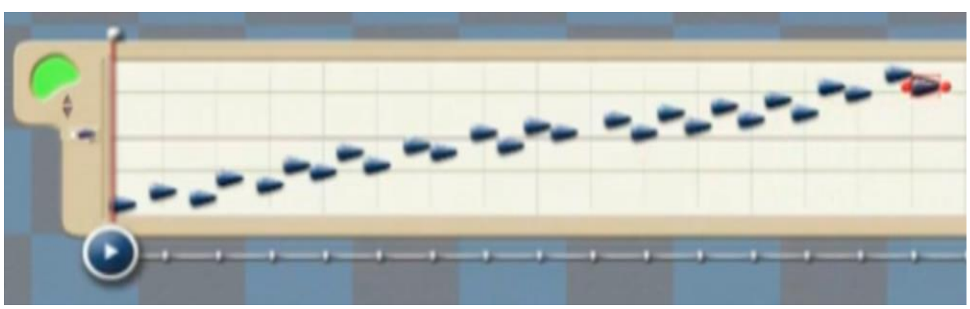


Figure 42. Example of Ryan's attempt to create an ascending, sequential timbale pattern.
(Return to document)

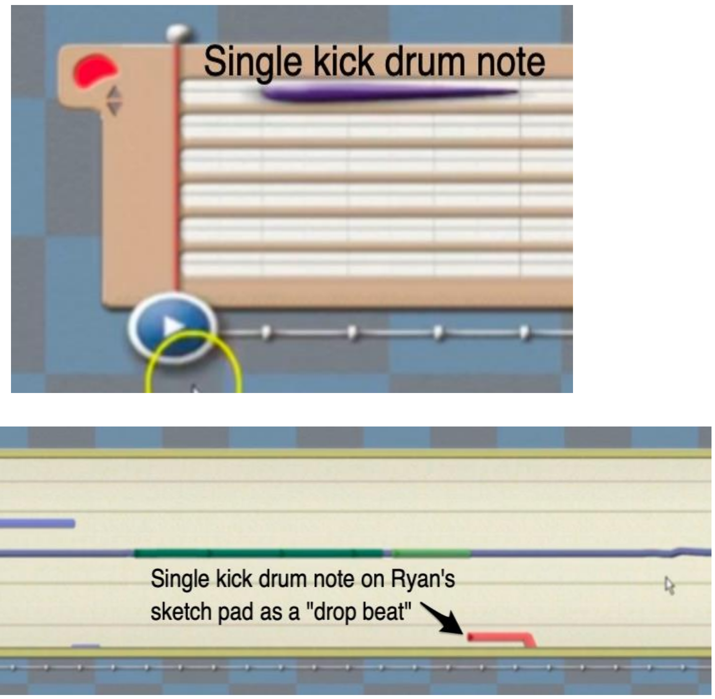


Figure 43. Ryan's use of a single kick drum note to create a "drop beat."
(Return to document)

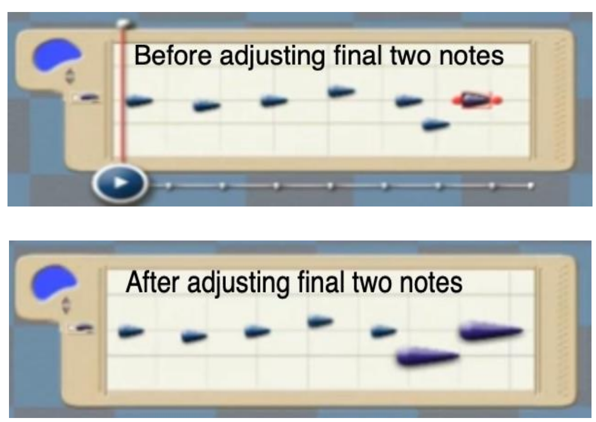


Figure 44. Example of Ryan's attention to rhythm by deliberately adjusting the length of the final two notes of his melody.
(Return to document)

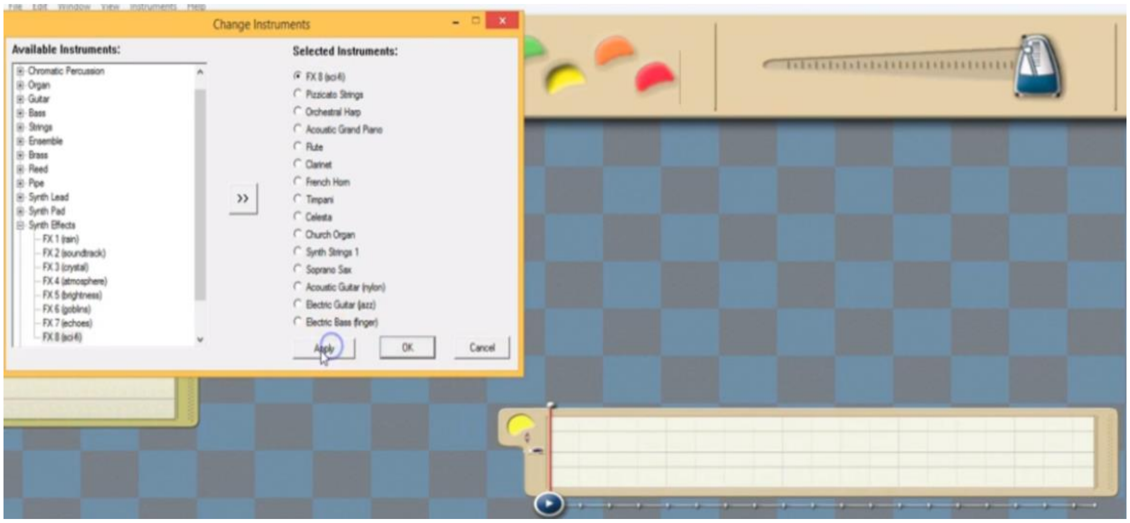


Figure 45. Example of how Ryan would sometimes draw a new melody window and previewed timbres before composing a melody.
(<u>Return to document</u>)

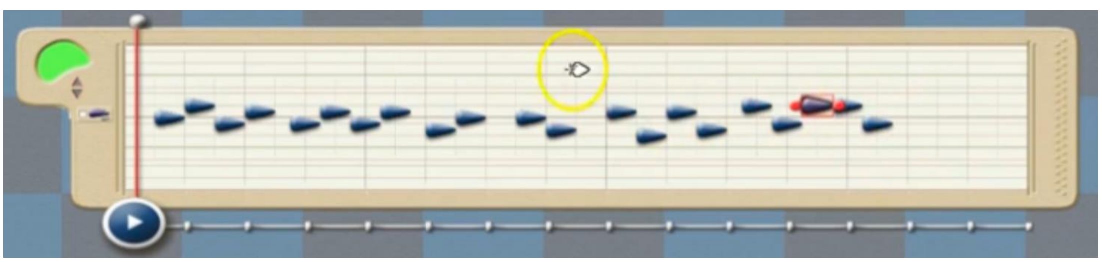


Figure 46. Example of how Ryan used multiple, small, compressed droplets to create the effect of a faster tempo.
(<u>Return to document</u>)

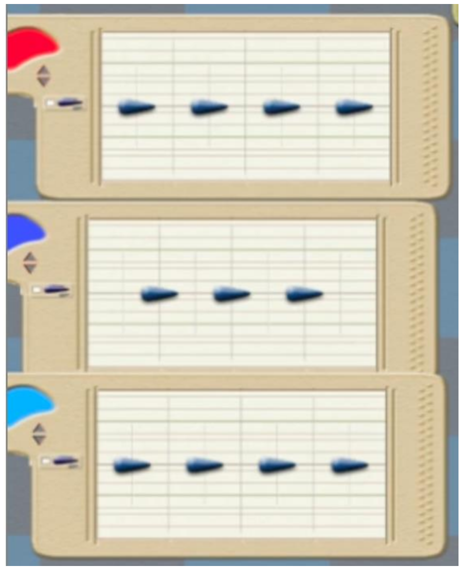


Figure 47. Ryan's strategy of vertically aligning three discrete motives ostensibly to examine their relationship and create a medieval hocket effect.
(Return to document)

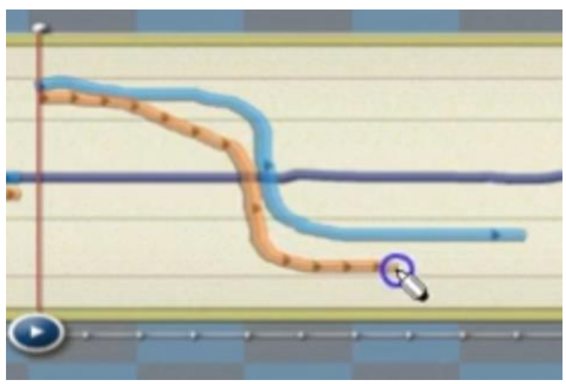


Figure 48. Example of two melodies Ryan overlapped on the sketchpad which he immediately deleted after listening to the dissonant result.
(Return to document)

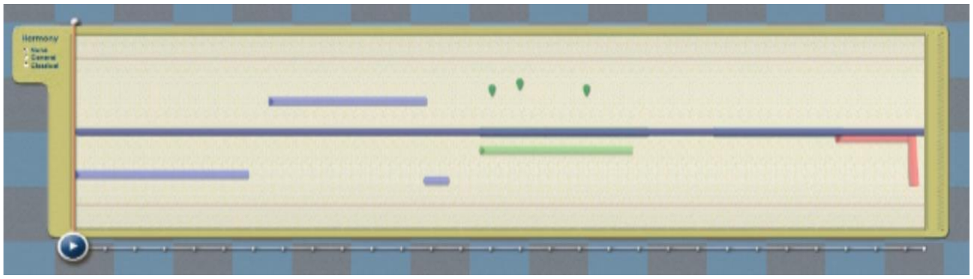


Figure 49. Ryan's minimalist, monophonic approach to his final composition. Note, the blue line running through the center of the sketchpad (the harmony line) does not represent any musical material.
(Return to document)

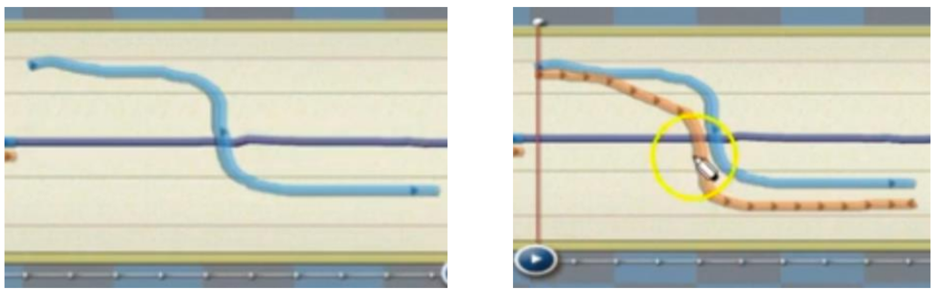


Figure 50. Example of how Ryan drew a curvilinear version of his light blue melody on the sketchpad and then combined it with a parallel version of his orange melody, ultimately deleting both after listening to the dissonant result.
(Return to document)

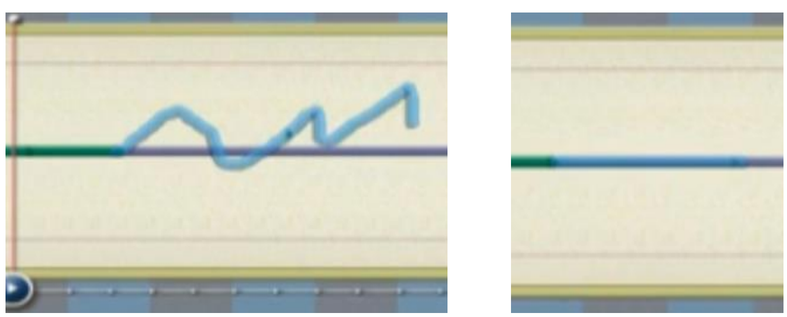


Figure 51. Example of how Ryan drew a curvilinear version of his light blue melody on the sketchpad, listened to it two times and converted it to a straight line ostensibly because he preferred his melody to remain at one pitch level.
(Return to document)

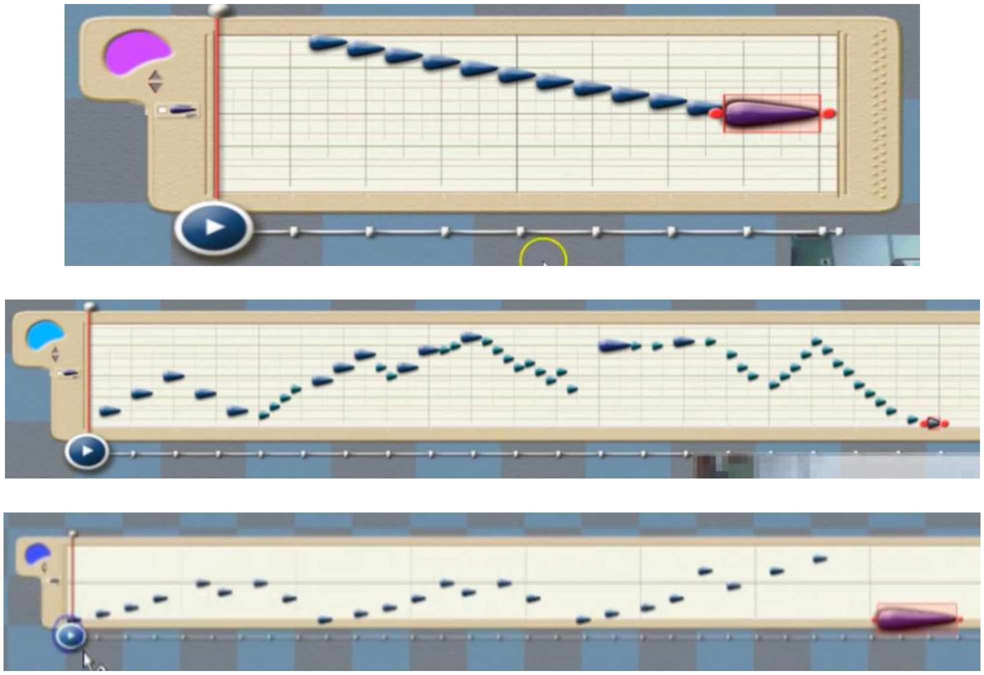


Figure 52. Example of contrasting contour among three of Ryan's melodies.
(Return to document)

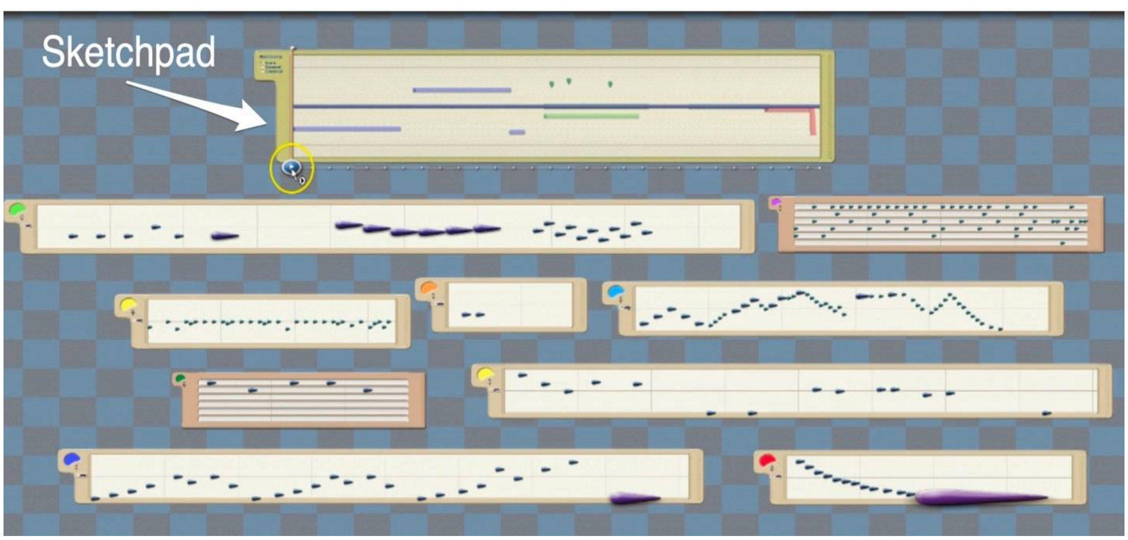


Figure 53. Screenshot of Ryan's final composition. The sketchpad window is on top and his various melodies and percussion patterns appear in discrete windows below the sketchpad. Note that Ryan did not incorporate five of his nine melodies and percussion patterns (e.g., light blue, orange, pink, two yellow) into the sketchpad and they were not included in the final version of his composition.
(Return to document)

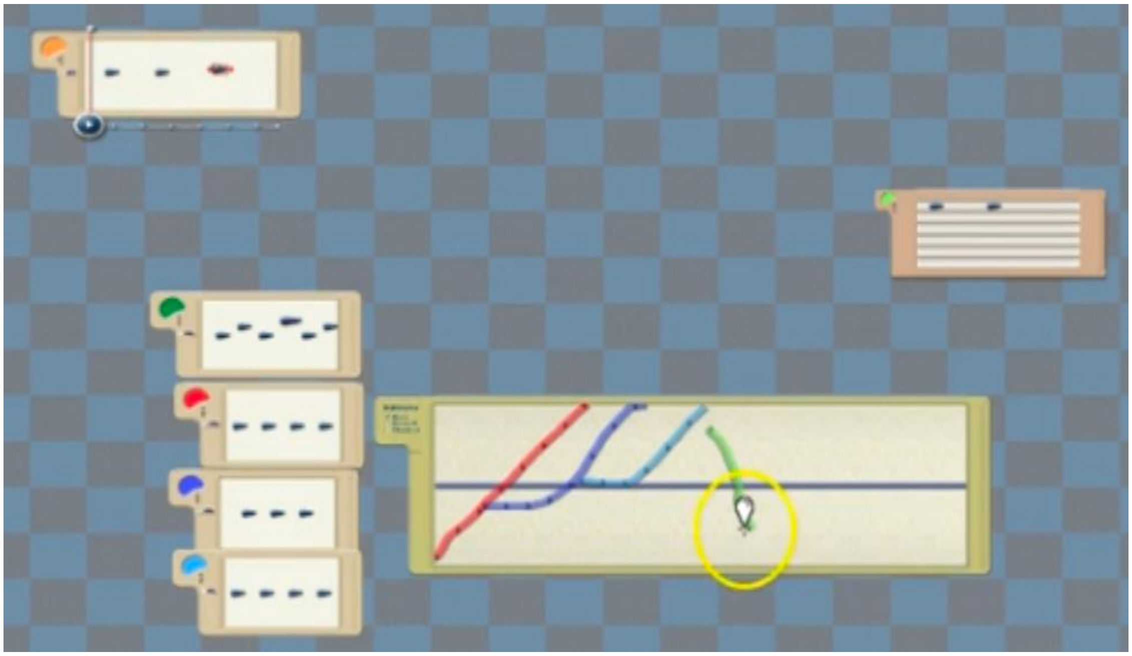


Figure 54. Ryan's motive-making process for his first composition, during which he drew sparse motives in mostly straight lines of repetitive pitches.
(Return to document)

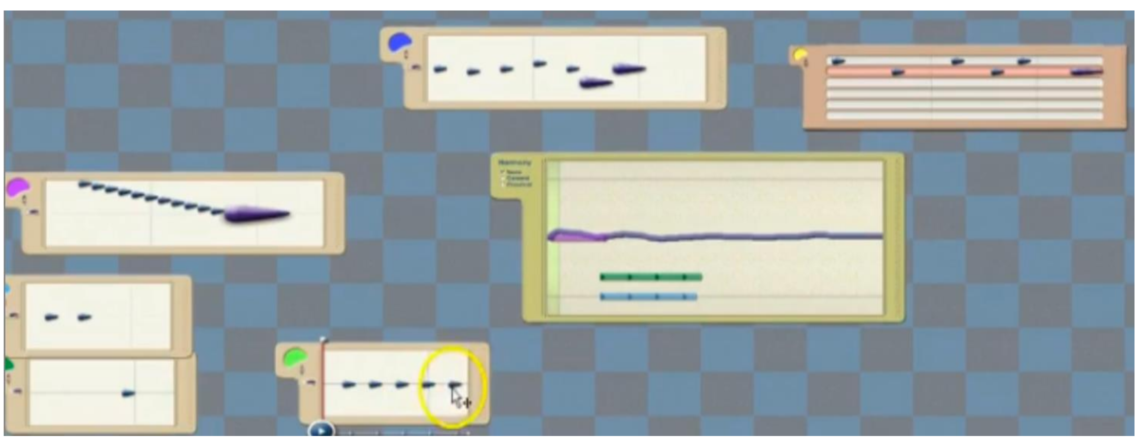


Figure 55. In his second composition, Ryan explored a scalar approach (purple melody) and wider intervals and lateral spacing (dark blue melody).
(Return to document)

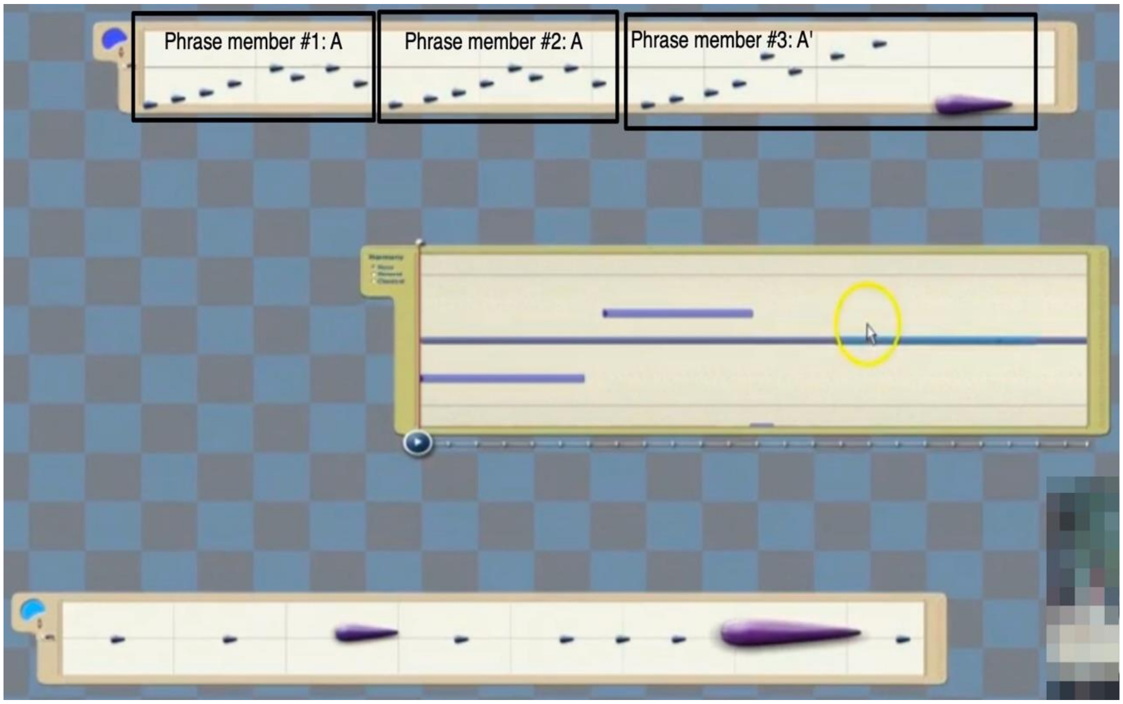


Figure 56. For his third composition, Ryan composed a melody with three distinct phrase members (dark blue) and another melody (light blue) reminiscent of his previous melodies comprised of one pitch.
(Return to document)

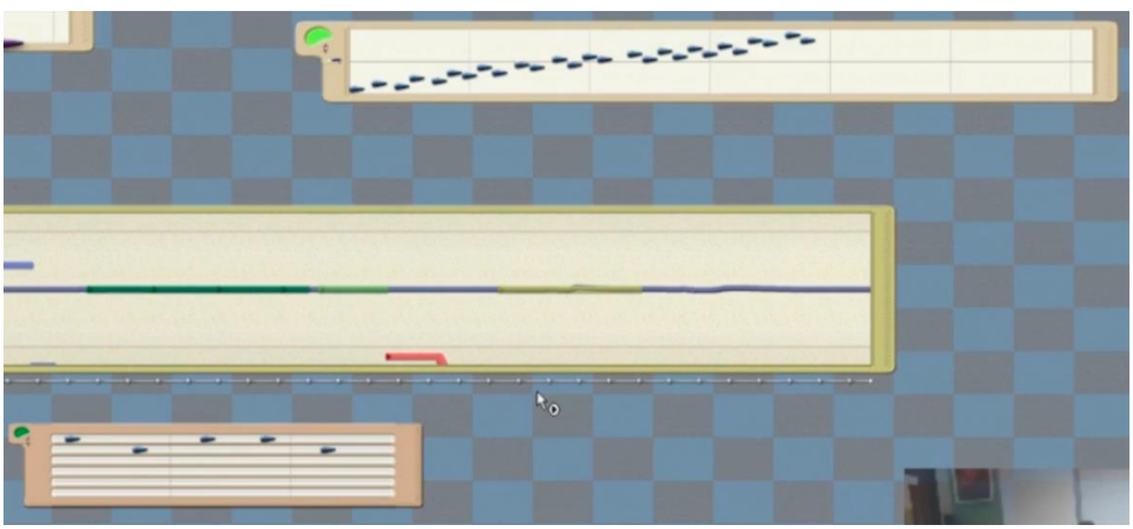


Figure 57. While developing his third composition, Ryan attempted to create an exact sequence (light green).
(Return to document)

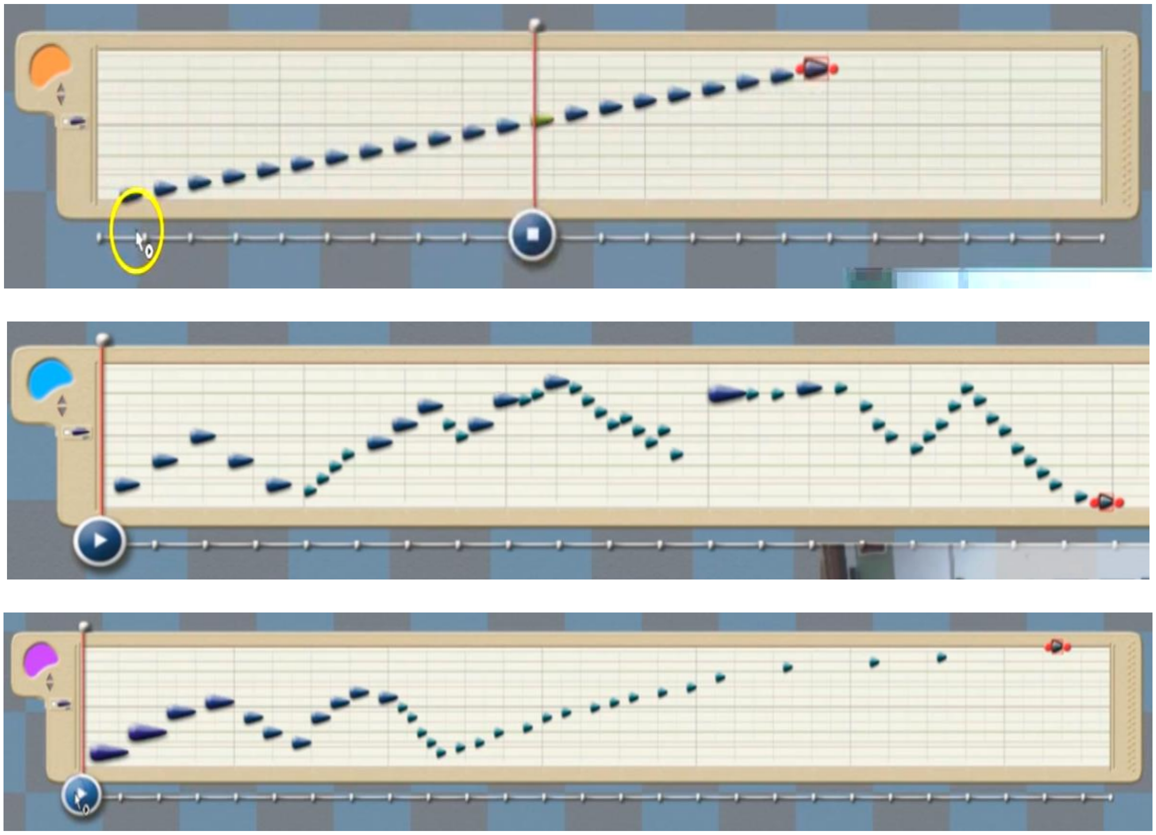


Figure 58. Three melodies Ryan created on the final day of individual composition, none of which he incorporated into his final composition.
(Return to document)

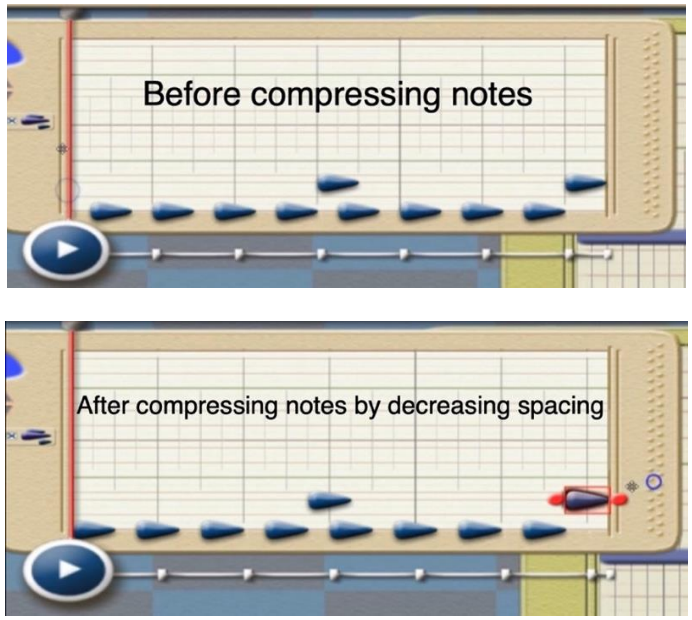


Figure 59. Screenshots illustrating how Ryan compressed notes and decreased spacing to make his melody sound “more repetitive.”
(Return to document)

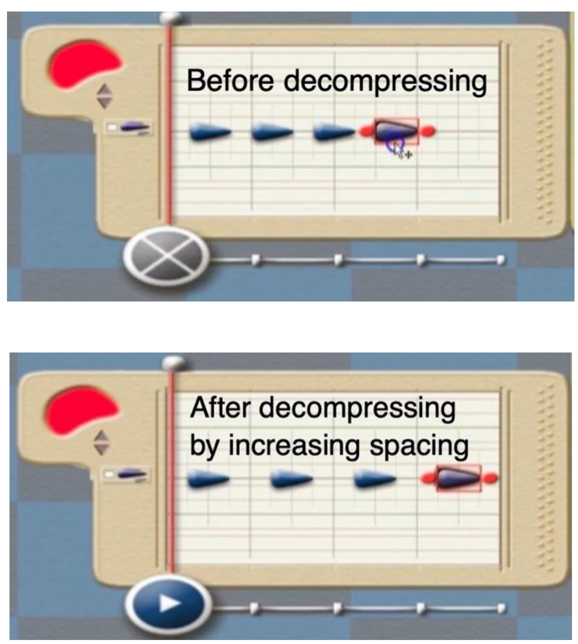


Figure 60. Screenshots illustrating how Ryan decompressed notes and increased spacing to make his melody “repeat each other note.”
(Return to document)

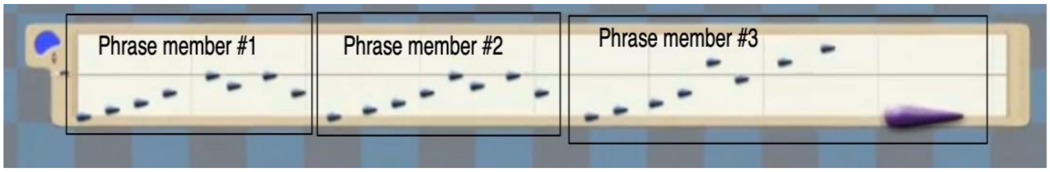


Figure 61. Screenshot of Ryan's main theme for his final composition.
(Return to document)

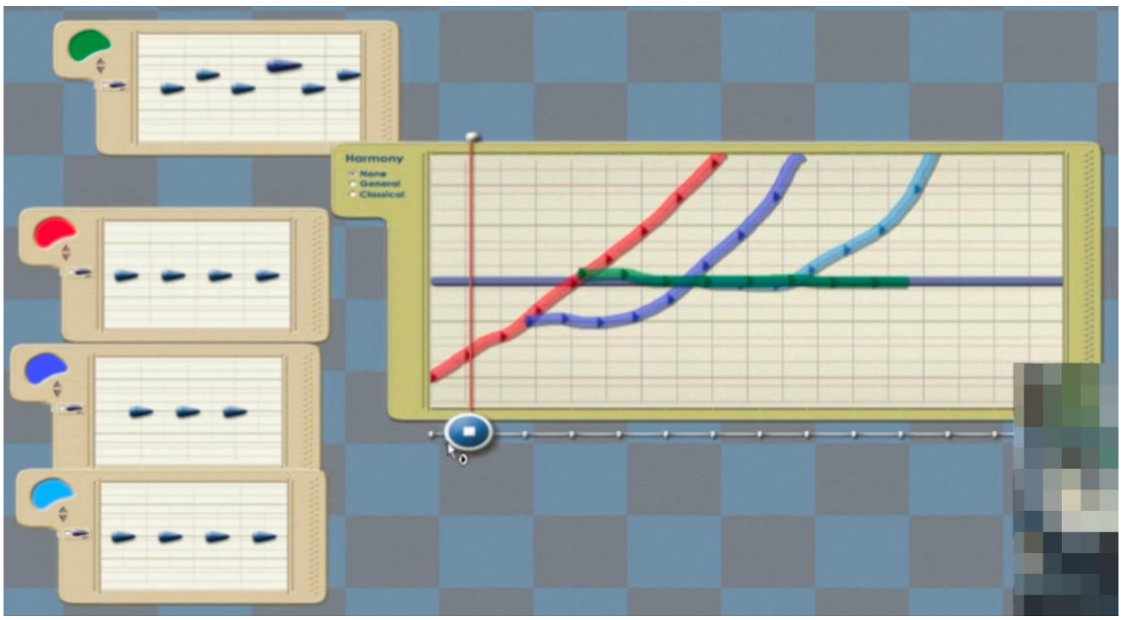


Figure 62. Screenshot from Ryan's first composition in which he applied parallel and oblique motion in the context of four-part counterpoint.
(Return to document)

Figure 63. Screenshot illustrating Ryan's use of geometric translation. The purple motive is transposed one octave higher, and the green motive is transposed up a major ninth.
(Return to document)

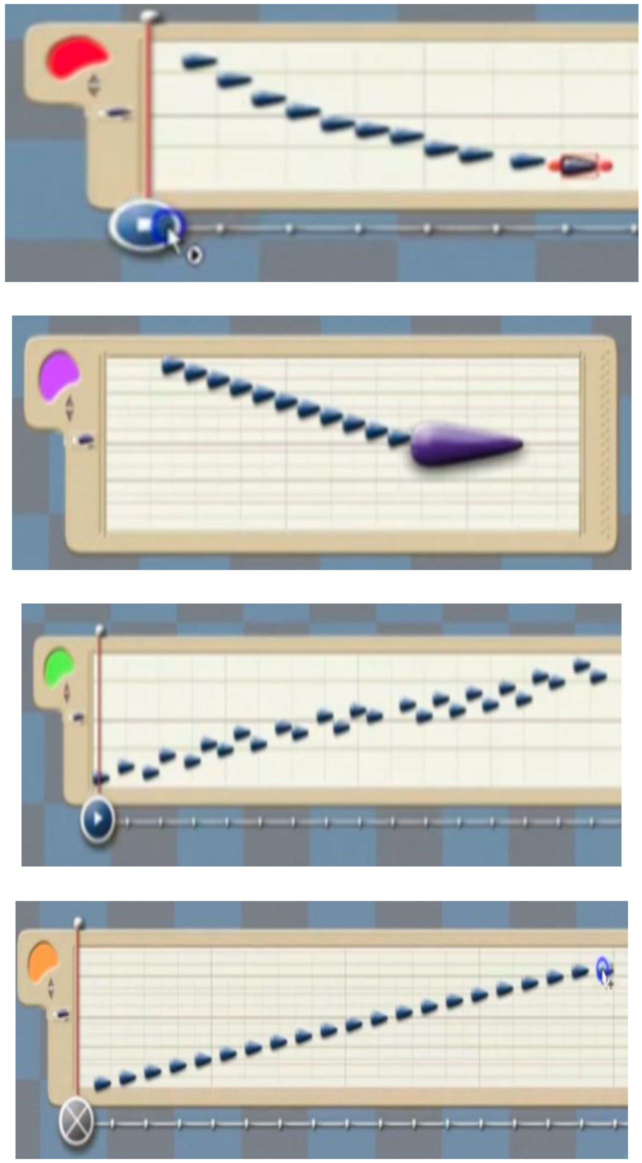


Figure 64. Screenshots illustrating Ryan's use of predictable patterns moving in one direction.

(Return to document)

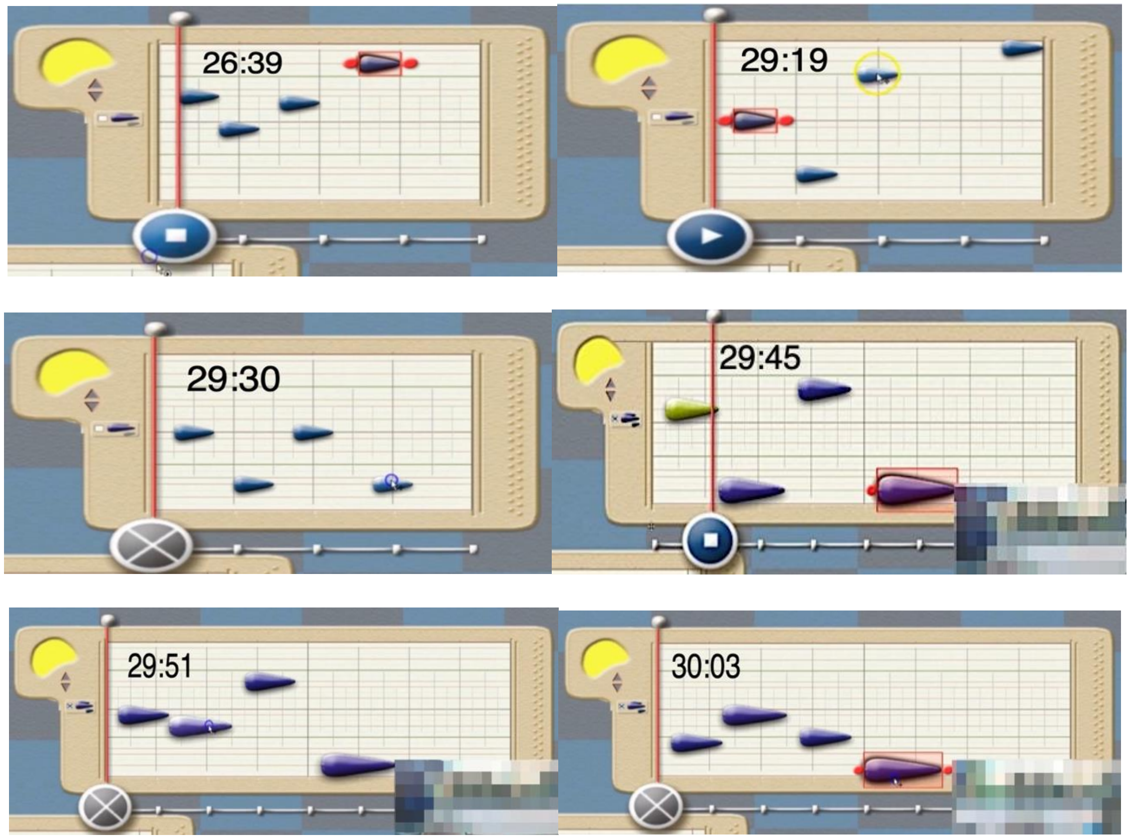


Figure 65. Time-lapse screenshots of Chelsea and Emily's transcription process (top left to bottom right) for their quasi-*Twilight Zone* motive.
(Return to document)

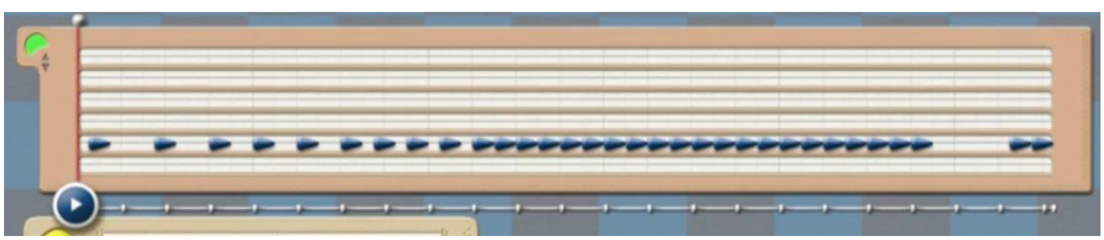


Figure 66. Chelsea and Emily's accelerating footsteps motive.
(Return to document)

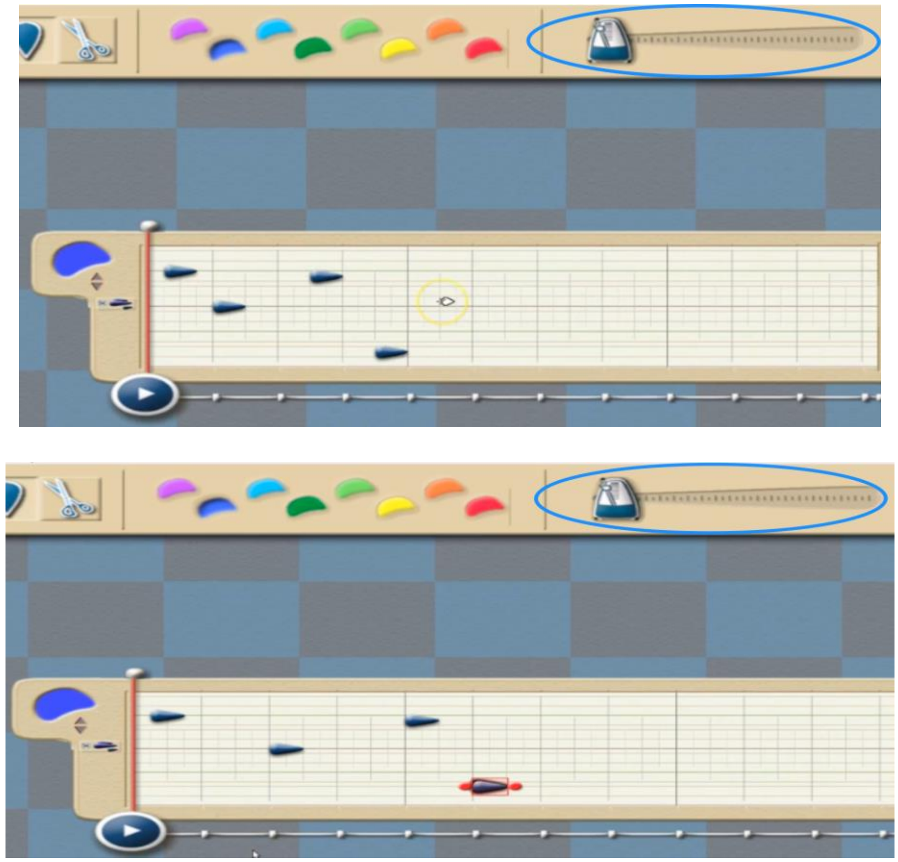


Figure 67. Chelsea’s strategy of increasing space between notes to create the effect of an even slower tempo after adjusting the metronome to the lowest setting.
(Return to document)

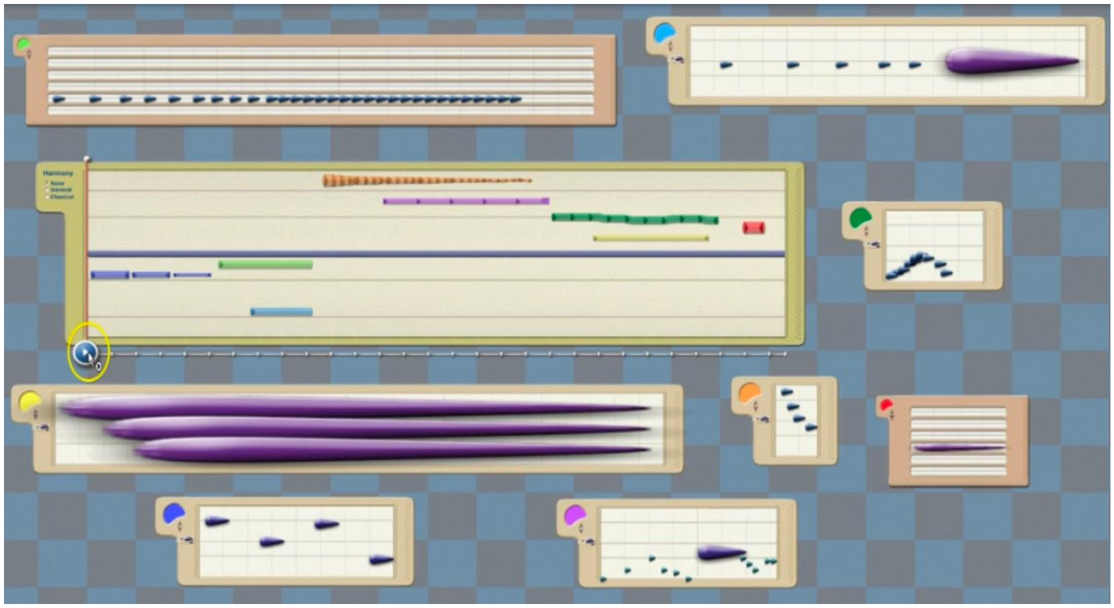


Figure 68. Screenshot of Chelsea and Emily's final composition that incorporated a relatively wide range of note values.
(Return to document)

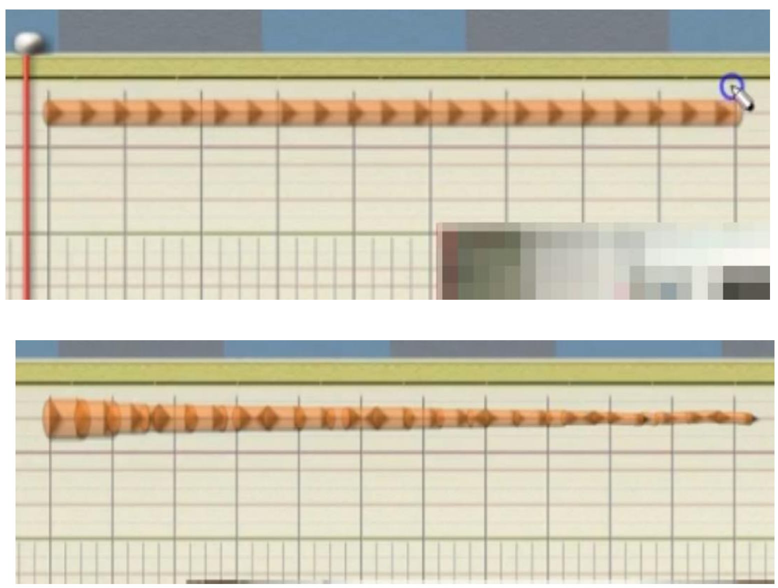


Figure 69. Before and after screenshots illustrating Chelsea and Emily's strategy of creating a decrescendo by dividing their orange motive into separate parts and adjusting the relative dynamic level of each part.
(Return to document)

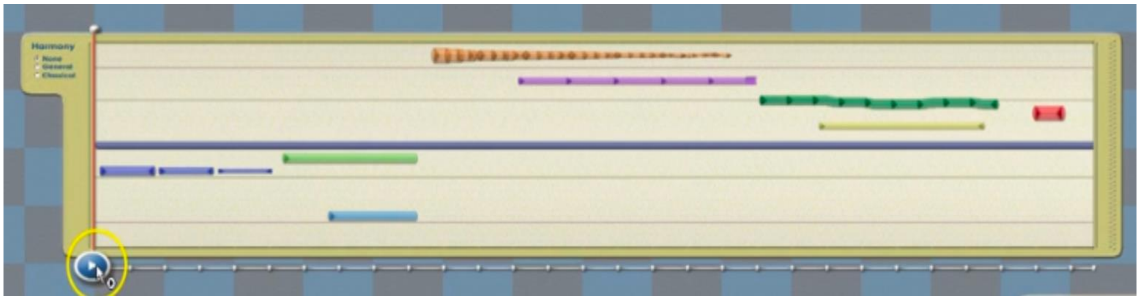


Figure 70. Screenshot of sketchpad for Chelsea and Emily's final composition. Varying line thicknesses represent Chelsea and Emily's use of dynamics.
(Return to document)

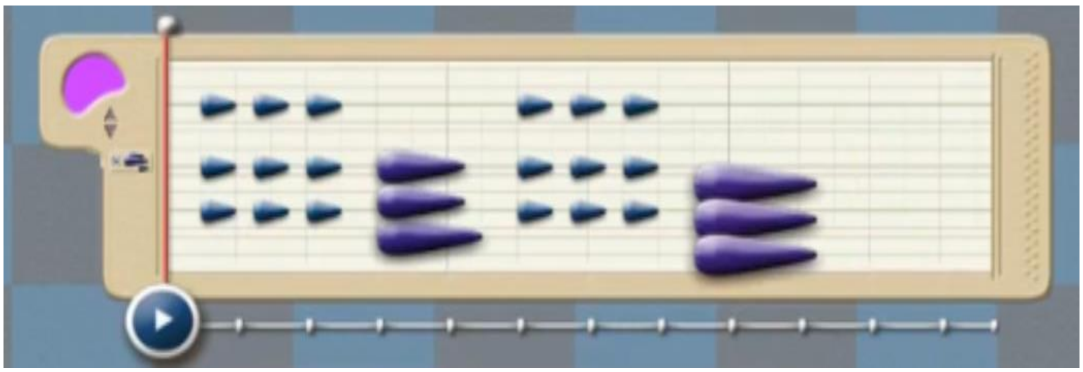


Figure 71. Screenshot of Chelsea and Emily's chordal variation on Beethoven's *Fifth Symphony* finale motive.
(Return to document)

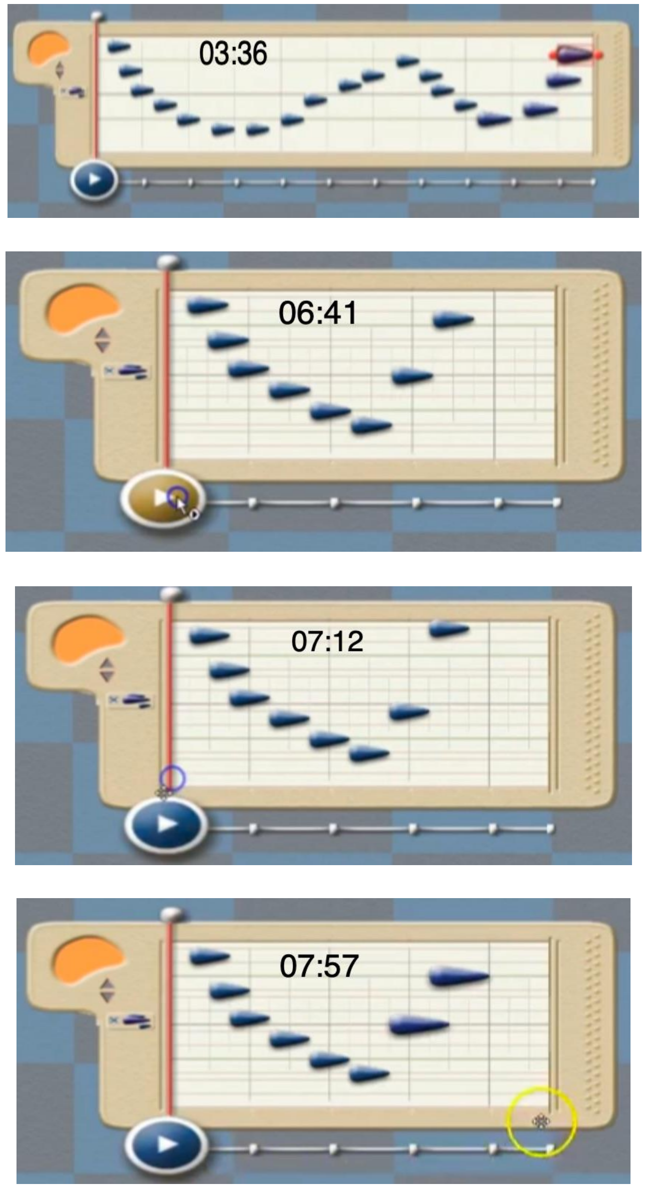


Figure 72. Time-lapse screenshots of Chelsea and Emily’s curved motive development. (Return to document)

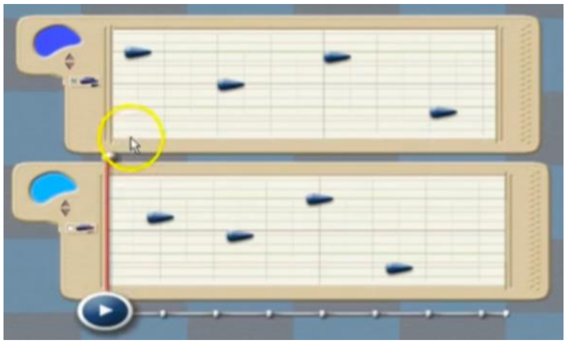


Figure 73. Chelsea and Emily’s two motives with similar contours.
(Return to document)

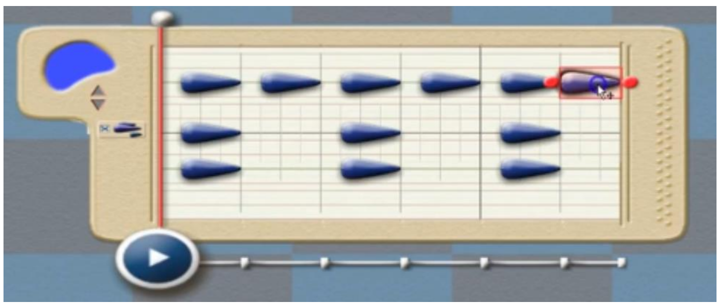


Figure 74. Example of Emily’s structured pattern approach to creating motives.
(Return to document)

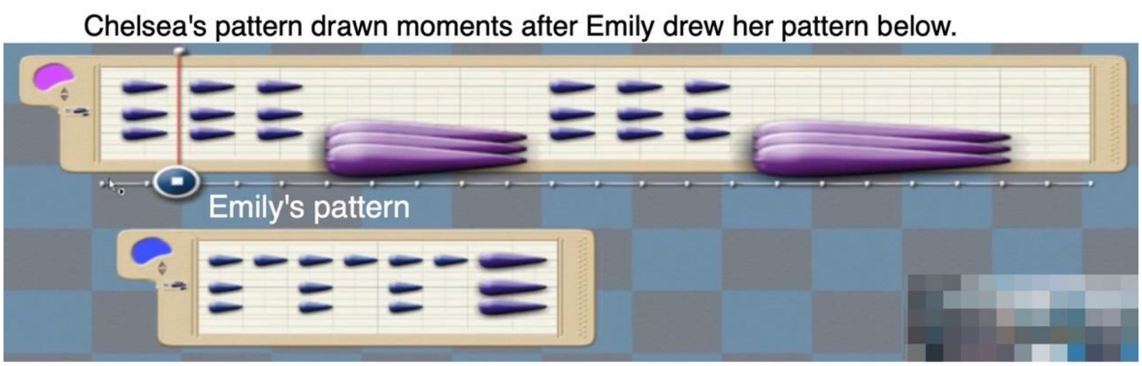


Figure 75. Chelsea’s pattern influenced by Emily’s pattern drawn moments earlier.
(Return to document)

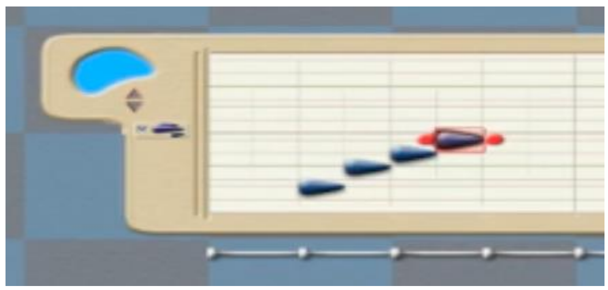


Figure 76. Chelsea's footsteps pattern (left) and Emily's footsteps pattern (right).
(Return to document)

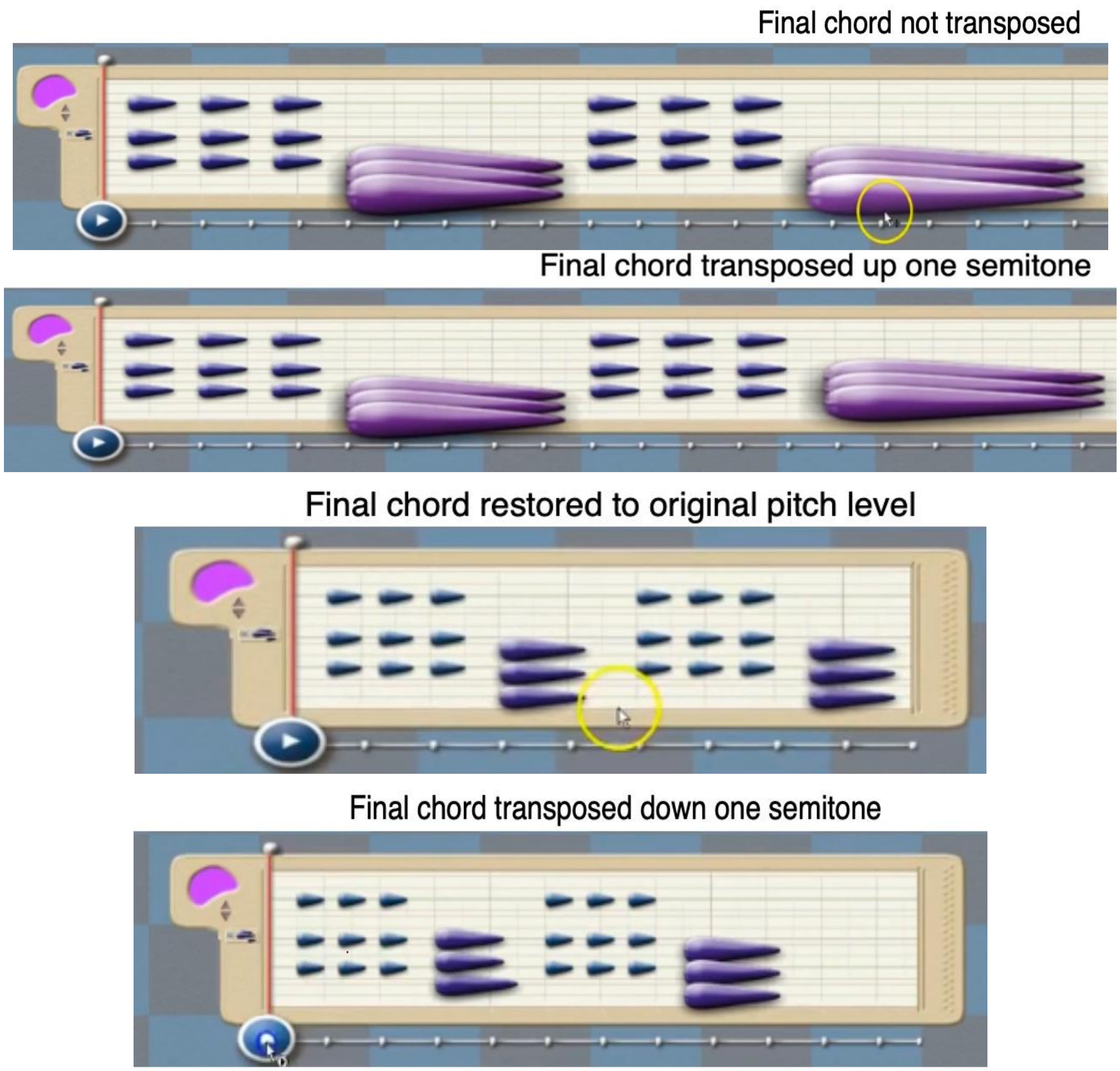


Figure 77. Chelsea and Emily’s translation process (from top to bottom).
(Return to document)

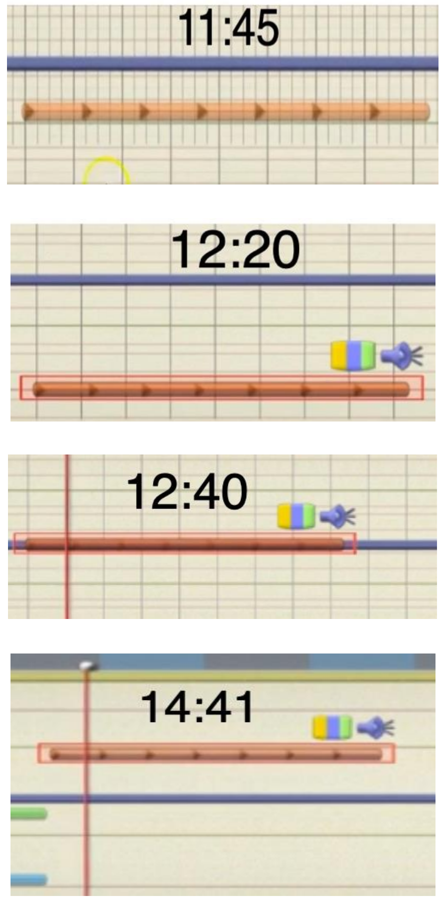


Figure 78. Time-lapse screenshots of Chelsea and Emily’s translation process, during which they aimed to find a pitch level that made their orange motive sound "spooky" and not "too happy."
(Return to document)

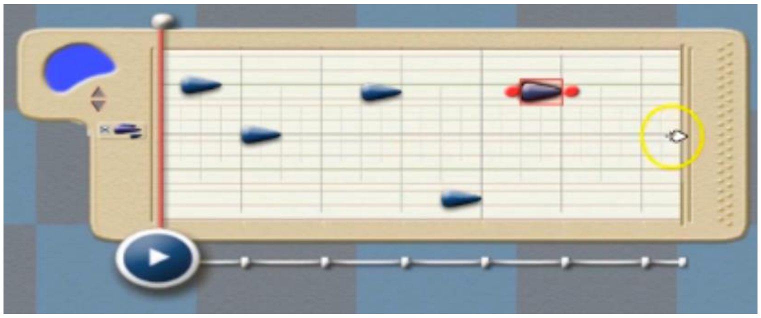


Figure 79. Chelsea and Emily's disjunct motive using the *echoes* timbre.
(Return to document)

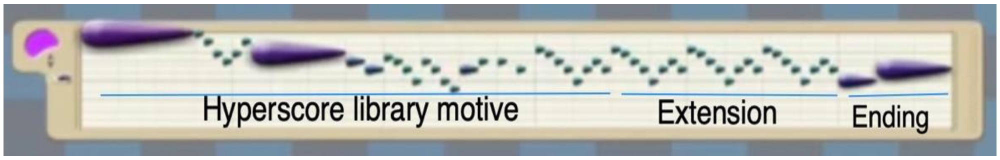


Figure 80. Draco and Ryan's main theme developed from a Hyperscore library motive.
(Return to document)

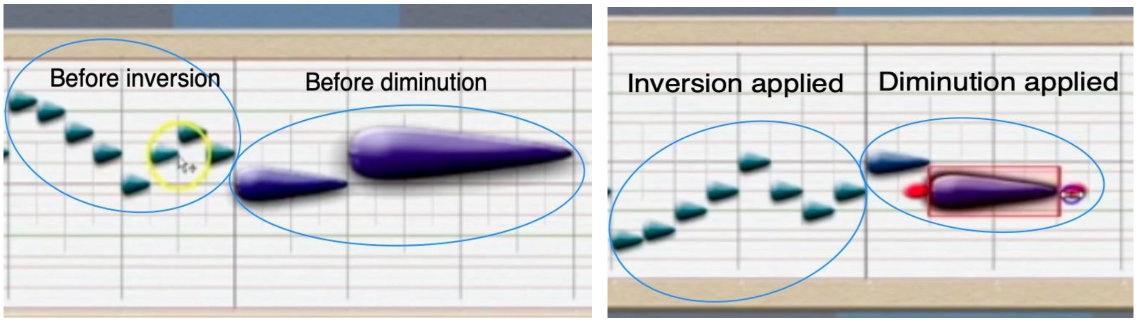


Figure 81. Draco and Ryan's use of inversion, and diminution to create rhythmic variation.
(Return to document)

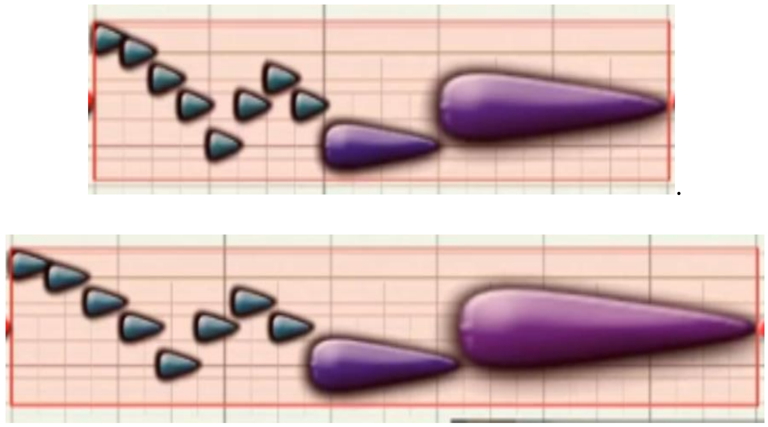


Figure 82. Draco and Ryan’s use of augmentation to create rhythmic variation.
(Return to document)

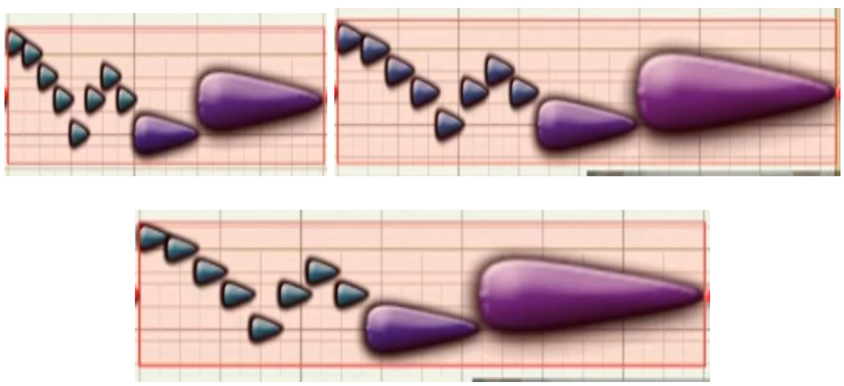


Figure 83. Illustration of how Draco and Ryan applied augmentation to create a ritardando.
(Return to document)

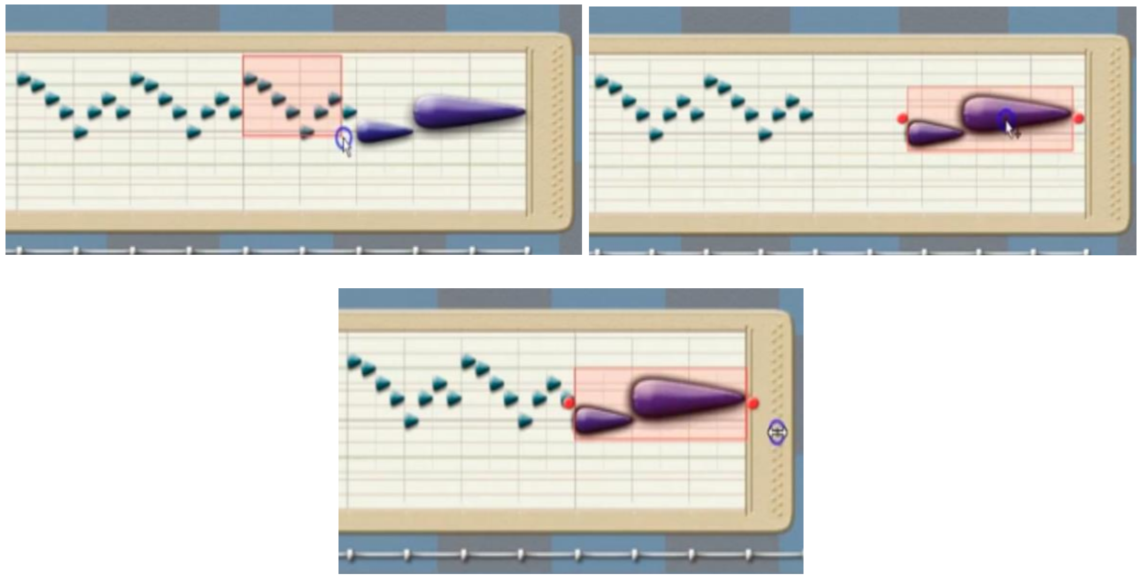


Figure 84. Example of how Draco and Ryan edited their melody to synchronize better with their drum pattern by removing one iteration of a pattern.
(Return to document)

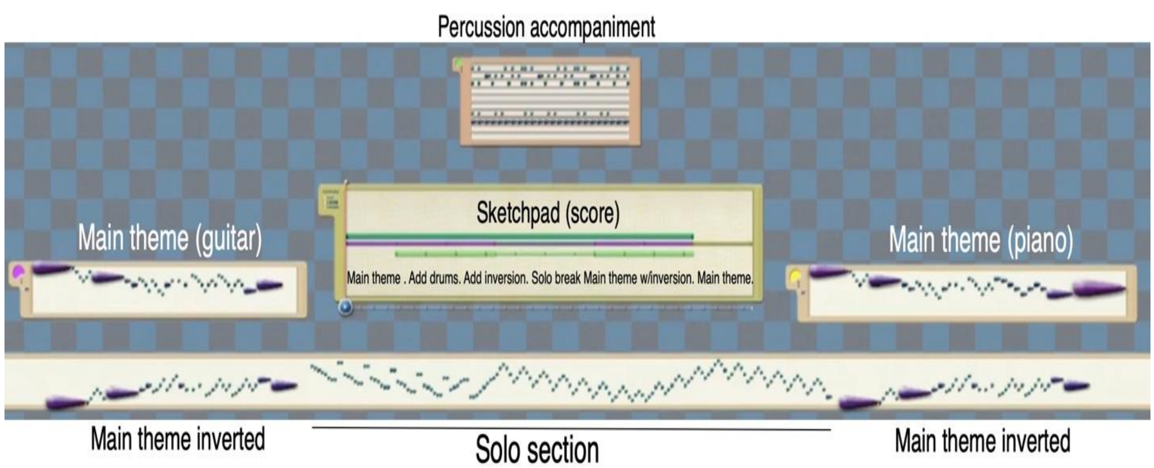


Figure 85. Draco and Ryan's highly structured final composition.
(Return to document)

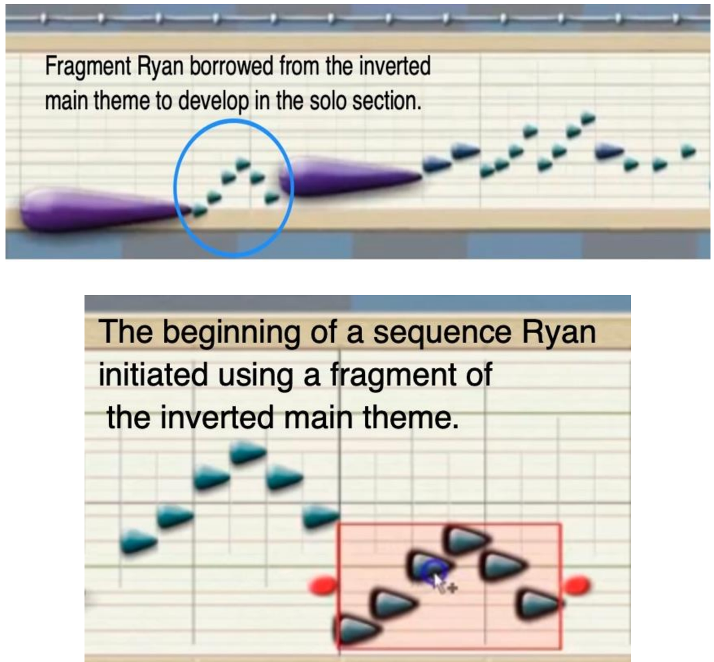


Figure 86. The fragment Ryan borrowed from the inverted main theme and the sequence he started with the fragment.
(Return to document)

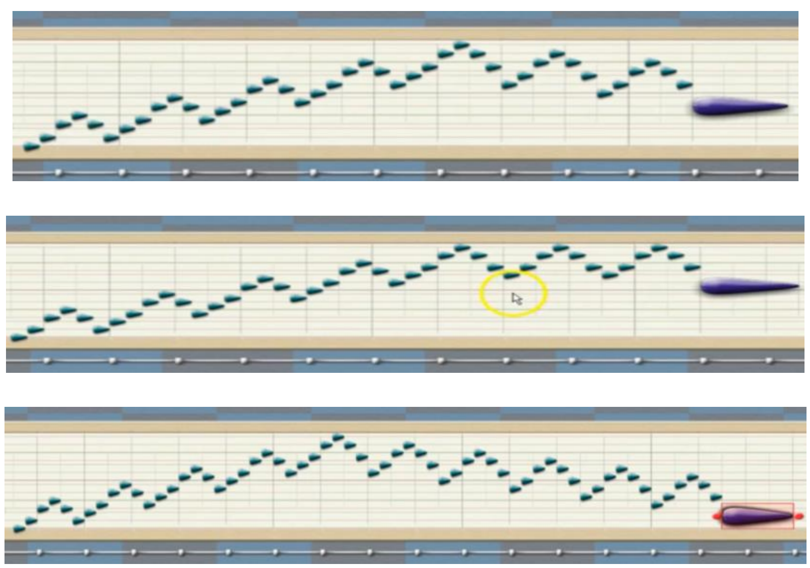


Figure 87. Three of the multiple possible sequences Draco created for the solo section.
(Return to document)

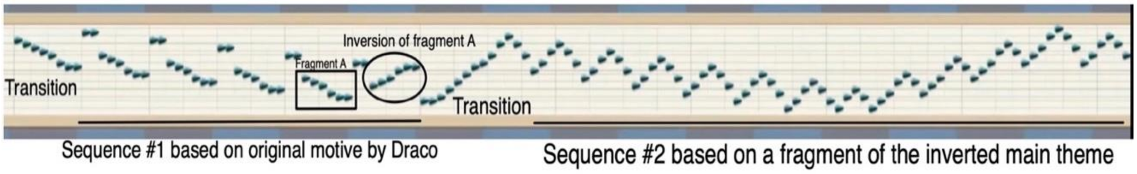
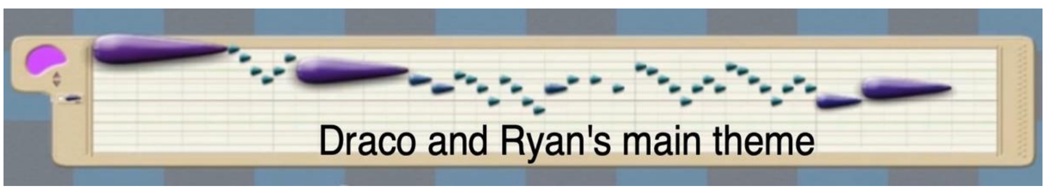


Figure 88. An analysis of Draco and Ryan’s solo section, which incorporated the traditional composition techniques of fragmentation, sequence, inversion, and transition. (Return to document)

Figure 89. Illustration of how Draco and Ryan chose a straight contour when drawing their motives on the sketchpad, which resulted in no change of tonal center as each motive played. The tonal center for each motive is relative to the harmony line, which is the dark blue line in the center of the screen.
(Return to document)



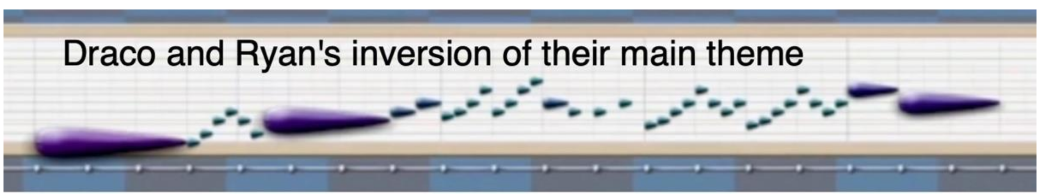


Figure 90. Draco and Ryan’s main theme and inversion which they combined at one point in their composition to create bi-tonality.
(Return to document)

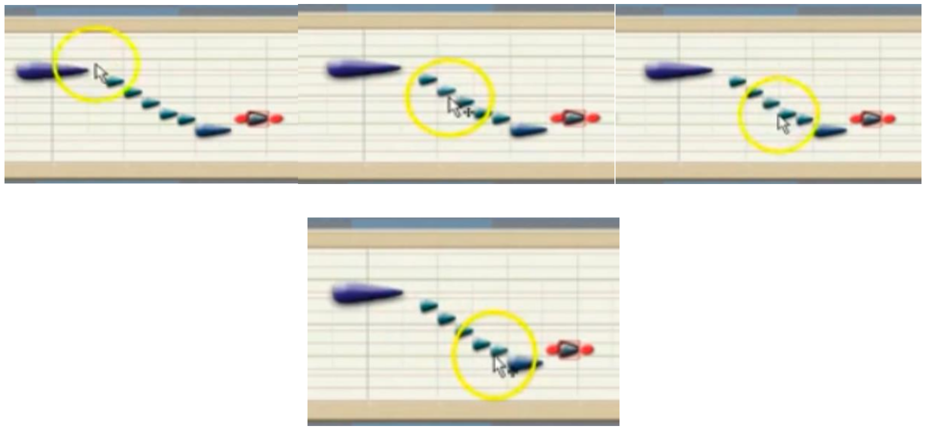


Figure 91. Example of how Draco traced his motive note-by-note with the mouse while singing to confirm his desired pitches.
(Return to document)

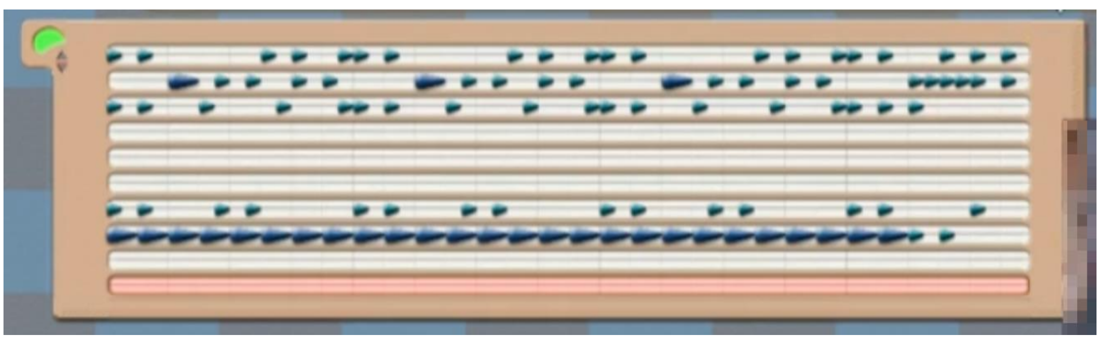


Figure 92. The be-bop style drum pattern Draco and Ryan chose for their composition.
(Return to document)

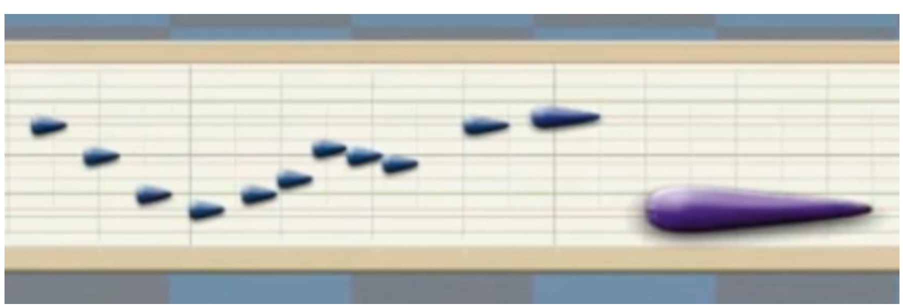


Figure 93. Ryan's original motive that was deleted from the final version of the composition.
(Return to document)

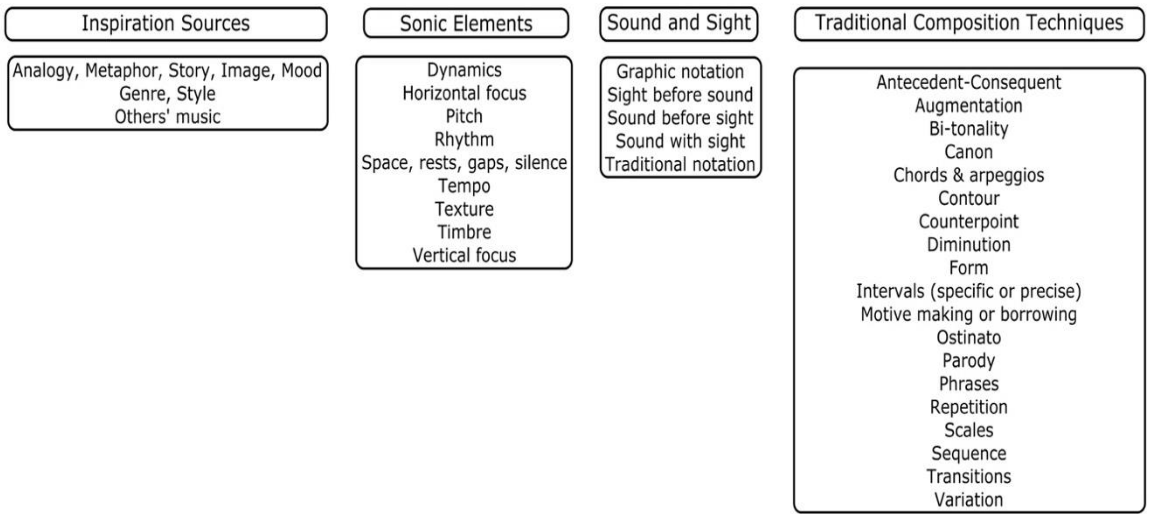


Figure 94. Themes and related categories pertinent to research question #1.
(Return to document)

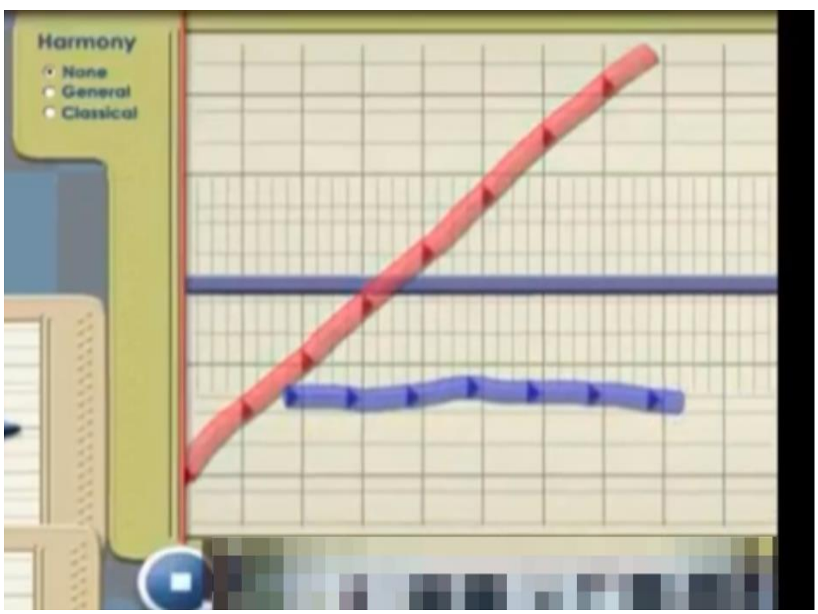


Figure 95. Ryan’s use of oblique motion to create suspense.
(Return to document)

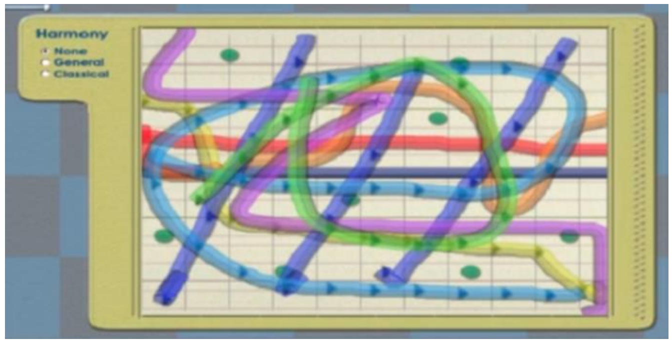


Figure 96. Chelsea's simultaneous use of the eight available Hyperscore colors (timbres).
(Return to document)

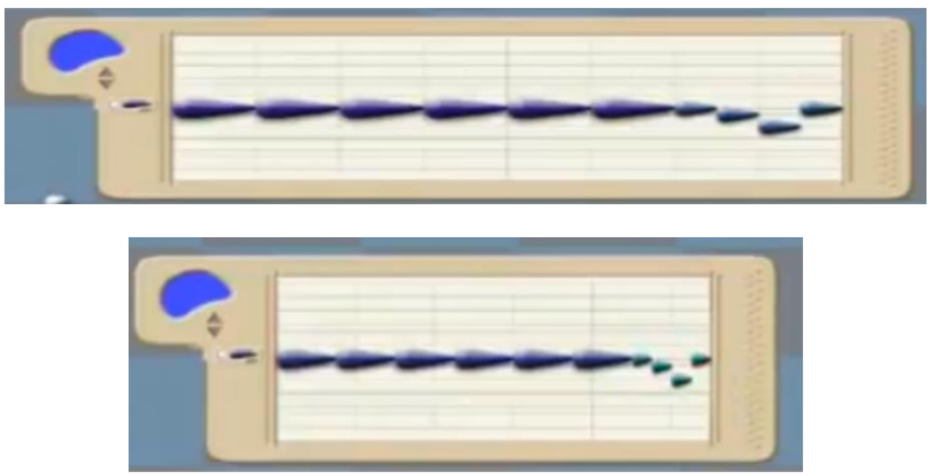


Figure 97. Draco's strategy of adjusting the tempo of his bass line by reducing note size and compressing notes.
(Return to document)

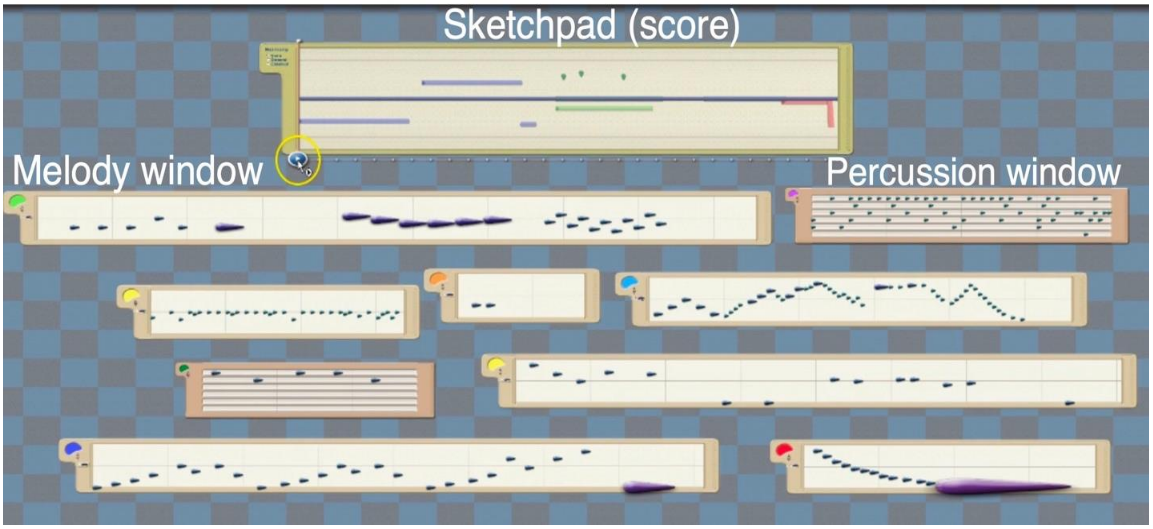


Figure 98. A screenshot highlighting the three main components of the Hyperscore interface: a melody window, percussion window, and the sketchpad (score).
(Return to document)

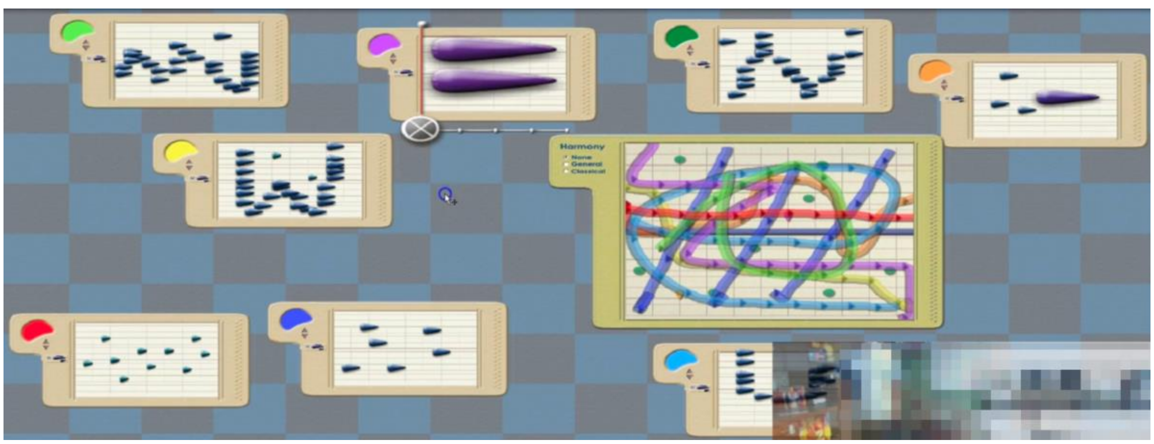


Figure 99. Chelsea's predominantly curvilinear approach to her first composition.
(Return to document)

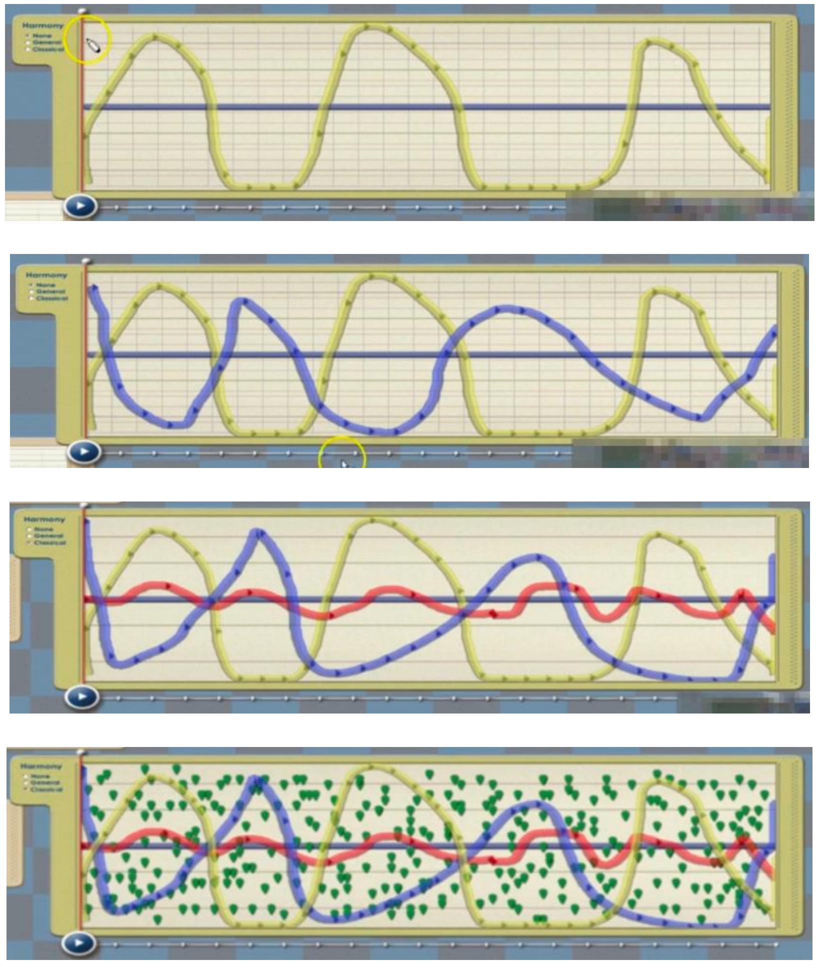


Figure 100. Four milestones (top to bottom) illustrating Emily's curvilinear approach to her final individual composition.
(Return to document)

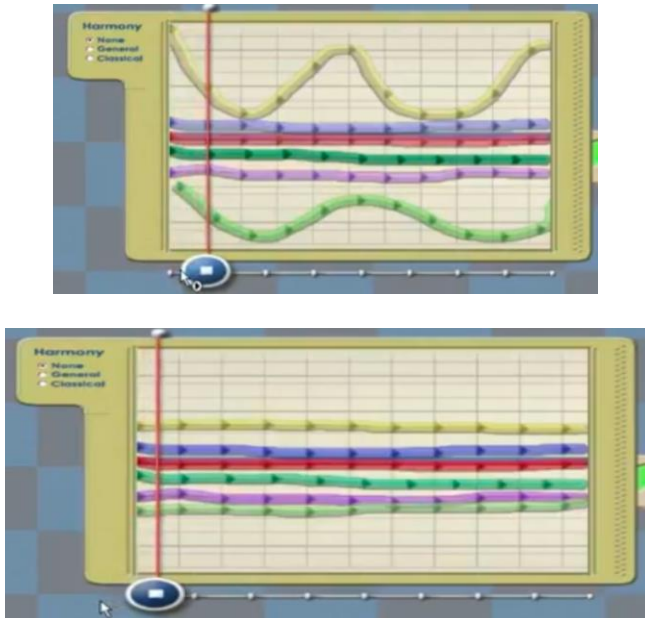


Figure 101. Before and after screenshots illustrating how Emily converted curved lines to straight lines on the sketchpad after listening to the effect of the curved lines.
(Return to document)

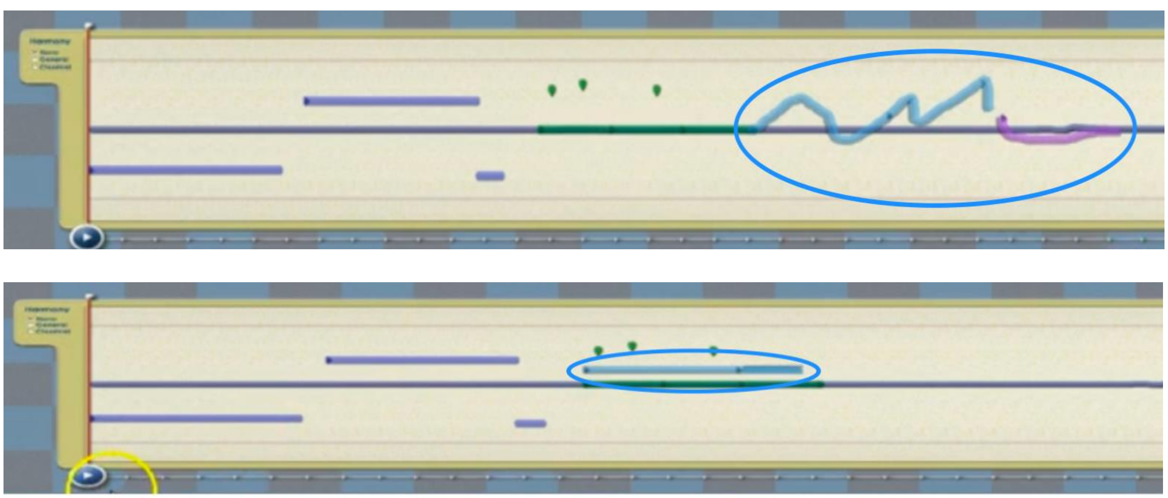


Figure 102. Before (top) and after (bottom) screenshots illustrating how Ryan converted one curved line to a straight line (light blue) and deleted another (purple) on his sketchpad.
(Return to document)

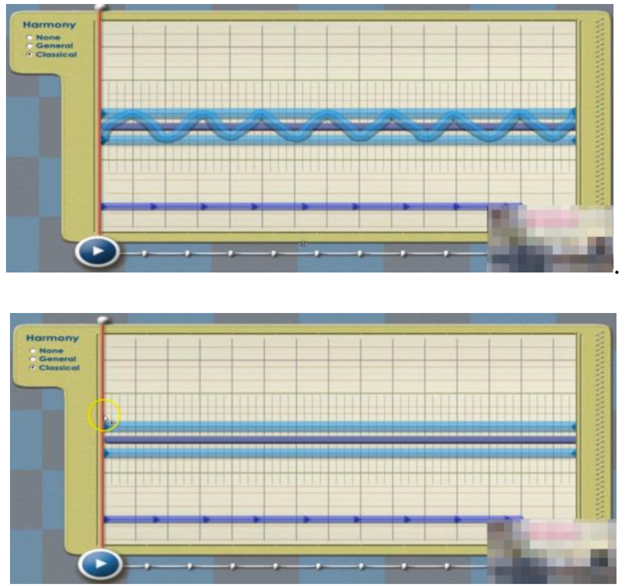


Figure 103. Before and after screenshots illustrating how Draco deleted a curved line to improve his composition.
(Return to document)

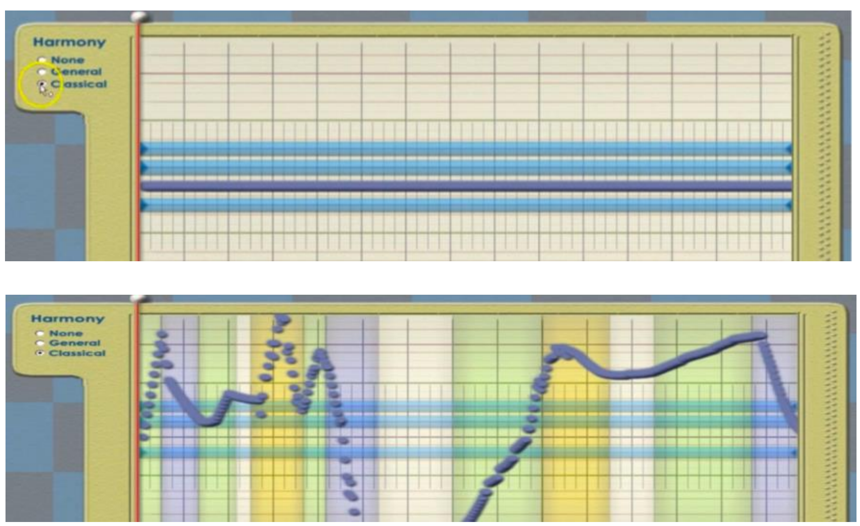


Figure 104. Draco’s use of polytonality before (top) and after (bottom) incorporating the harmony line to vary the tonal center of his piece. Note, (dark blue line running through the center of the sketchpad) varies the tonal center and does not itself represent any musical material.
(Return to document)

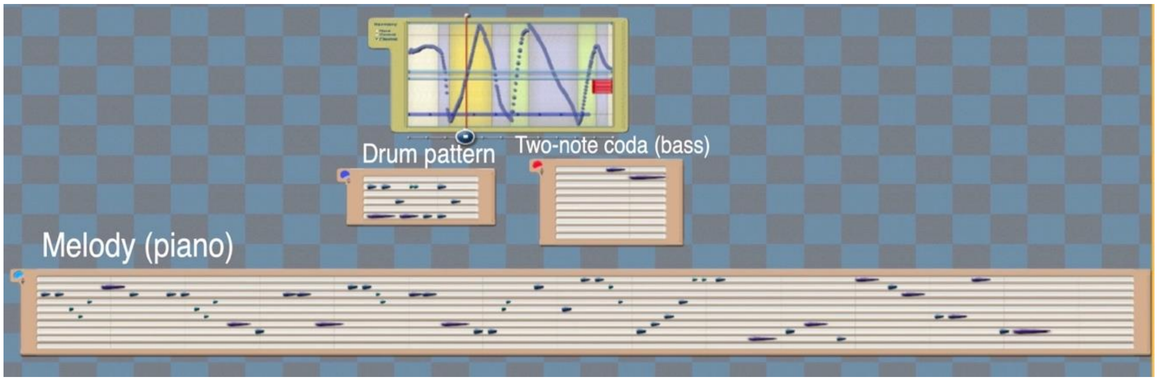


Figure 105. Draco's individual composition with an extended melody accompanied by a short drum pattern.
(Return to document)

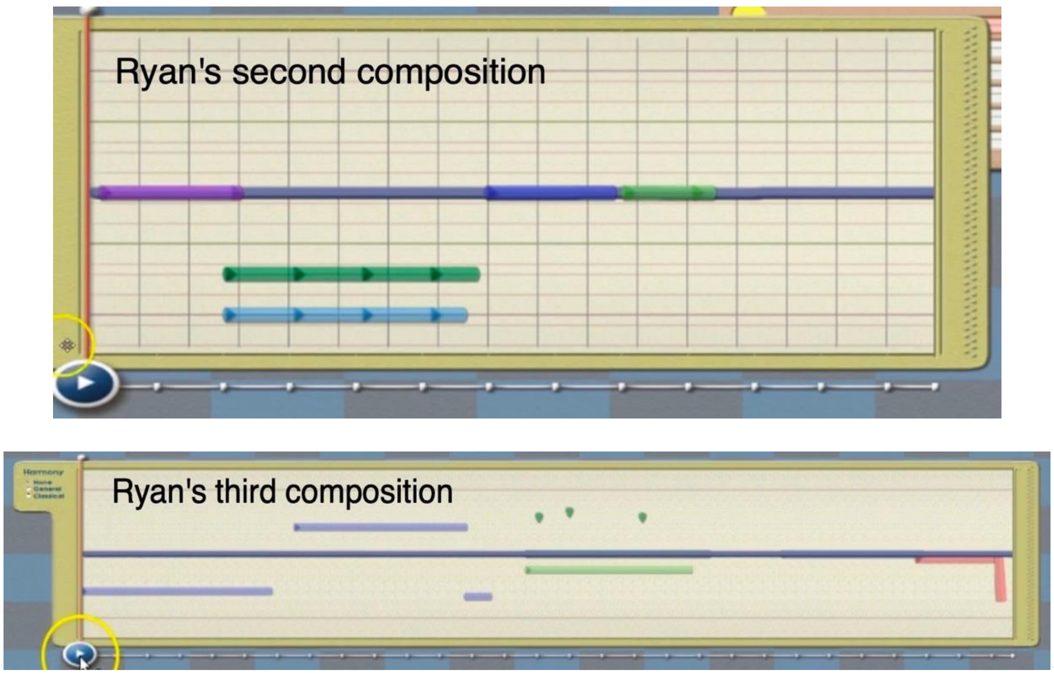


Figure 106. Ryan's second and third compositions exemplifying his horizontal, minimalistic, predominantly monophonic approach. Note, the blue line running through the center of the sketchpad is the harmony line and does not represent any musical material.
(Return to document)

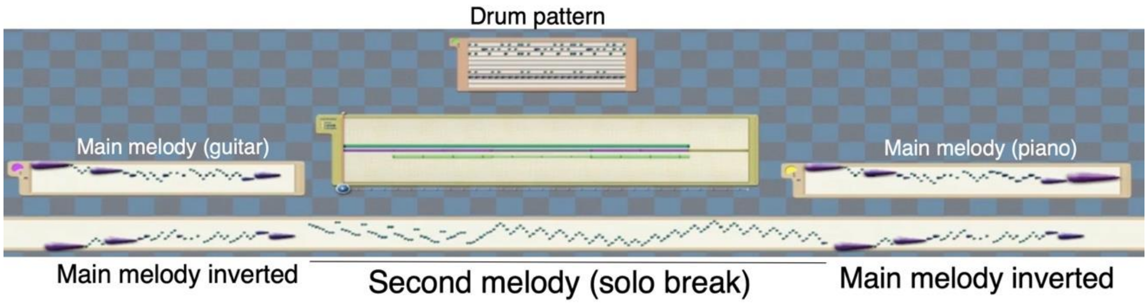


Figure 107. Draco and Ryan's collaborative composition comprising a main melody and its inversion, a drum pattern, and a second melody that functions as a solo break.
(Return to document)

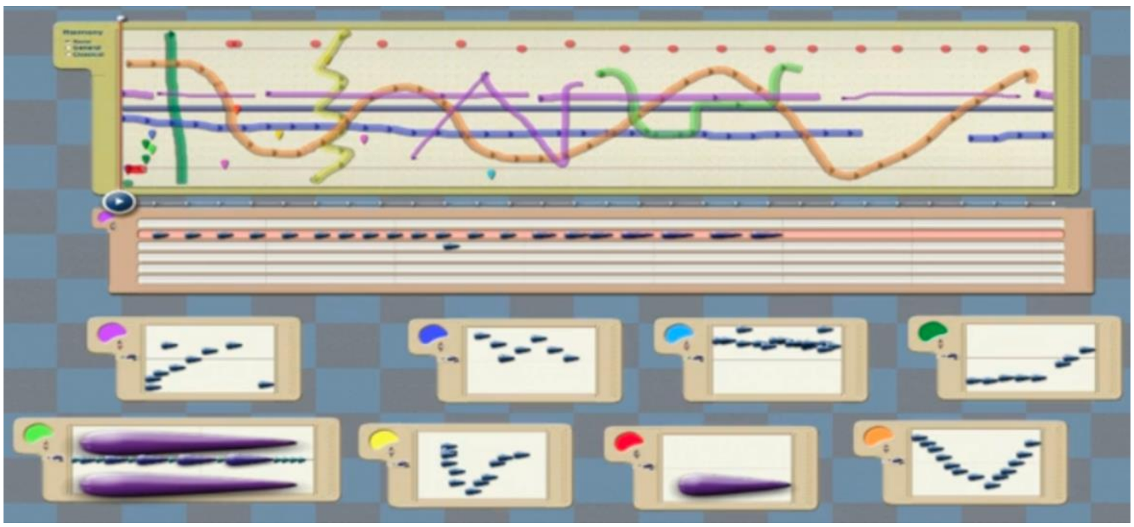


Figure 108. Chelsea's second composition.
(Return to document)

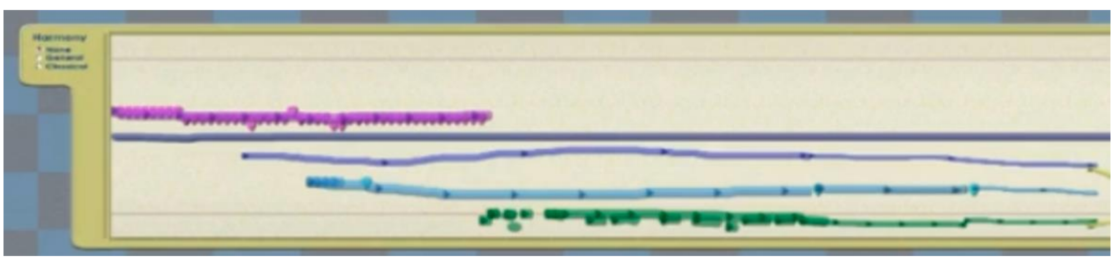


Figure 109. Chelsea's quasi-stretto effect at the beginning of her final individual composition.
(Return to document)

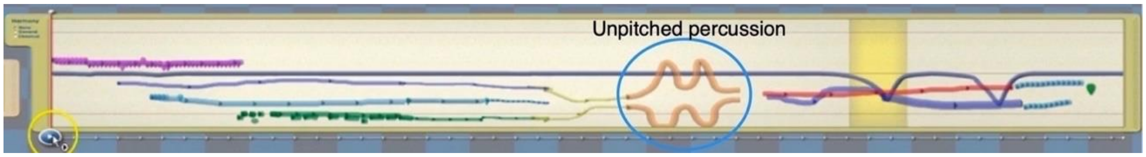


Figure 110. Chelsea's predominantly horizontal approach to her final individual composition. Note, the blue line running through the center of the sketchpad is the harmony line used to vary the tonal center of the composition and does not represent any musical material.
(Return to document)

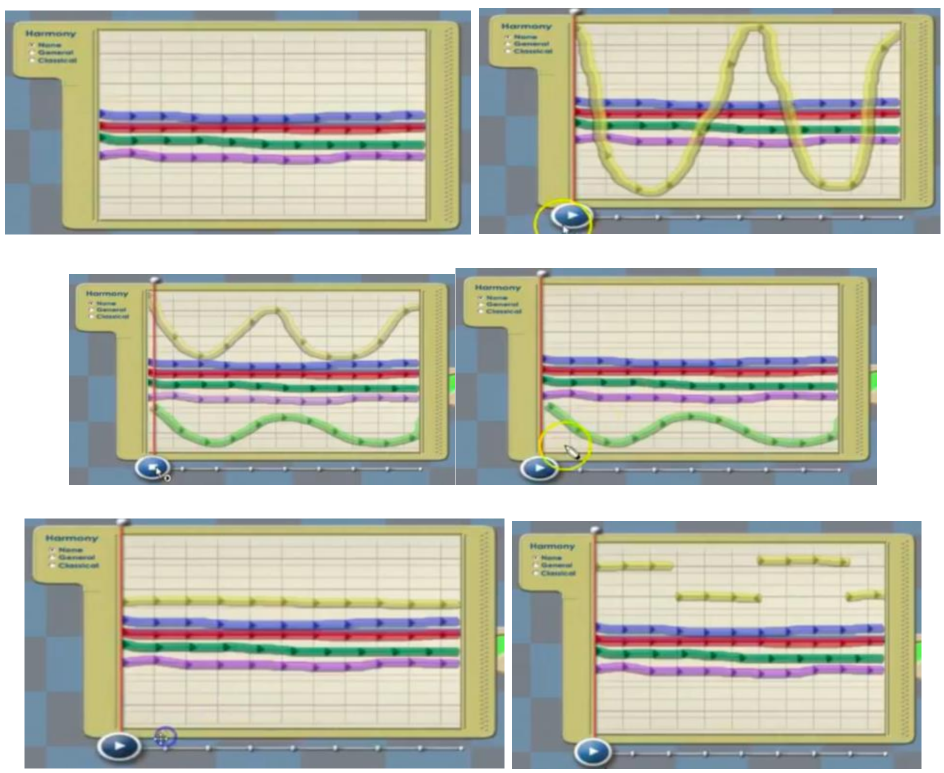


Figure 111. From top left to bottom right, Emily's gradual addition and ultimate deletion of curvilinear shapes in her first composition.
(Return to document)

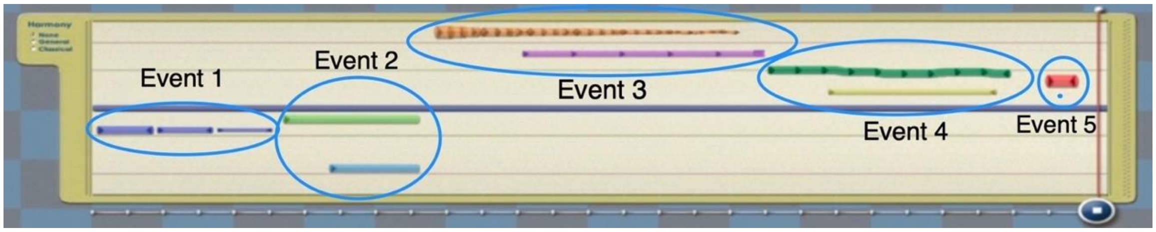


Figure 112. Chelsea and Emily's collaborative composition comprising five discrete events.
(Return to document)

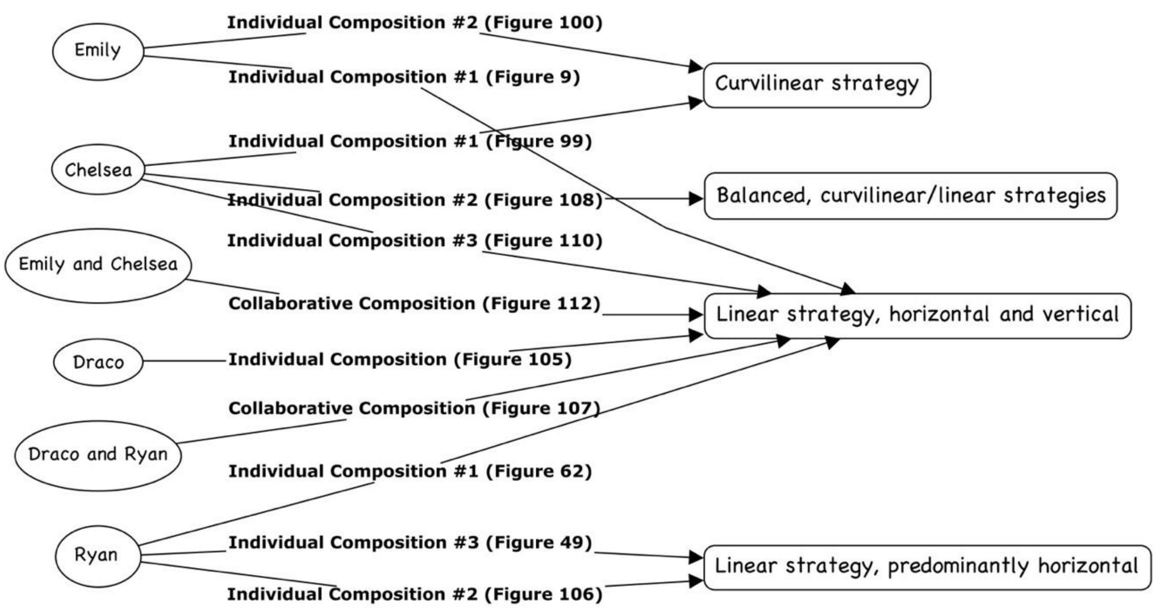


Figure 113. Summary of directional approaches to composition displayed or expressed by the four focus composers.
(Return to document)

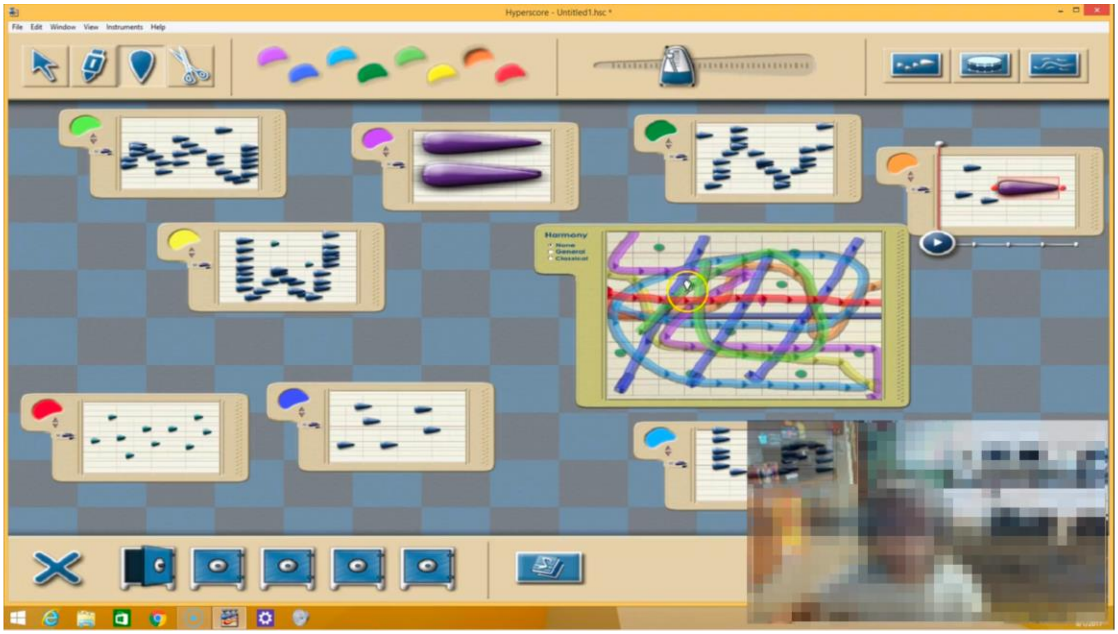


Figure 114. Chelsea’s sight before sound approach as it emerged within minutes of creating her first composition.
(Return to document)

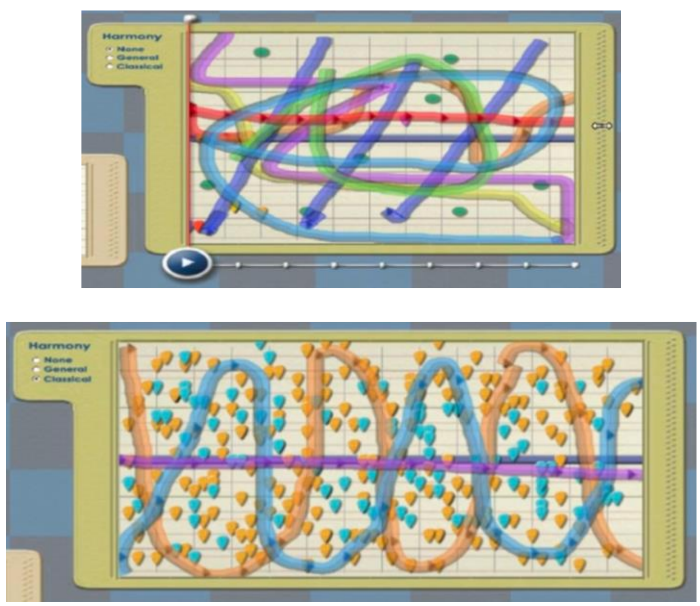


Figure 115. Chelsea’s first composition (left) and Emily’s second composition (right). Chelsea’s strategy was strictly sight to sound. Emily used a sight to sound strategy when drawing the scattered dots (chords) but not for her other sonic elements.
(Return to document)

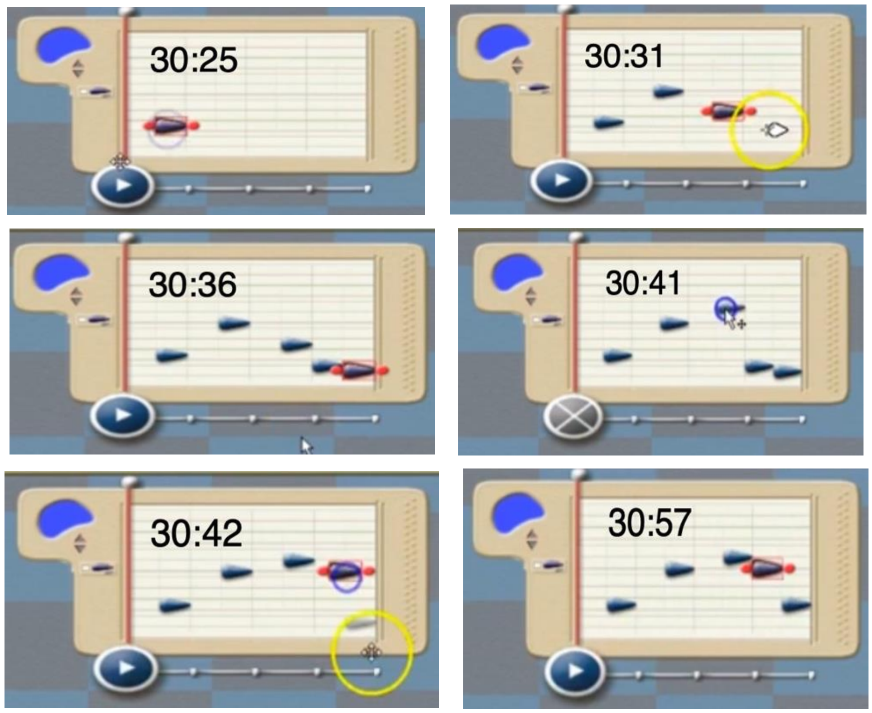


Figure 116. Time-lapse screenshots of Emily's sound with sight process as she transcribed the first five notes of Arabesque by Burgmüller.
(Return to document)

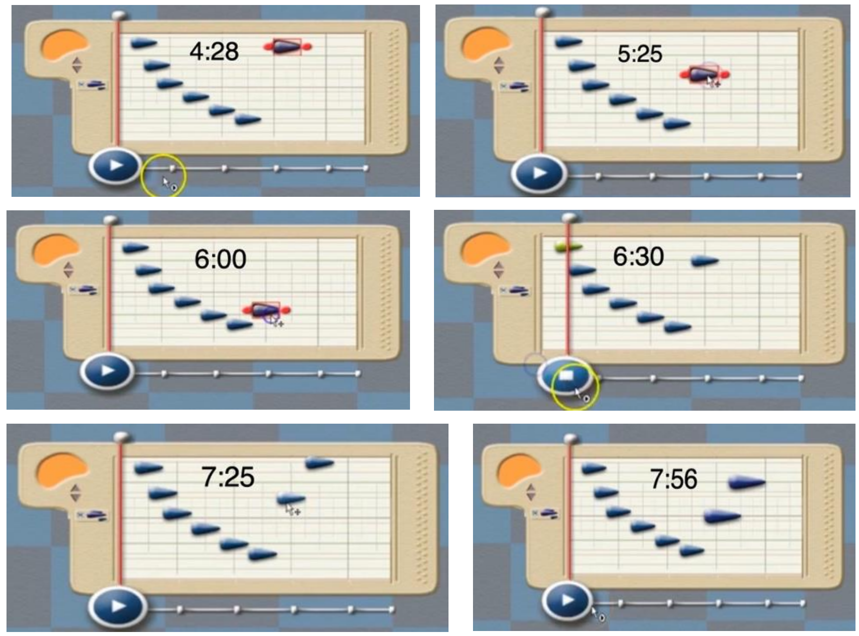


Figure 117. Time-lapse screenshots of Chelsea and Emily's sound with sight process as they transcribed multiple versions of the ending for their melody.
(Return to document)

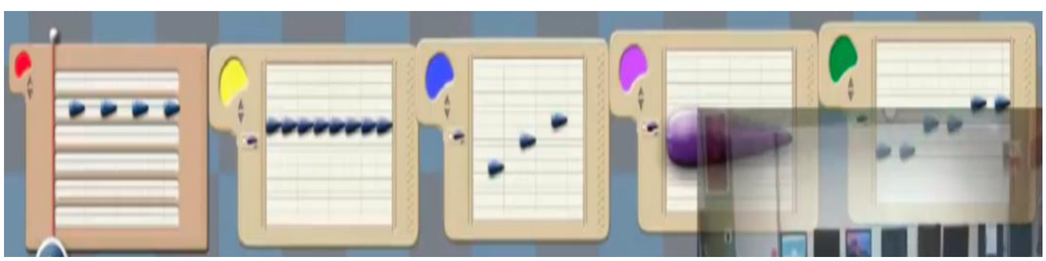


Figure 118. Screenshot of Emily's consistently aligned and evenly spaced notes.
(Return to document)

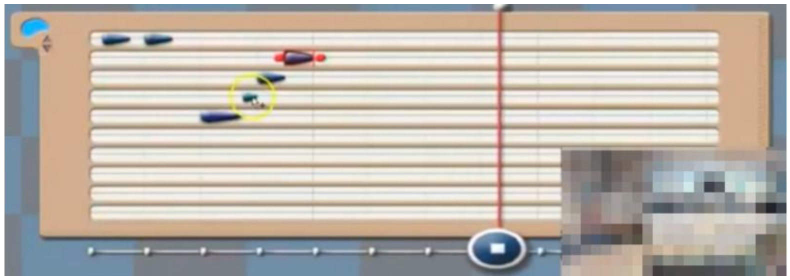


Figure 119. Screenshot illustrating how Draco 'hacked' the ten-line Hyperscore percussion window to emulate a traditional staff and notate a single-timbre melody by assigning each line of the percussion staff to the same timbre.
(Return to document)

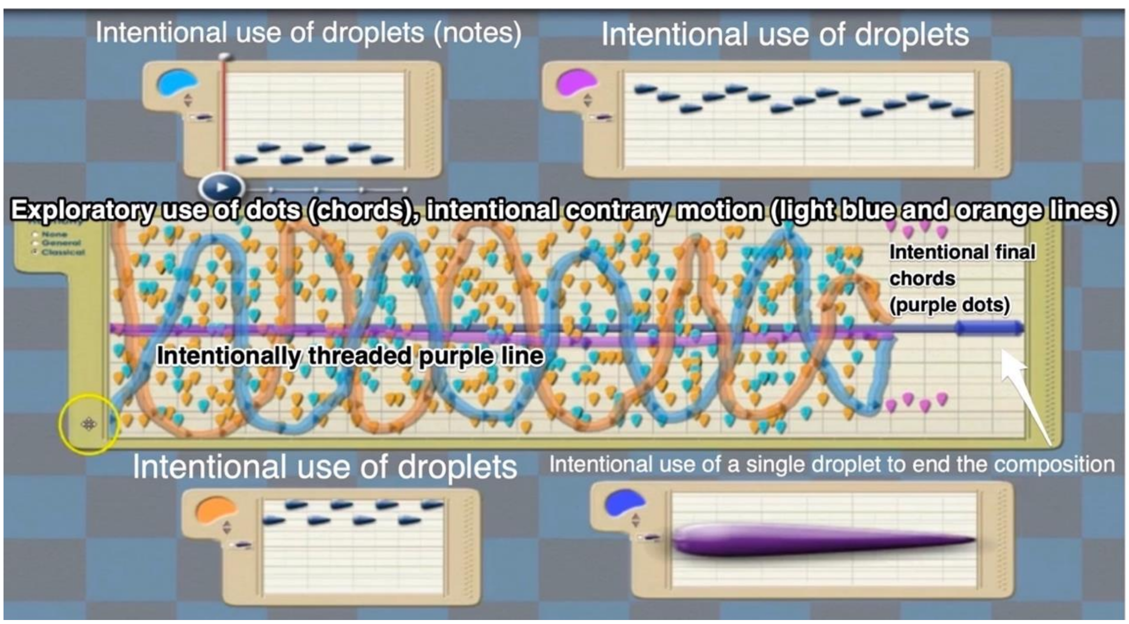


Figure 120. Screenshot of Emily's final individual composition displaying how she combined exploratory and intentional use of Hyperscore's graphic notation tools. Note, the blue line running through the center of the sketchpad (the harmony line) does not represent any musical material.
(Return to document)

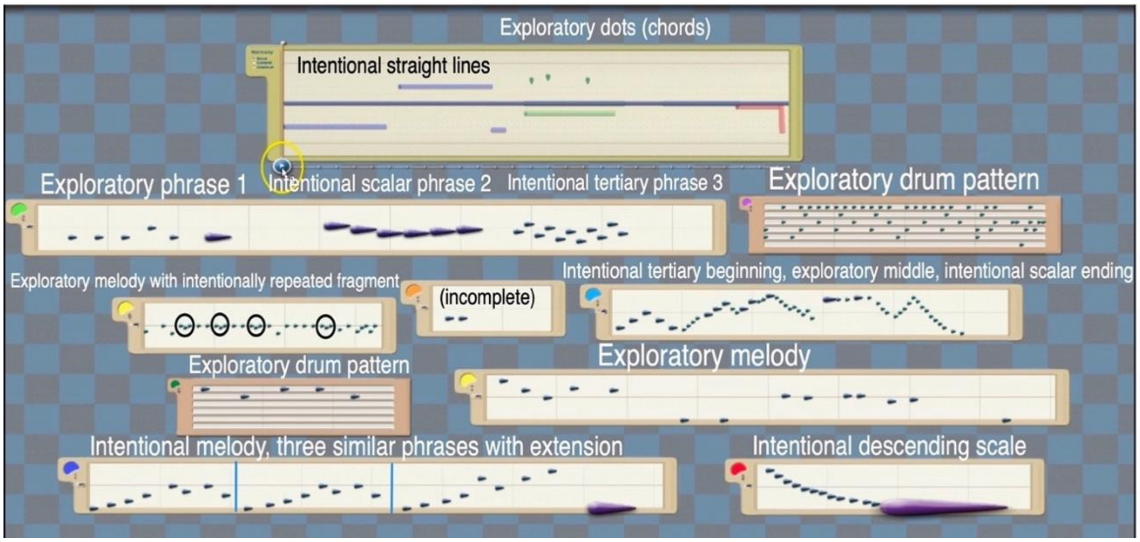


Figure 121. Screenshot of Ryan's final individual composition displaying a balance of exploratory and intentional approaches used to create his sonic elements.
(Return to document)

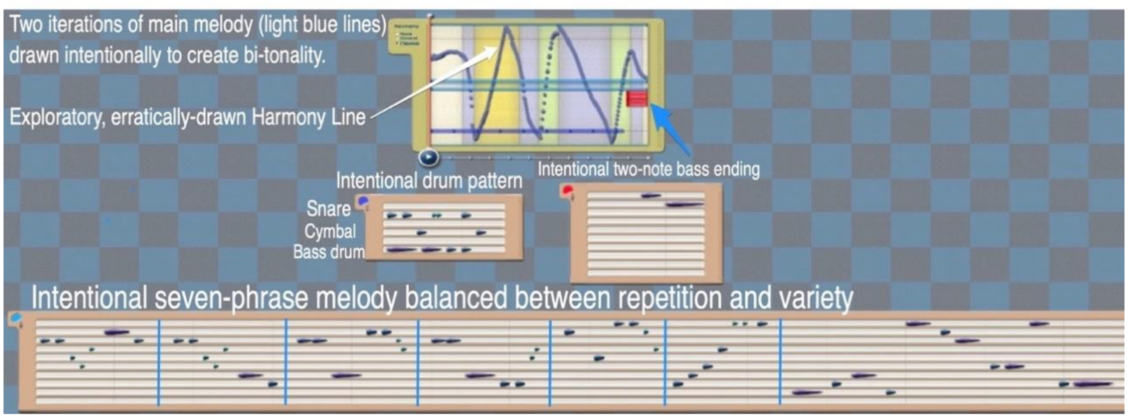


Figure 122. Screenshot of Draco's final individual composition displaying a distinctly intentional use of droplets (notes) to create his sonic elements, intentionally drawn straight lines on the sketchpad, and an exploratory, erratically drawn harmony line. Note, the harmony line varies the tonal center and does not itself represent any musical material.
(Return to document)

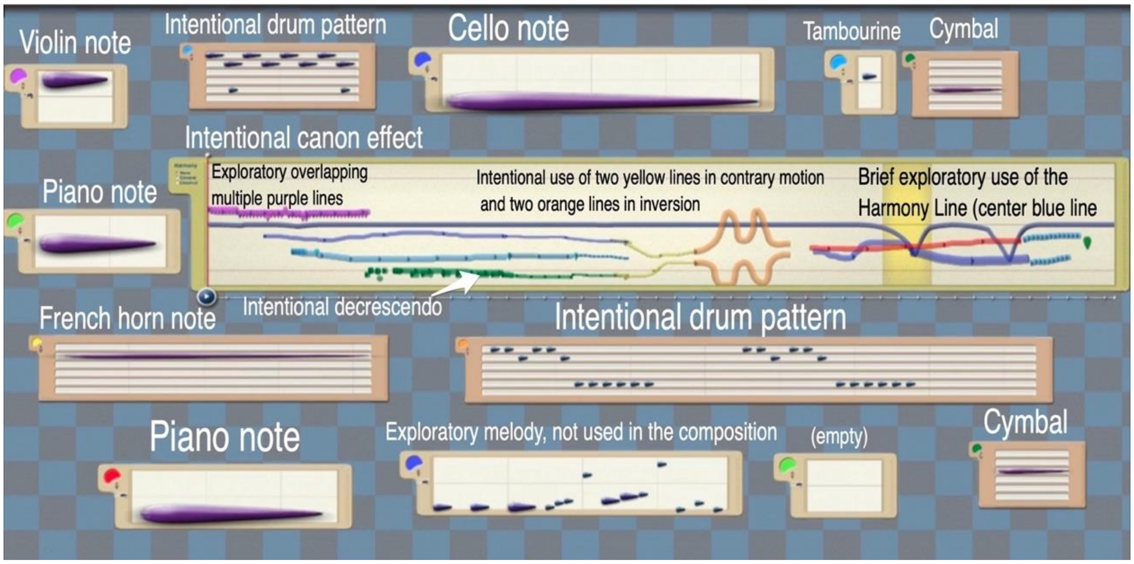


Figure 123. Screenshot of Chelsea's final individual composition displaying the use of intentional drum patterns, contrary motion, and inversion, as well as one exploratory melody and brief exploratory use of the harmony line. Note, the harmony line varies the tonal center and does not itself represent any musical material.
(Return to document)

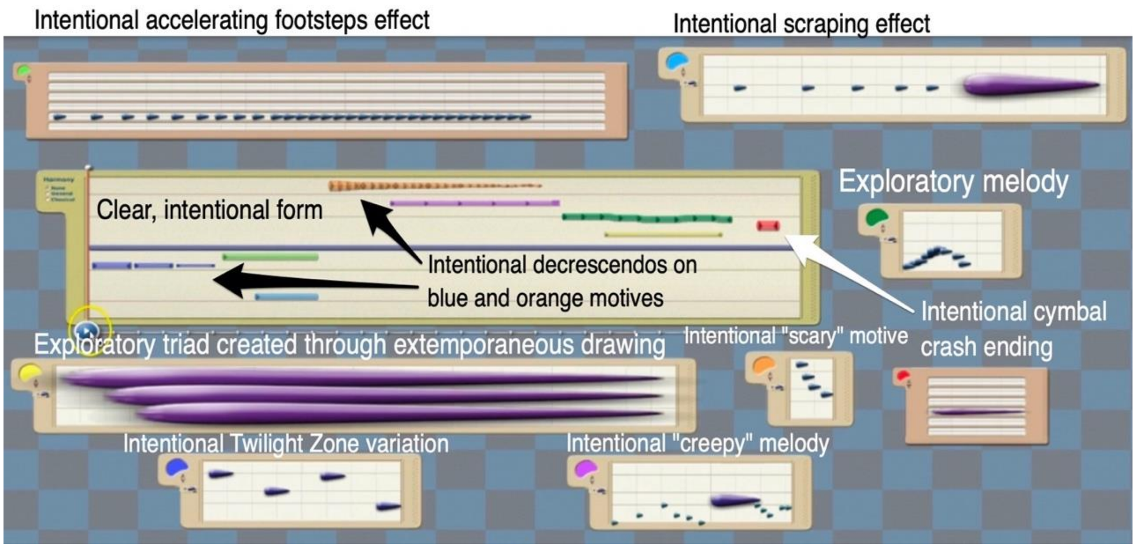


Figure 124. Screenshot of Chelsea and Emily's collaborative composition illustrating predominantly intentional uses of the graphic notation tools with two sonic elements (yellow and green windows) emanating from an exploratory process. Note, the blue line running through the center of the sketchpad (the harmony line) does not represent any musical material.
(Return to document)

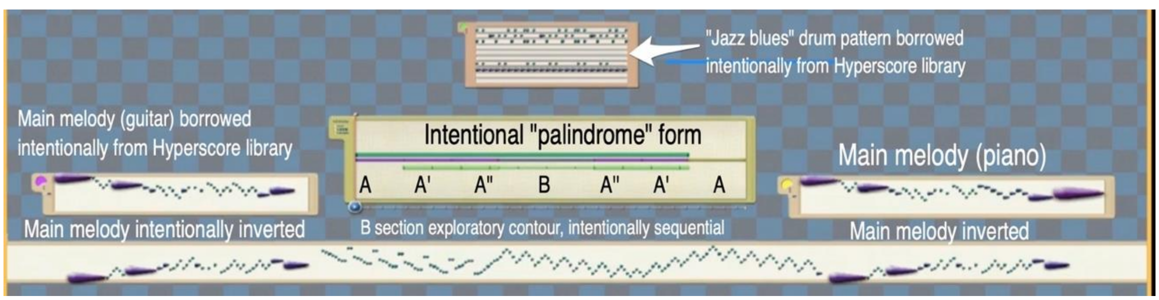


Figure 125. Screenshot of Draco and Ryan's collaborative composition illustrating predominantly intentional uses of the graphic notation tools. The B section melody incorporated a contrasting exploratory contour.
(Return to document)

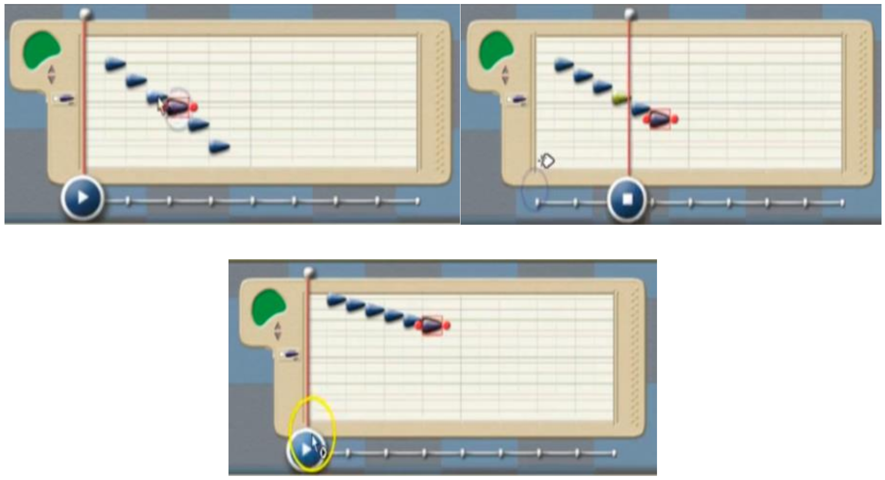


Figure 126. Screenshots of Emily's translation (transposition) process while she sang a chromatic scale and transcribed droplets to match the range of her voice.
(Return to document)

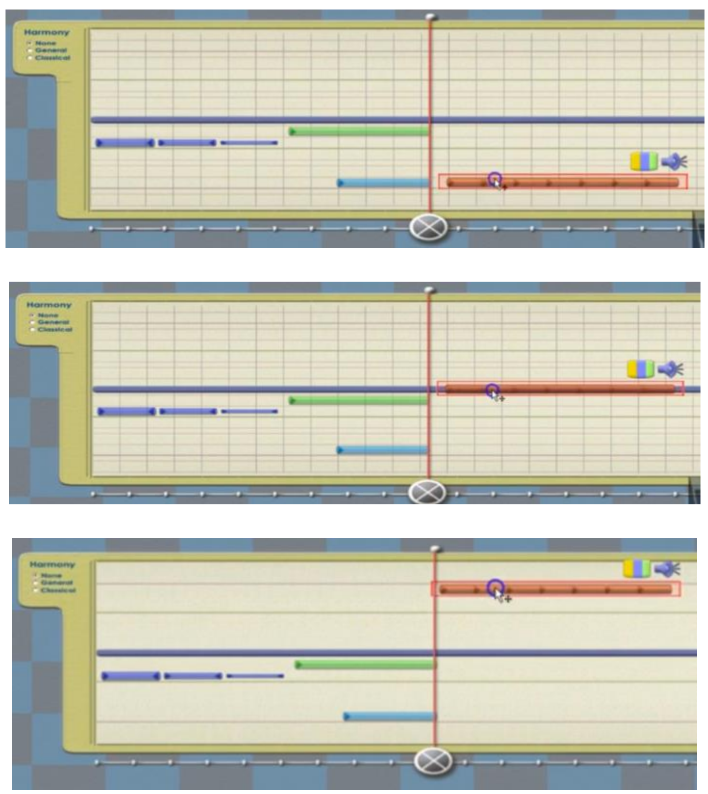


Figure 127. Screenshots of Chelsea and Emily's translation (transposition) process (top to bottom) to create a high-pitched, more eerie sound.
(Return to document)

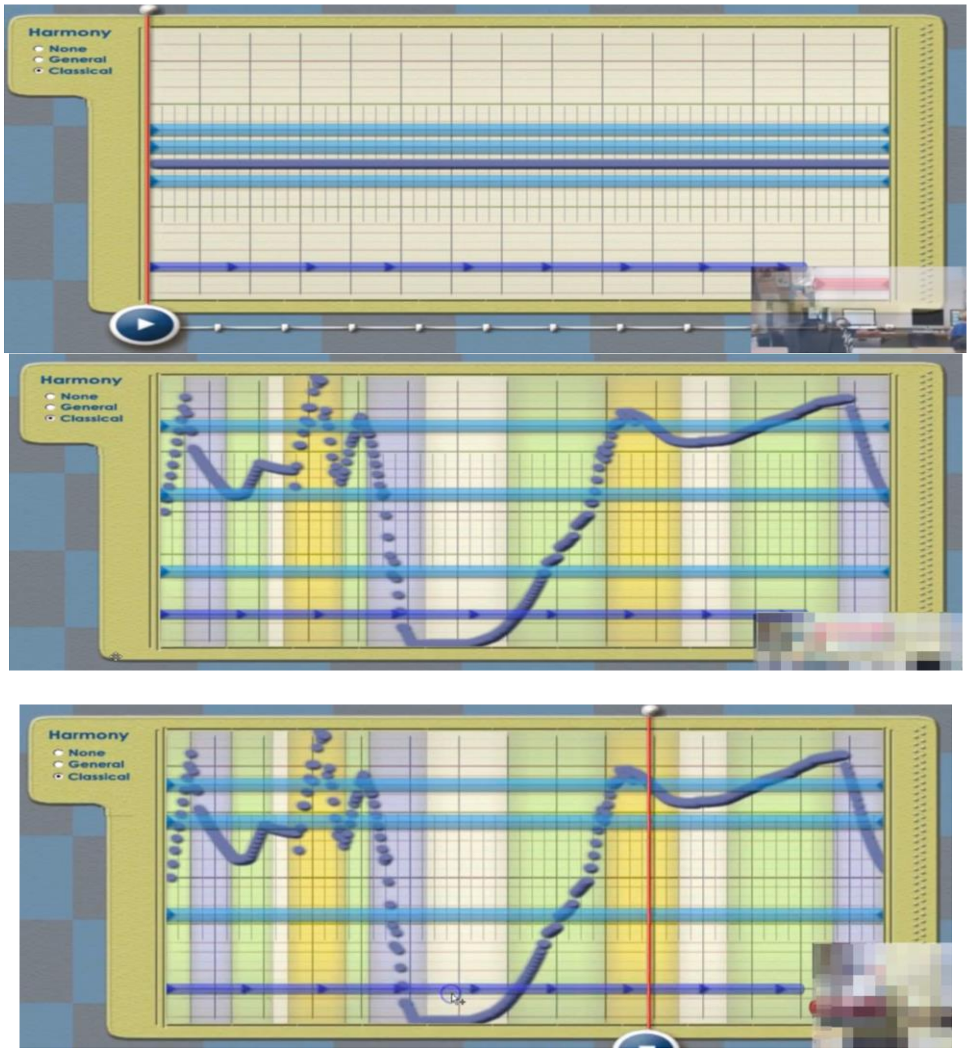


Figure 128. Screenshots of Draco’s translation process to determine how three iterations of his melody (light blue line) harmonized best with one another. The erratic dark blue line is the harmony line, with which Draco experimented by drawing it haphazardly. The harmony line does not represent any musical material.

(Return to document)

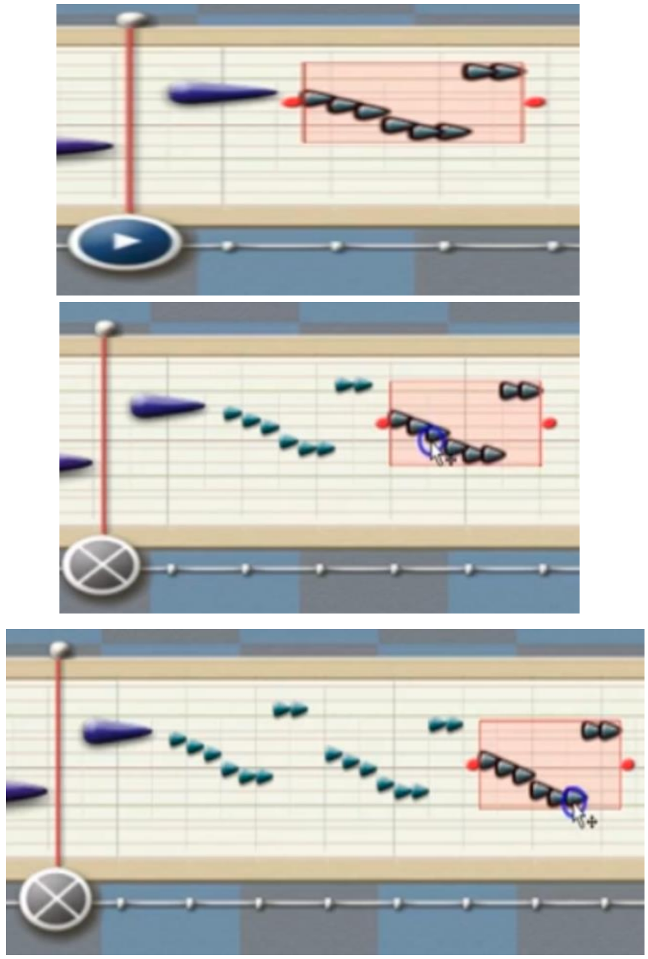


Figure 129. Screenshots (top to bottom) depicting how Draco and Ryan translated an eight-note motive two times to create a sequence.
(Return to document)

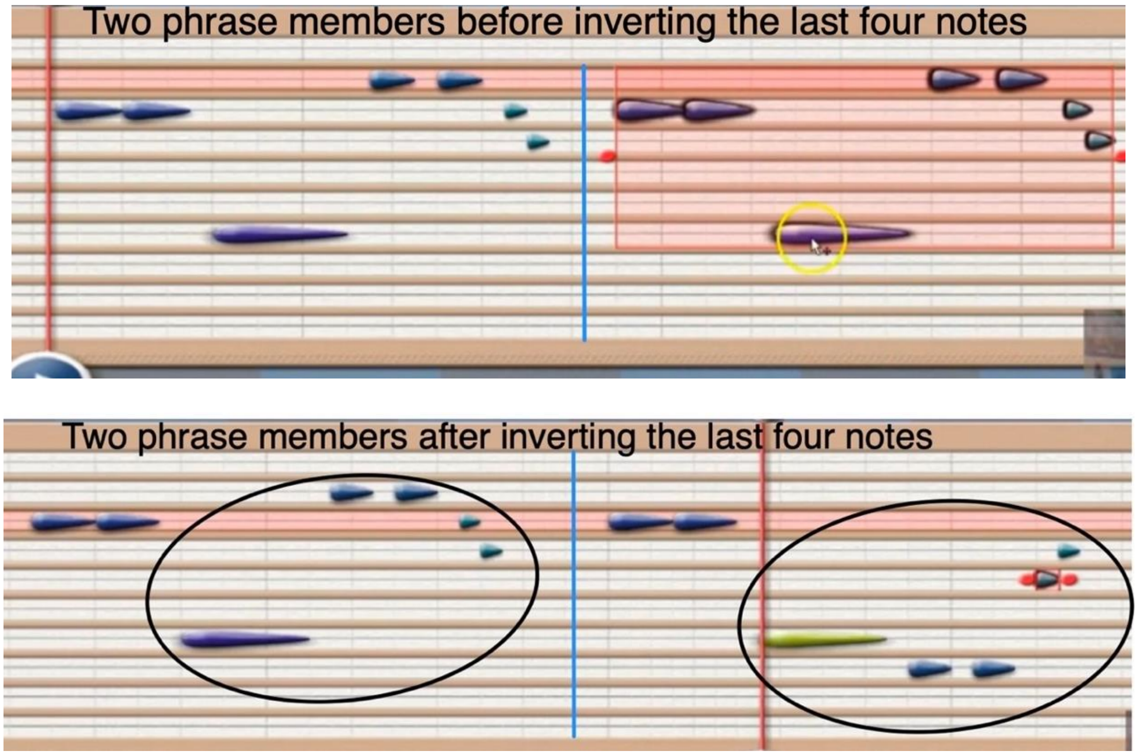


Figure 130. Screenshots depicting how Draco applied reflection to the end of a phrase.
(Return to document)

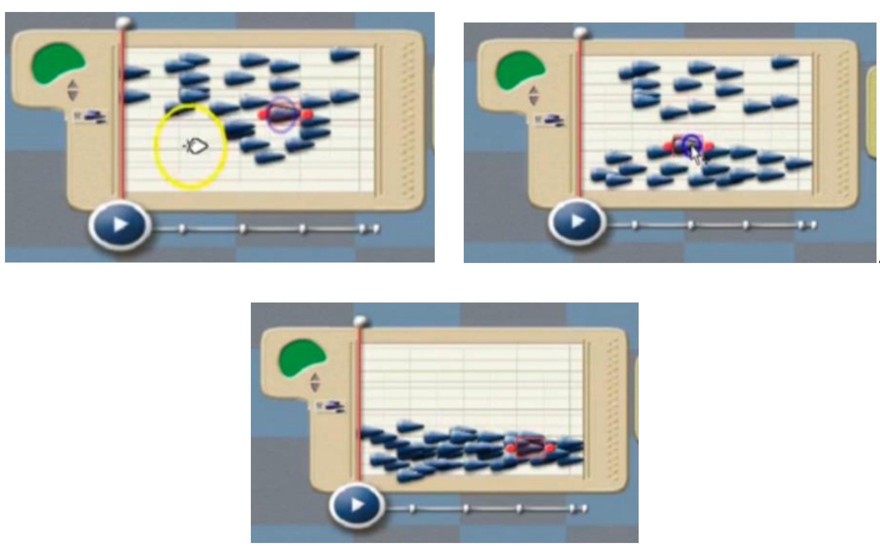


Figure 131. Three screenshots illustrating from left to right how Chelsea explored translation (transposition) as a strategy by moving each note down individually to create a denser cluster.
(Return to document)

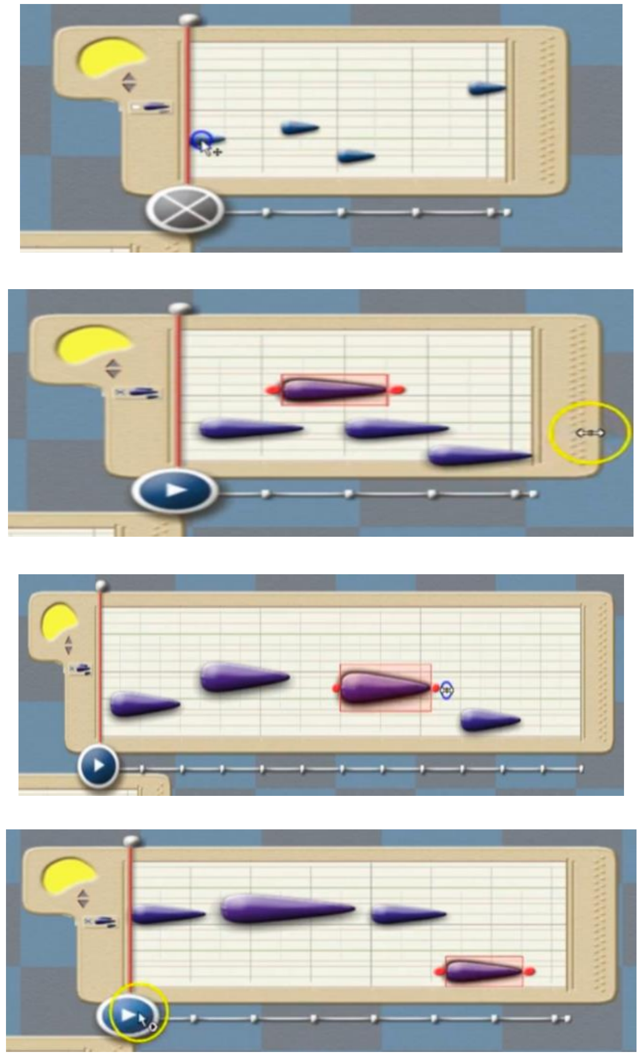


Figure 132. Screenshots, from top to bottom, depicting the changes in contour that took place over a few minutes as Chelsea and Emily strived to emulate the *Twilight Zone* motive.

(Return to document)

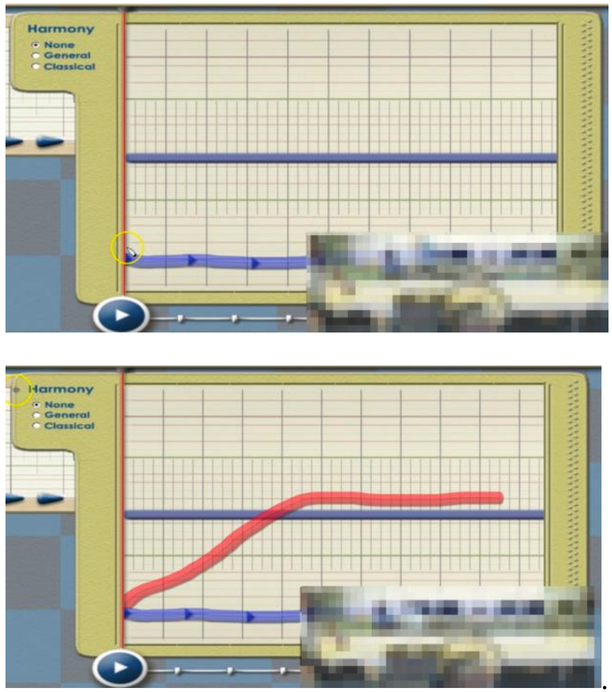


Figure 133. Before and after screenshots displaying how Ryan planned the contrasting contour of the red melody before he drew it. Note, the blue line running through the center of the sketchpad (the harmony line) does not represent any musical material.
(Return to document)

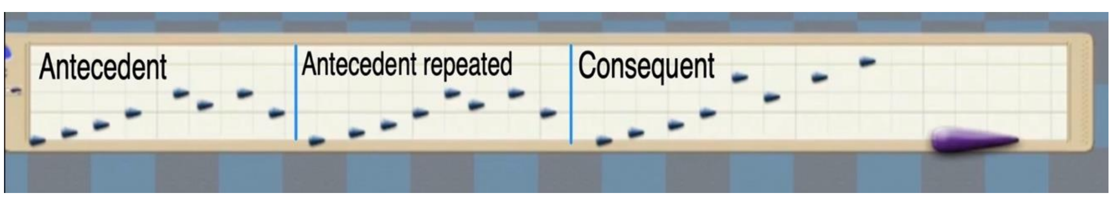


Figure 134. Illustration of how Ryan applied an antecedent-consequent approach to one of his melodies.
(Return to document)

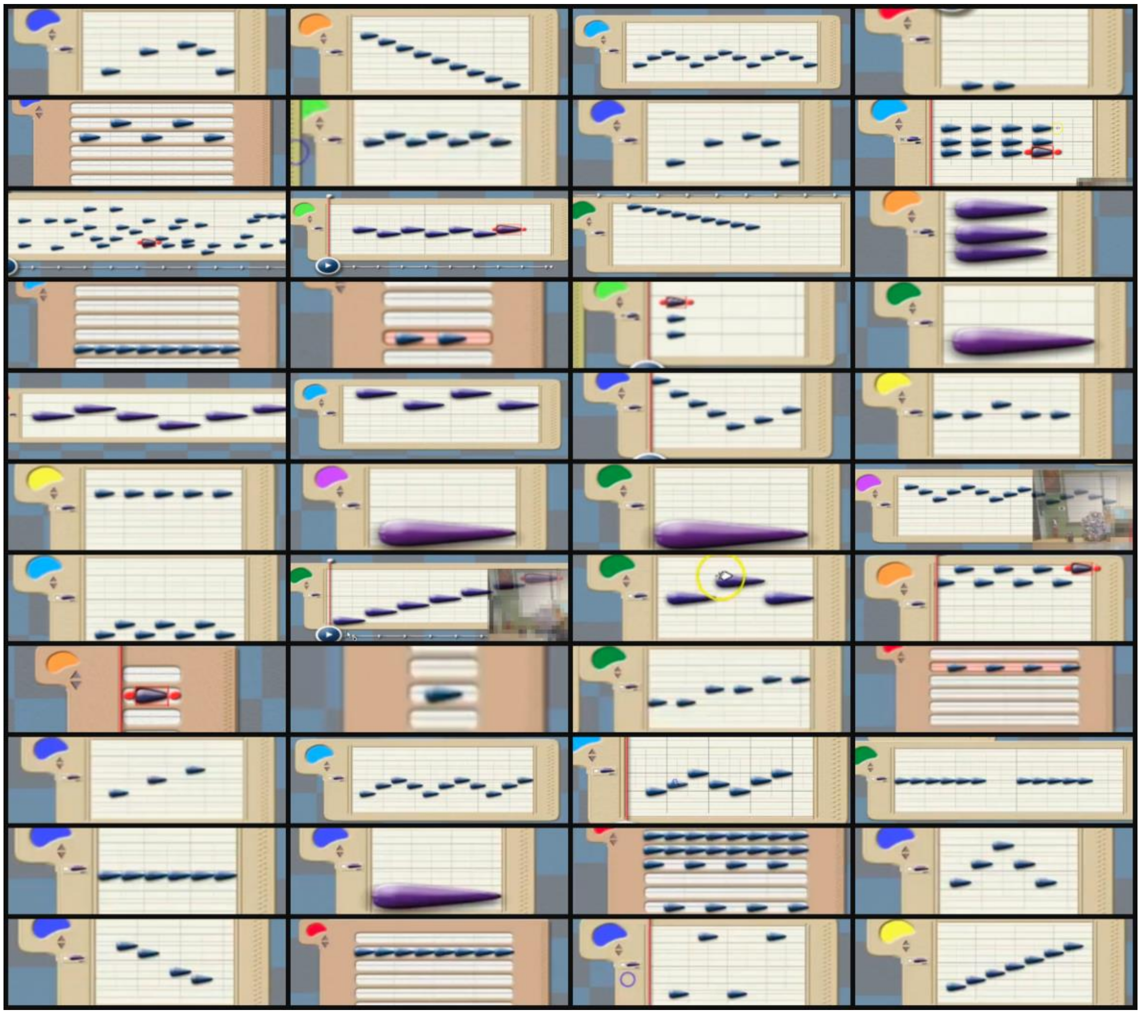


Figure 135. Illustrated inventory of Emily's motive-making process during Weeks 1–5 that revealed her concept of melody as primarily scalar and occasionally tertiary.
(Return to document)

Table 2

Sonic Elements in Emily's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Dynamics	1	1	2	0	2	6
Horizontal focus	1	0	0	0	0	1
Melody	0	1	0	2	0	3
Pitch	0	0	0	3	1	4
Rhythm	2	13	3	10	0	28
Space, rests, gaps, silence	3	5	0	2	3	13
Tempo	5	2	13	5	4	29
Texture	0	3	0	0	0	3
Overlapping	0	0	0	0	2	2
Timbre	4	9	6	6	2	27
Vertical focus	1	5	2	1	2	11
Layering things	1	1	0	1	1	4

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 2 is Sonic Elements, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1–5.

Table 3

Traditional Composition Techniques in Emily's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Chords & Arpeggios	1	4	7	8	4	24
Contour	27	23	8	9	11	78
Counterpoint	0	0	0	1	0	1
Form	6	5	1	0	4	16
Imitation	0	1	0	0	1	2
Intervals (specific or precise)	0	0	1	0	0	1
Motive-making or borrowing	8	11	7	1	2	29
Phrases	1	1	0	0	0	2
Repetition	1	2	1	5	0	9
Scales	5	4	0	1	2	12

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 3 is Traditional Composition Techniques, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1–5.

Table 4

Sound and Sight in Emily's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Graphic notation	11	19	12	5	14	61
Sight before sound	0	0	0	1	0	1
Sound before sight	1	0	1	2	2	6
Traditional notation	1	1	1	0	1	4

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 4 is Sound and Sight, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 5

Sonic Elements in Chelsea's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Dynamics	2	5	1	12	11	31
Horizontal focus	4	2	0	1	1	8
Pitch	8	13	1	2	2	26
Rhythm	5	14	2	1	4	26
Space, rests, gaps, silence	1	5	1	0	2	9
Tempo	8	20	2	0	0	30
Texture	0	3	0	0	0	3
Timbre	3	3	6	7	4	23
Orchestra, band	0	2	0	0	0	2
Vertical focus	3	1	0	3	1	8
Layering things	0	9	3	3	2	17

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 5 is Sonic Elements, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 6

Traditional Composition Techniques in Chelsea's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Canon	0	0	1	0	1	2
Chords & Arpeggios	1	0	0	0	0	1
Contour	20	10	4	7	7	48
Counterpoint	0	0	1	0	0	1
Form	1	0	0	0	1	2
Motive-making or borrowing	7	9	0	1	2	19
Sketching phrases before creating motives	2	0	0	0	1	3
Repetition	1	0	0	0	0	1
Transitions	0	0	0	3	3	6

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 6 is Traditional Composition Techniques, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 7

Sound and Sight in Chelsea's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Graphic notation	12	3	0	3	5	23
Traditional notation	1	0	0	0	0	1

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 7 is Sound and Sight and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 8

Sonic Elements in Draco's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Dynamics	0	0	2	3	2	7
Horizontal focus	3	4	12	2	6	27
Rhythm	13	3	1	2	2	21
Space, rests, gaps, silence	6	1	1	2	3	13
Tempo	1	0	1	0	4	6
Texture	0	1	0	1	0	2
Timbre	10	4	3	3	5	25
Orchestra, band	1	1	0	0	0	2
Vertical focus	5	3	0	5	2	15
Layering things	0	0	1	0	1	2

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 8 is Sonic Elements, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 9

Traditional Composition Techniques in Draco's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Antecedent-Consequent	0	1	0	0	0	1
Bi-tonality	0	0	0	2	0	2
Contour	9	0	2	2	2	15
Form	2	1	2	0	5	10
Intervals (specific or precise)	0	1	0	0	0	1
Motive-making or borrowing	3	2	0	1	6	12
Ostinato	0	1	0	0	0	1
Phrases	0	0	1	1	0	2
Sketching phrases before creating motives	0	0	2	0	0	2
Repetition	2	4	2	1	1	10
Variation	0	2	0	0	0	2

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 9 is Traditional Composition Techniques, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 10

Sound and Sight in Draco's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Graphic notation	5	3	1	8	1	18
Sound before sight	2	5	6	2	1	16
Sound with sight	0	0	0	1	0	1
Traditional notation	0	1	1	0	0	2

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 10 is Sound and Sight, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 11

Sonic Elements in Ryan's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Dynamics	1	0	0	2	0	3
Horizontal focus	1	1	8	2	2	14
Pitch	5	1	3	3	0	12
Rhythm	11	10	7	9	2	39
Space, rests, gaps, silence	5	2	1	0	0	8
Tempo	4	5	4	2	2	17
Timbre	5	15	5	11	2	38
Vertical focus	5	2	0	0	5	12

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 11 is Sonic Elements, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1-5.

Table 12

Traditional Composition Techniques in Ryan's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Antecedent-Consequent	0	0	0	0	1	1
Canon	1	0	0	0	0	1
Chords & Arpeggios	0	1	0	0	0	1
Contour	11	5	8	5	9	38
Form	1	2	2	0	2	7
Modulation	1	0	0	0	0	1
Motive-making or borrowing	2	11	6	1	3	23
Phrases	2	0	1	0	0	3
Repetition	8	1	7	1	0	17
Scales	0	2	0	0	1	3
Transitions	0	0	1	0	0	1

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 12 is Traditional Composition Techniques, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1–5.

Table 13

Sound and Sight in Ryan's Composition Process (Return to document)

Nodes	Week 1	Week 2	Week 3	Week 4	Week 5	Total
Graphic notation	10	2	2	7	1	22
Sight before sound	1	0	0	0	0	1
Sound before sight	3	0	2	0	0	5
Traditional notation	0	1	0	0	0	1

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 13 is Sound and Sight, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 1–5.

Table 14

Sonic Elements in Chelsea and Emily's Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Dynamics	3	0	12	0	9	24
Horizontal focus	0	0	1	1	0	2
Melody	0	0	0	0	1	1
Pitch	9	0	12	0	2	23
Rhythm	7	0	6	2	6	21
Space, rests, gaps, silence	14	0	5	1	7	27
Tempo	6	0	11	4	5	26
Texture	2	0	3	0	3	8
Timbre	39	0	13	6	5	63
Vertical focus	1	0	2	0	2	5

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 14 is Sonic Elements, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 6–10.

Table 15

Traditional Composition Techniques in Chelsea and Emily’s Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Canon	0	0	0	0	1	1
Chords & Arpeggios	1	0	3	2	2	8
Contour	5	0	4	2	3	14
Counterpoint	0	0	0	0	2	2
Diminution	0	0	0	1	0	1
Form	2	0	0	0	3	5
Imitation	2	0	1	4	0	7
Intervals (specific or precise)	2	0	0	0	0	2
Motive-making or borrowing	6	0	9	5	3	23
Ostinato	0	0	0	0	1	1
Phrases	0	0	1	0	0	1
Sketching phrases before creating motives	0	0	0	1	0	1
Repetition	0	0	0	2	1	3
Scales	0	0	1	0	0	1
Transitions	0	0	0	0	1	1

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 15 is Traditional Composition Techniques, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category.

Table 16

Sound and Sight in Chelsea and Emily's Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Graphic notation	7	0	5	2	4	18
Sight before sound	0	0	0	0	1	1
Sound before sight	6	1	4	3	1	15
Sound with sight	0	0	1	0	0	1
Traditional notation	0	0	0	1	1	2

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 16 is Sound and Sight, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 6–10.

Table 17

Inspiration Sources in Chelsea and Emily's Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Analogy, Metaphor, Story, Imagery, Mood	31	0	12	0	5	47
Genre, Style	4	0	0	0	1	5
Others' music	3	0	4	6	4	17

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 17 is Sound and Sight, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 6–10.

Table 18

Sonic Elements in Draco and Ryan's Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Dynamics	0	1	1	5	1	8
Horizontal focus	0	0	0	0	1	1
Melody	6	13	2	9	6	36
Pitch	1	0	4	1	0	6
Rhythm	5	6	5	10	0	26
Rhythm	0	4	0	0	0	4
Space, rests, gaps, silence	6	1	0	4	0	11
Tempo	3	4	2	6	0	15
Texture	2	0	0	0	1	3
Timbre	5	3	1	1	2	12
Vertical focus	4	11	3	0	0	18

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 18 is Sonic Elements, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 6–10.

Table 19

Traditional Composition Techniques in Draco and Ryan's Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 09	Week 10	Total
Augmentation	0	0	0	4	2	6
Bi-tonality	0	0	1	0	0	1
Canon	0	2	0	0	0	2
Contour	5	3	1	8	2	19
Counterpoint	0	0	1	0	0	1
Diminution	0	0	1	0	0	1
Form	3	14	1	10	6	34
Intervals (specific or precise)	0	0	1	5	0	6
Motive-making or borrowing	8	2	2	5	1	18
Phrases	1	0	0	0	1	2
Repetition	2	3	1	9	2	17
Sequence	0	0	0	5	1	6
Transitions	0	0	0	1	3	4
Variation	0	0	0	1	0	1

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 19 is Traditional Composition Techniques, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category.

Table 20

Outline of Form in Draco and Ryan's Composition (Return to document)

A	A′	A″	B	A″	A′	A
Main theme played by guitar	Main theme repeated, with drums	Main theme combined with inversion of main theme; drums continue	Solo break based partially on a fragment of the main theme; two sequences; quieter drums	Exact restatement of A″	Exact restatement of A′	Main theme played by piano; drums tacet

Table 21

Sound and Sight in Draco and Ryan's Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Graphic notation	1	3	11	21	2	38
Sight before sound	1	0	0	1	0	2
Sound before sight	0	3	2	11	2	18
Traditional notation	0	0	0	2	0	2

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 21 is Sound and Sight, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 6-10.

Table 22

Inspiration Sources in Draco and Ryan's Process (Return to document)

Nodes	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Analogy, Metaphor, Story, Imagery, Mood	0	3	0	1	0	4
Genre, Style	7	1	0	1	0	9
Others' music	6	0	3	5	3	17

Note. NVivo uses the term *nodes* to represent categories that can be grouped into broader themes. The theme represented in Table 22 is Inspiration Sources, and related categories appear in the nodes column. The numeric values refer to the number of coding references for each category during weeks 6-10.

Table 23

Inspiration Sources in the Composers' Processes (Return to document)

	Chelsea	Emily	Chelsea and Emily collaborating	Draco	Ryan	Draco and Ryan collaborating	Total
Analogy, Metaphor, Story, Imagery, Mood	0	0	66	1	4	6	77
Genre, Style	0	0	7	0	1	10	18
Others' music	12	14	25	14	3	29	97

Note. The theme represented in Table 23 is Inspiration Sources, and related categories appear in the table. The numeric values refer to the number of coding references for each category and each individual or collaborative pair.

Table 24

Sonic Elements in the Focus Composers' Processes (Return to document)

	Chelsea	Emily	Chelsea and Emily collaborating	Draco	Ryan	Draco and Ryan collaborating	Total
Curvilinear focus	22	26	0	4	7	4	63
Dynamics	31	6	32	7	3	10	89
Horizontal focus	8	4	6	26	16	51	111
Pitch	26	4	33	1	12	7	83
Rhythm	26	28	28	25	39	33	179
Space, rests, gaps, silence	9	13	34	13	8	16	93
Tempo	30	29	33	6	17	21	136
Texture	3	5	10	2	4	4	28
Timbre	25	27	100	27	38	15	232
Vertical focus	25	15	6	17	12	29	104

Note. The theme represented in Table 24 is Sonic Elements, and related categories appear in the table. The numeric values refer to the number of coding references for each category and each individual or collaborative pair.

Table 25

Sound and Sight in the Composers' Processes (Return to document)

	Chelsea	Emily	Chelsea and Emily collaborating	Draco	Ryan	Draco and Ryan collaborating	Total
Sight before sound	0	1	1	0	1	2	5
Sound before sight	0	6	23	16	4	25	74
Sound with sight	0	1	2	2	0	1	6
Traditional notation	1	4	2	2	1	2	12
Graphic notation	23	61	27	18	23	51	203

Note. The theme represented in Table 25 is Sound and Sight, and related categories appear in the table. The numeric values refer to the number of coding references for each category and each individual or collaborative pair.

Table 26

Cross-Case Synthesis of Geometric Strategies Used (Return to document)

	Chelsea	Emily	Chelsea and Emily collaborating	Draco	Ryan	Draco and Ryan collaborating
Sequential Patterns	-	-	-	Figure 87	Figures 42, 57, 86	Figure 88
Translation (Transposition)	Figure 131	Figures 11, 126	Figures 77, 78, 127	Figures 40, 128	Figure 63	Figure 129
Reflection (Inversion)	Figure 123	Figure 10	-	Figure 130	-	Figures 81, 88, 90
Parallel motion	-	-	-	-	Figures 50, 62	-
Contrary motion	Figure 123	Figure 10	-	-	-	-
Oblique motion	-	-	-	-	Figure 62	-

Table 27

Traditional Composition Techniques in the Composers' Processes (Return to document)

	Chelsea	Emily	Chelsea and Emily collaborating	Draco	Ryan	Draco and Ryan collaborating	Total
Antecedent-Consequent	0	0	0	1	1	0	2
Augmentation	0	0	0	0	0	7	7
Bi-tonality	0	0	0	2	0	2	4
Canon	2	0	2	0	0	4	8
Chords & Arpeggios	1	24	15	0	1	0	41
Contour	48	78	17	15	38	31	227
Counterpoint	1	1	3	0	1	2	8
Diminution	0	0	2	0	0	2	4
Form	2	16	6	10	7	57	98
Intervals (specific or precise)	0	1	3	1	0	8	13
Modulation	0	0	0	0	1	0	1
Motive-making or borrowing	19	29	34	12	23	28	145
Ostinato	0	0	2	1	0	0	3
Parody	0	7	10	0	0	0	17
Phrases	3	2	5	4	3	2	19
Repetition	1	9	5	10	17	20	62
Scales	0	12	2	0	3	0	17
Sequence	0	0	0	0	0	8	8
Transitions	6	0	1	0	1	6	14
Variation	0	0	0	2	0	2	4

Note. The theme represented in Table 27 is Traditional Composition Techniques, and related categories appear in the table. The numeric values refer to the number of coding references for each category and each individual or collaborative pair.

Table 28

Micro- and Macro-Level Form-Oriented Strategies in the Composers' Processes (Return to document)

	Micro-level strategies (creating discrete melodies, motives, and drum patterns using droplets in the melody and percussion windows)	Macro-level strategies (combining sonic elements by drawing phrases represented by lines on the sketchpad)
Chelsea	No intentional form overall, mostly erratic (Figures 99, 108, 123)	No intentional form in first and second compositions (Figures 99, 108); counterpoint in third composition (Figure 123)
Emily	Highly structured for both compositions (Figures 9, 120)	Two contrasting approaches: simple and conservative—multiple, simultaneous iterations of three melodies and a drum pattern in first composition (Figure 9); contrapuntal approach in second composition (Figure 120)
Chelsea and Emily collaborating	Short, undeveloped creepy motives and sound effects (Figure 112)	Through-composed series of five musical events (Figure 112)
Draco	Structured melody with use of traditional compositional devices (Figure 27)	Simple, thin texture—one extended melody stated one time with drum accompaniment (Figure 122)
Ryan	Short, simple motives with repetitive notes in first composition (Figure 62); sparse motives with one chromatic scale in second composition (Figure 55); four extended melodies and intricate drum pattern in third composition (Figure 121)	Four-part counterpoint in first composition (Figure 62); mostly monophonic, thin texture with one polyphonic section in second composition (Figure 55); entirely monophonic, through-composed approach in third composition (Figure 121)
Draco and Ryan collaborating	Highly structured (Figure 125)	Highly structured, ternary form with introduction and coda (Figure 125)

Table 29

Time-Ordered Matrix of Themes and Related Categories for Research Question #1 (Return to document)

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Inspiration Sources											
Analogy, Metaphor, Story, Imagery, Mood	2	2	2	1	0	37	1	14	1	5	65
Genre, Style	2	2	0	0	1	11	1	0	1	1	19
Others' music	0	9	3	9	17	10	0	12	11	7	78
Sonic Elements											
Dynamics	4	7	6	20	16	4	1	16	6	15	95
Horizontal focus	7	8	16	6	8	6	15	3	11	9	89
Pitch	12	13	4	11	3	10	0	16	1	2	72
Rhythm	35	43	14	29	9	14	11	13	15	7	190
Space, rests, gaps, silence	11	13	3	7	9	20	1	7	5	10	86
Tempo	18	27	21	7	10	11	6	14	18	6	138
Texture	4	9	0	8	6	6	1	3	1	7	45
Timbre	22	38	33	49	33	67	7	25	14	10	298
Vertical focus	16	23	6	19	12	5	11	6	3	3	104
Sound and Sight											
Sight before sound	3	0	0	3	0	1	1	1	4	2	15
Sound before sight	4	6	8	4	3	5	3	5	15	3	56
Sound with sight	0	0	0	2	0	0	0	0	1	0	3
Traditional notation	2	3	2	1	1	0	1	1	9	1	21
Graphic notation	40	28	15	31	30	11	3	16	25	9	208

Table 29 (continued) (Return to document)

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Traditional Composition Techniques											
Antecedent-Consequent	0	1	0	0	1	0	0	0	0	0	2
Augmentation	0	0	0	0	0	0	0	0	4	2	6
Bi-tonality	0	0	0	1	0	0	0	1	0	1	3
Canon	2	0	1	0	1	0	2	0	0	1	7
Chords & Arpeggios	2	6	7	9	5	1	0	5	2	2	39
Contour	68	39	23	33	40	17	2	8	11	5	246
Counterpoint	0	0	1	1	0	0	0	1	0	2	5
Diminution	0	0	1	0	0	0	0	1	1	0	3
Form	9	8	5	0	14	8	18	3	13	11	89
Imitation	0	1	0	1	1	2	0	1	5	1	12
Intervals (specific or precise)	0	1	1	0	0	2	0	1	5	0	10
Modulation	1	0	0	0	0	0	0	0	0	0	1
Motive making or borrowing	20	33	13	8	13	15	2	14	15	6	139
Ostinato	0	1	0	0	1	0	0	0	0	1	3
Phrases	5	1	3	0	1	1	0	1	2	1	15
Repetition	11	7	9	9	1	2	3	1	11	3	57
Scales	5	6	0	5	3	0	0	1	0	0	20
Sequence	0	0	0	0	0	0	0	0	5	1	6
Transitions	0	0	1	3	3	0	0	0	1	4	12
Variation	0	2	0	1	0	0	0	0	1	0	4

Table 30

Crosstab Matrix of Themes and Related Categories for Research Question #1 (Return to document)

	Chelsea	Emily	Chelsea and Emily collaborating	Draco	Ryan	Draco and Ryan collaborating	Total
Inspiration Sources							
Analogy, Metaphor, Story, Imagery, Mood	0	0	66	1	4	6	77
Genre, Style	0	0	7	0	1	10	18
Others' music	12	14	25	14	3	29	97
Sonic Elements							
Dynamics	31	6	32	7	3	10	89
Horizontal focus	8	4	6	26	16	51	111
Pitch	26	4	33	1	12	7	83
Rhythm	26	28	28	25	39	33	179
Space, rests, gaps, silence	9	13	34	13	8	16	93
Tempo	30	29	33	6	17	21	136
Texture	3	5	10	2	4	4	28
Timbre	25	27	100	27	38	15	232
Vertical focus	25	15	6	17	12	29	104
Sound and Sight							
Sight before sound	0	1	1	0	1	2	5
Sound before sight	0	6	23	16	4	25	74
Sound with sight	0	1	2	2	0	1	6
Traditional notation	1	4	2	2	1	2	12
Graphic notation	23	61	27	18	23	51	203

(Table 30 continued) (Return to document)

	Chelsea	Emily	Chelsea and Emily collaborating	Draco	Ryan	Draco and Ryan collaborating	Total
Traditional Composition Techniques							
Antecedent-Consequent	0	0	0	1	1	0	2
Augmentation	0	0	0	0	0	7	7
Bi-tonality	0	0	0	2	0	2	4
Canon	2	0	2	0	0	4	8
Chords & arpeggios	1	24	15	0	1	0	41
Contour	48	78	17	15	38	31	227
Counterpoint	1	1	3	0	1	2	8
Diminution	0	0	2	0	0	2	4
Form	2	16	6	10	7	57	98
Intervals (specific or precise)	0	1	3	1	0	8	13
Modulation	0	0	0	0	1	0	1
Motive-making or borrowing	19	29	34	12	23	28	145
Ostinato	0	0	2	1	0	0	3
Parody	0	7	10	0	0	0	17
Phrases	3	2	5	4	3	2	19
Repetition	1	9	5	10	17	20	62
Scales	0	12	2	0	3	0	17
Sequence	0	0	0	0	0	8	8
Transitions	6	0	1	0	1	6	14
Variation	0	0	0	2	0	2	4

APPENDIX E: FIGURES AND TABLES RELATED TO RESEARCH QUESTION #2

Table 31

Time-Ordered Matrix of Participants' Displayed or Expressed Responses to the Composition Process and their Products
(Return to document)

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Total
Composition Essentials											
Composer traits	3	9	4	9	2	6	4	8	13	8	66
Development	14	24	15	22	23	16	11	9	16	50	200
New ideas	1	1	7	7	4	4	3	7	10	9	53
Prior experience, knowledge, work	0	3	1	1	4	0	4	1	2	4	20
Time spent or needed	1	2	0	4	2	0	1	5	4	13	32
Partner Collaboration											
Mouse control	0	0	2	0	0	4	8	9	3	0	26
New ideas	1	1	7	7	4	4	3	7	10	9	53
Two minds	1	0	0	0	0	5	4	9	12	12	43
Technology as a Tool											
Hyperscore	11	4	1	8	1	3	2	11	13	6	60
Mouse control	0	0	2	0	0	4	8	9	3	0	26
Technical problem-solving	5	3	4	10	1	12	0	2	6	0	43
Value											
Value of the process	16	35	29	34	22	26	14	33	36	49	294
Value of the product	7	9	0	9	5	6	4	2	7	15	64

Note: The coding references in Table 31 illustrate the extent to which each theme-related category for research question #2 manifested itself over the 10-week period.

Table 32

Crosstab Matrix of Participants' Displayed or Expressed Responses to the Composition Process and their Products (Return to document)

	Bri	Brittany	Jeff	Josh	Chelsea	Emily	Draco	Ryan	Total
Being A Composer									
Composer and composition traits	6	3	11	15	7	8	18	11	79
Developing and persisting	7	22	21	24	35	41	45	31	226
Generating ideas	1	4	2	2	12	10	19	19	69
Prior experience, knowledge, work	0	1	5	7	8	3	10	1	35
Time spent or needed	0	3	3	4	5	8	10	6	39
Partner Collaboration									
Generating ideas	1	4	2	2	12	10	19	18	68
Mouse control	0	0	3	2	3	3	16	10	37
Two perspectives	3	1	15	10	4	3	16	13	65
The Hyperscore Experience									
Composition with Hyperscore	2	11	9	9	10	5	10	9	65
Mouse control	0	0	3	1	3	4	16	10	37
Technical problem-solving	0	1	10	6	30	18	36	15	116
Value									
Value of the process	17	58	39	37	45	43	47	38	324
Value of the product	6	5	20	10	14	4	11	5	80

Note: The coding references in Table 32 illustrate the extent to which each theme-related category for research question #2 manifested itself for each of the participants.

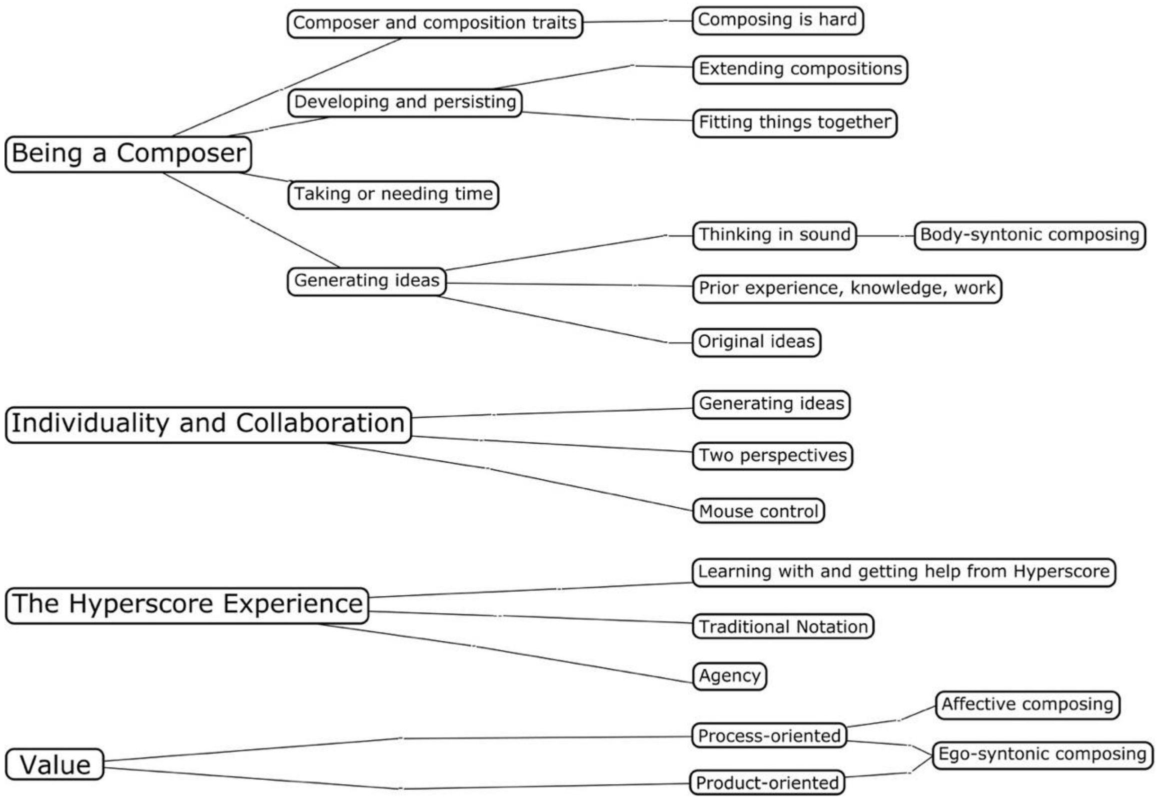


Figure 136. Themes and related categories pertinent to research question #2.
(Return to document)

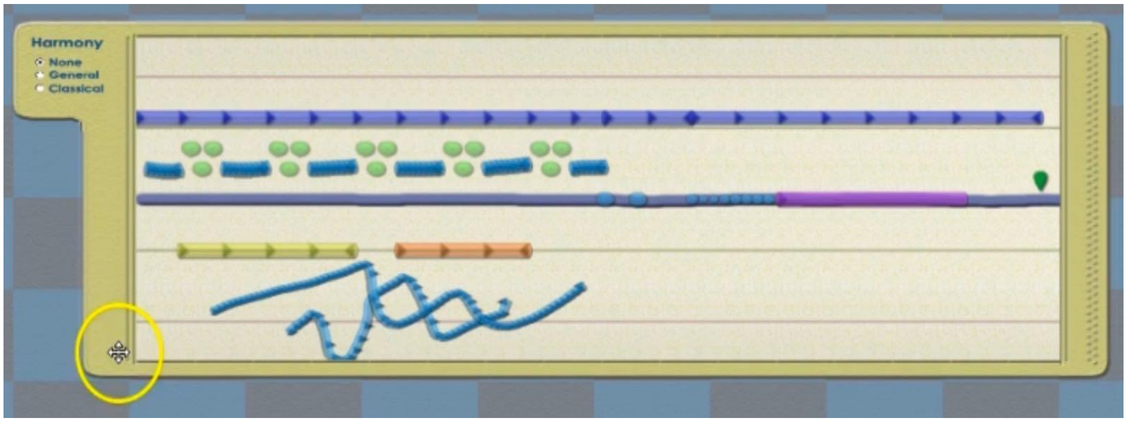


Figure 137. Bri's final composition in which she used patterns made from dots and lines to develop her piece.
(Return to document)

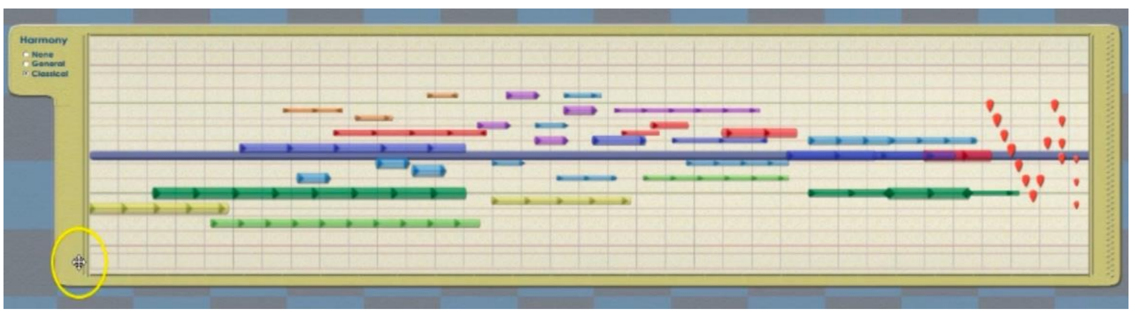


Figure 138. Screenshot of Brittany's "meaty" final composition, which she developed over four individual composition sessions.
(Return to document)

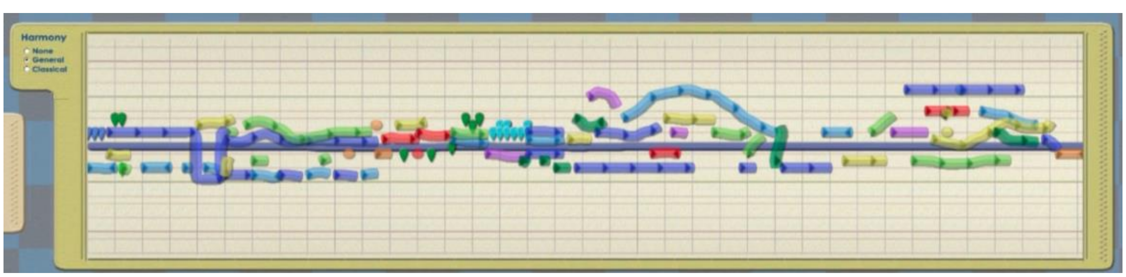


Figure 139. Screenshot of Jeff's composition, which he described as "not organization."
(Return to document)

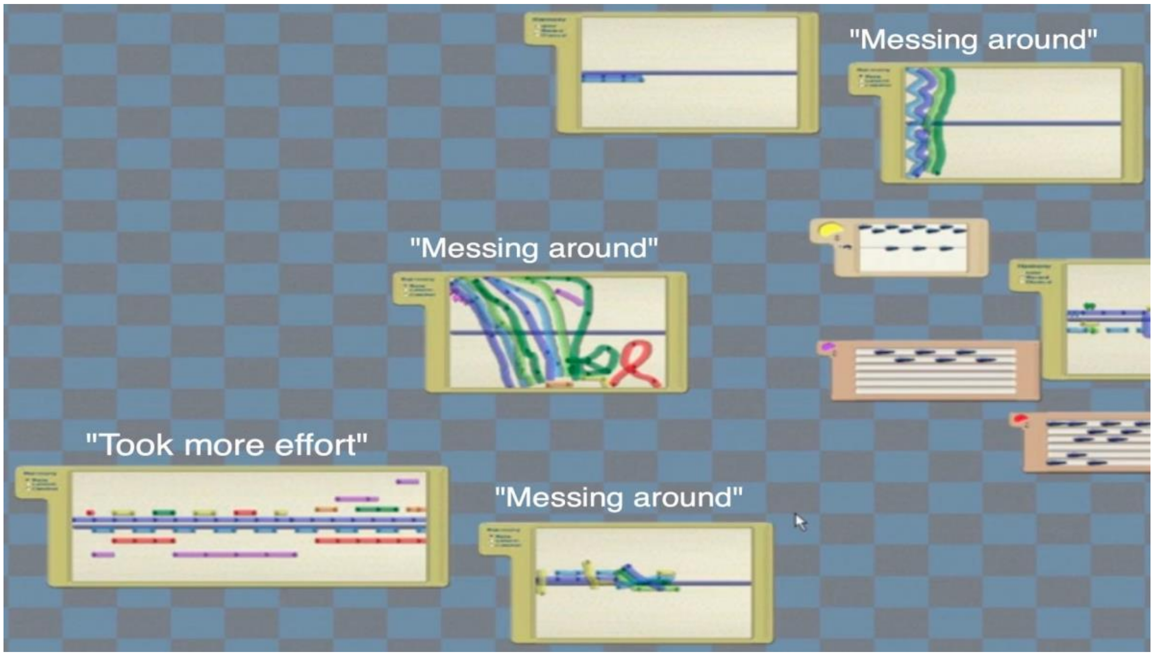


Figure 140. Screenshot displaying four versions of Jeff's composition, three "messing around" versions and one that "took more effort."
(Return to document)

Figure 141. Jeff and Josh's final composition, including "careful" and "graffiti" versions. Most of their time was spent developing and aligning their eight discrete, complementary motives before drawing them on the sketchpads. Note, the blue line running through the center of each sketchpad (the harmony line) does not represent any musical material.
(Return to document)

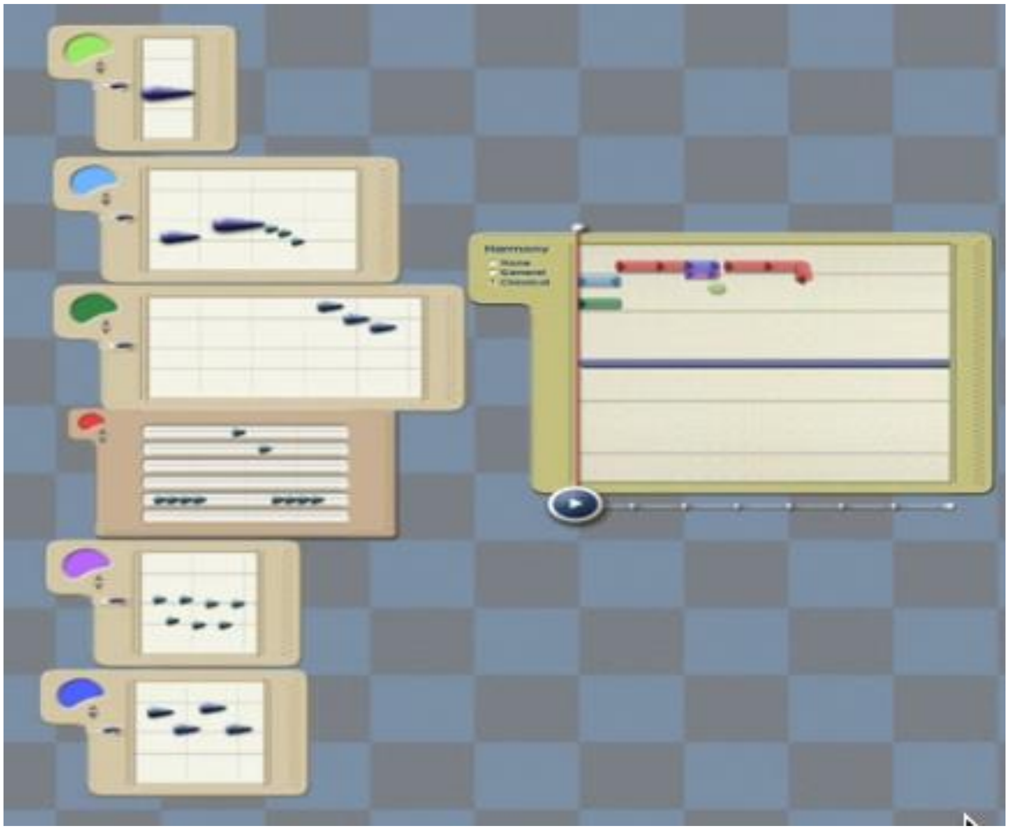


Figure 142. Screenshot depicting one of Josh's 'minimalist' compositions. Each musical idea is less than one measure in length, and phrases drawn on the sketchpad are all relatively short. Note, the blue line running through the center of the sketchpad (the harmony line) does not represent any musical material.
(Return to document)

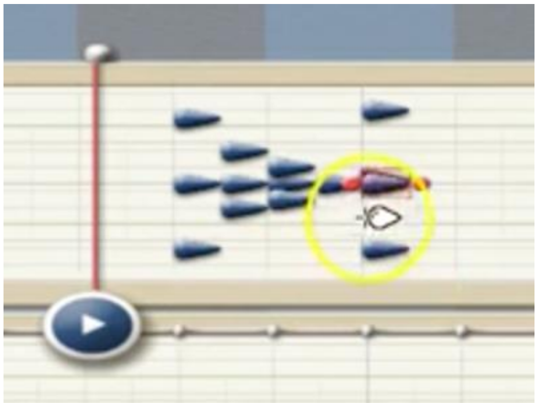


Figure 143. Screenshot depicting Josh's starship motive.
(Return to document)

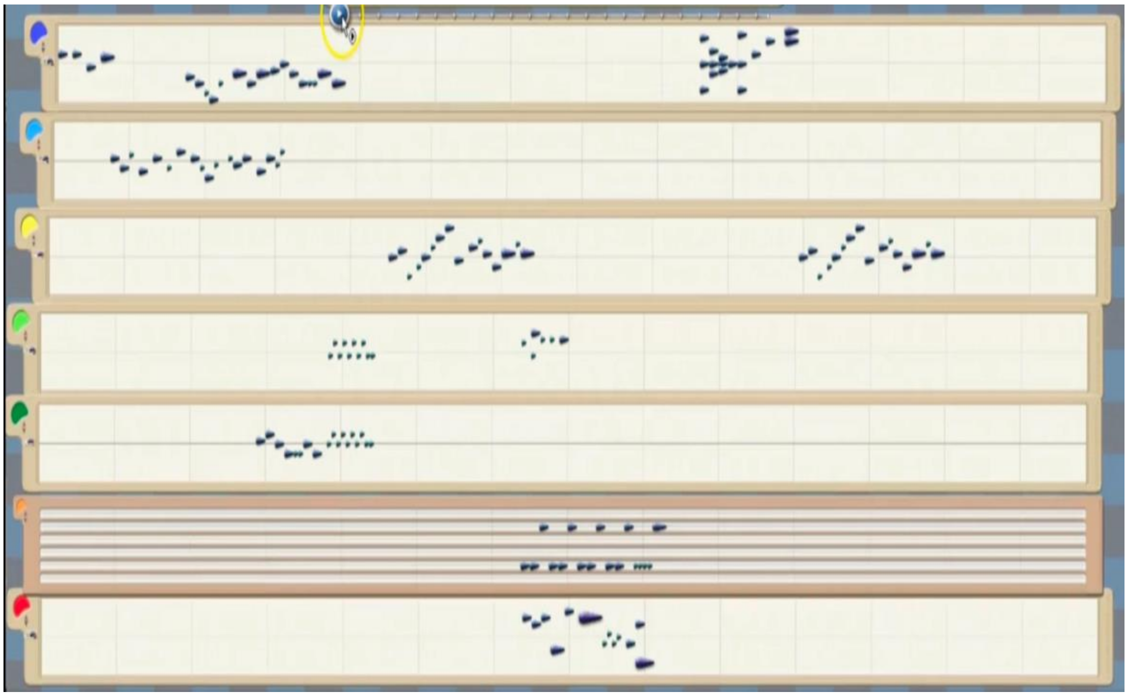


Figure 144. Screenshot depicting how Jeff and Josh borrowed Draco's conductor's score 'hacking' strategy and expanded it to create a full quasi-traditional conductor's score.
(Return to document)

Figure 145. Being a Composer theme-related categories and sub-categories.
(Return to document)

Table 33

Theme: Being a Composer; Category: Composer and Composition Traits (Return to document)

Bri	Brittany	Jeff	Josh	Emily	Chelsea	Draco	Ryan
Composer and conductor are synonymous	Composer decides which instruments are louder and softer	Idea of composer evolved from elitist to inclusive, albeit conflicted along the way	Felt like he was a "learning composer;" overall, felt he was not a composer Composers make thoughtful pieces, get ideas from their lives	Composer influences and inspires; more than a system Affective aspects of composing matter	Concept of composer evolved; most people think of "proper people"	Composers think in sound; can bridge abstract and concrete thinking Considers himself a mechanical thinker (concrete), not abstract	Mostly expressed shortcomings and uncertainty as an individual composer; more confident collaborating Knowing instruments is important
Composing is telling instruments to play or stop, be louder or quieter	Not a composer because Hyperscore helped		Implied that help from Hyperscore made him not a composer A composer is a trained professional with experience on instruments	Past experience and music theory help ‘Classical’ music comes to mind first; people like Taylor Swift second	The quality of your work matters in definition of composer	Implied he is not qualified to be a composer; almost qualifies, depending on the quality of the composition Innate ability matters	“Have to do a lot in your head (thinking in sound) rather than just placing everything down"

Table 34

Theme: Being A Composer; Category: Developing and Persisting (Return to document)

Bri	Brittany	Jeff	Josh	Emily	Chelsea	Draco	Ryan
"I made a nice little short one; I think I want to make a longer one," but never did	Many components ("meat") make development easier; more options to work with	More prolific than others; five short compositions; developed variations rather than longer pieces	Wanted to extend his pieces, but unsure how to do so	"It takes a long time…you have to work with it and make sure everything works together well and complements each other"	Development is about making good separate lines and then fitting things together	Extremely persistent; long periods of time on one melody; sometimes seemed like a state of flow	Discarded ideas that did not work almost immediately rather than persist with them or revise
Add dynamics (loud/soft); add instruments Used repeating patterns	Talked a lot about strong endings			Used prior experience and theory to help develop and persist		"It's gonna be hard to do a longer composition with the time we have"	
Persistence and development led to pride and excitement; which qualifies as ego-syntonic (Papert, 1980a, p. 63)	Making a lot of things fit together: sound, gaps, instruments, melody, harmony	Preferred less dense texture; more notes is not better; likes "simple"	Conservative approach to development and exploration (individually); more exploration when collaborating	Some indications of hard fun (Papert, 1996, 1999b); "The harder part is…figuring out what will fit…great part is when you get that right combination"		Melodic development strategy was ostensibly in lieu of spending time on getting multiple sonic elements to fit together	It was difficult to combine two or more lines and make them fit together and sound good.

Table 35

Theme: Being A Composer; Category: Taking or Needing Time (Return to document)

Brittany	Jeff	Josh	Emily	Chelsea	Draco	Ryan
Satisfied, even though it was only her second composition	Final piece was better quality because he took more time	Felt like he did not have enough time to develop individual compositions	Learned it takes a long time to get piece where you want it	Needed more time to figure out how things (different motives) fit together	"If I had more time I would develop it"	"We didn't have much time"
If she had more time, would give it more "meat" and stronger ending	"It took more effort, and it sounds better"		"Could have built on it more," but it took time to find the chord idea	"I got them to sound good together because I spent a lot of time on them"	Often spent extended periods of time on one melody	"It could have been better if I had more time"
				Spent a lot of time (with Emily) to get only six lines of music	"How did that take me the whole time?"	
				It took time to get quality	"Seems like I was not that productive in that amount of time"	

Table 36

Theme: Being A Composer; Category: Generating Ideas (Return to document)

Brittany	Jeff	Emily	Chelsea	Draco	Ryan
If I don't have something in my mind, I play around	Had no problem coming up with ideas; did not need loops	Reflexive (Duffy & Cunningham, 1996) composer (lots of listening and revising)	Did not want to use motives, wanted to generate only original ideas	It's good to take inspiration and "steal" a few notes from other things (i.e., loops)	"I think we should maybe use loops for ideas, but then do it on our own"
Can't plan out a whole piece then write it down. (Implied you need a helping tool like Hyperscore)		New ideas flowed easily; prolific generator of new ideas	"So, I'd listen to one, then I would listen to the other, then I would listen to them together and like, tweak it" (reflexive)	When going for original sound, don't use the loops and it would be a better composition	"The more I work on it the more ideas come up"
More interested in coming up with original ideas and not using the loops		Exploratory approach to finding new ideas; curiosity		I prefer using the loops because it's faster, it took longer to do all original work	"Playing it (listening) would give us more and more ideas."
		Wanted to use loops in collaborative composition			Thought of ideas before coming to class (reflexive)

Table 37

Theme: Being a Composer; Category: Prior Knowledge, Experience, Work (<u>Return to document</u>)

Brittany	Jeff	Josh	Emily	Chelsea	Draco
Used musical terminology fluently (piano lessons)	Got stuck working with Josh at one point near the end; looked back at their individual pieces for inspiration	Composers are trained “I could go back to my old work and combine it”	Used prior experience and theory to help develop and persist; borrowed from *Arabesque*, *Phantom of the Opera*	Used her prior experience on drums along with body-syntonic reasoning (Papert, 1980a)	"I just realized this is like a solo section on my trumpet" Related composing to trumpet playing
	Used two of his compositions to create a remix	Suggested looking back at previous individual pieces when working with partner	Borrowed from Beethoven’s *Fifth Symphony* and *Twilight Zone* theme while collaborating with Chelsea		Composed something he might be able to play on my trumpet at home
	If you have previous experience playing the piano, it’s composing, even if it’s only five notes	Making a piece that could be played by school band would be a good goal			

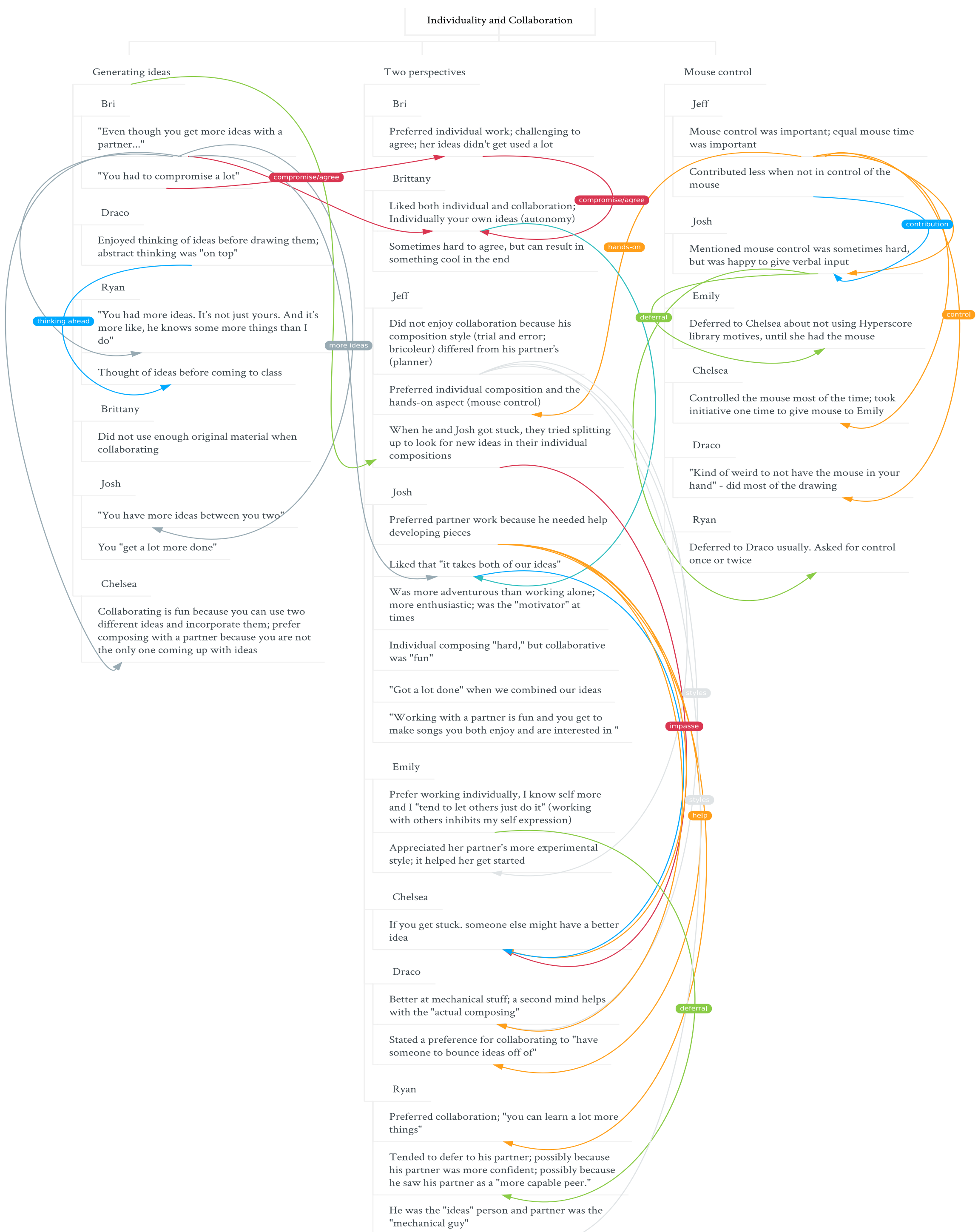


Figure 146. Individuality and Collaboration theme-related categories and sub-categories. (Return to document)

Table 38

Theme: Individuality and Collaboration; Category: Generating Ideas (Return to document)

Bri	Brittany	Josh	Chelsea	Draco	Ryan
"Even though you get more ideas with a partner…"	Did not use enough original material when collaborating	"You have more ideas between you two"	Collaborating is fun because you can use two different ideas and incorporate them	Enjoyed thinking of ideas before drawing them	"You had more ideas. It's not just yours. And it's more like, he knows some more things than I do"
"…you had to compromise a lot"		You "get a lot more done"	Preferred composing with a partner because "you are not the only one coming up with ideas"	Abstract thinking was "on top"	Thought of ideas before coming to class

Table 39

Theme: Individuality and Collaboration; Category: Two Perspectives (<u>Return to document</u>)

Bri	Brittany	Jeff	Josh	Emily	Chelsea	Draco	Ryan
Preferred individual work; it was challenging to agree	Enjoyed both individual and collaboration	Did not enjoy collaboration because his composition style (trial and error/ bricoleur) differed from his partner's (planner)	Preferred collaborative work because he needed help developing pieces	Prefer working individually, I know myself more and I "tend to let others just do it"	If you get stuck. someone else might have a better idea	He's better at mechanical stuff	Preferred collaboration; "you can learn a lot more things"
Her ideas didn't get used a lot	Individually, appreciated expressing her own ideas (autonomy)	Preferred individual composition and the hands-on aspect (mouse control.)	"It takes both of our ideas"	Working with others inhibits her self-expression		A second mind helps with the "actual composing"	Tended to defer to his partner; possibly because his partner was more confident; possibly because he saw his partner as a "more capable peer"
	Sometimes hard to agree, but can result in "something cool in the end"	When he and his partner got stuck, they tried splitting up to look for new ideas in their individual compositions	Was more adventurous than working alone; more enthusiastic; was the "motivator" at times	Appreciated her partner's experimental style; it helped her get started			He was the "ideas" person and his partner was the "mechanical guy"

Table 40

Theme: Individuality and Collaboration; Category: Mouse Control (Return to document)

Jeff	Josh	Emily	Chelsea	Draco	Ryan
Mouse control was important; equal mouse time was important	Mentioned mouse control was sometimes hard, but was happy to give verbal input	Deferred to partner about not using Hyperscore library motives, until she had the mouse	Controlled the mouse most of the time; took initiative one time to give mouse to Emily	"Kind of weird to not have the mouse in your hand"	Usually deferred to partner. Asked for control once or twice
Contributed less when not in control of the mouse		Controlled the mouse most of the time; took initiative one time to give mouse to partner		Did most of the drawing	

Figure 147. The Hyperscore Experience theme-related categories and sub-categories.
(Return to document)

Table 41

Theme: The Hyperscore Experience; Category: Learning with Hyperscore (Return to document)

Bri	Brittany	Emily	Chelsea	Draco	Josh
Early on, did not learn anything about composition. Later, said Hyperscore helps you learn and grow in your knowledge	Responded with excitement to the classical algorithm (scaffolding); "I’m kind of proud of myself" (affective computing)	Using classical algorithm shifted her attitude; "I’m kind of proud of myself" (scaffolding)	Focused on Hyperscore limitations (e.g., timbral)	Described a type of partnership with Hyperscore	Wished there was a better tutorial, but also liked exploring without it.
Don’t have piano skills, so Hyperscore makes it easier to compose	It’s like having a robot (AI); helps you learn on your own (scaffolding)		"It’s all about the process" (learning)		“It gives you an easy environment to make the music”
Learned to use dynamics, incorporate rests, patterns, chords	Sample motives are a source of inspiration (scaffolding)		Suggested more software guidance would have been helpful at the beginning		
Hyperscore "can help you like, use items like, tools you can use to make it sound better or to help you grow in your knowledge"	I don’t think of myself as a composer; I am still using something else (Hyperscore) to help me compose, which makes me think I am not a composer				

Table 42

Theme: The Hyperscore Experience; Category: Traditional Notation (Return to document)

Jeff	Brittany	Emily	Ryan	Draco	Josh
Appreciated easy and fun drawing method; drawing; does not like sheet music	Easier than traditional notation	Hyperscore makes it easy because you can "scrap" it and start over	Hacked the software to create ‘hocket’ effect	"Hacked" the software to simulate a miniature conductor’s score; showed Jeff, who showed Josh	"Hacked" the software to create a pseudo-conductor’s score (with Jeff)
Making a pseudo conductor’s score (with Josh) made it easier to follow	Hyperscore makes it easy to notate so you can remember what you composed; "If you have a whole piece in your head and write it down [later], you might forget some parts"	"Nice not having to worry about different notes"	With Draco, incorporated multiple melodies in one window; graphic notation in sketchpad not clear enough	Incorporated multiple melodies (with Ryan) in one window; graphic notation in sketchpad not useful enough	Not using traditional notation made him not a composer
		Later in the process, thought actual notes (traditional) would be more useful	"I like to line things up like this and use the lines" (like a staff)		

Table 43

Theme: The Hyperscore Experience; Category: Agency (Return to document)

Bri	Brittany	Emily	Chelsea	Josh	Jeff	Draco	Ryan
It was hard trying to find an instrument that actually matched what I wanted to do Her ideas did not get used a lot	"Not to be selfish," but it’s cool that you’re on your own “Express yourself and do what you want, not what someone else wants you to do”	“I know myself more” – prefers working along “I don’t think I had figured out how to use the software yet”	At the end, "I think it’s good we got to figure it out for ourselves" Focused on Hyperscore’s apparent limitations when working alone; focused on limited sounds	"I like that it appeals to me, but it sounds a little not professional"	Intimated that the software facilitates autonomy because no directions are required; does not like following directions	"Composing is fun because you have complete and total control over it"	You get to choose the notes you want to do; you can make your own beats not like other programs “I am looking for electric type sounds” (did not find them)
	Composing makes it easier to express yourself than speaking, like a silent message, expresses your point without having to say anything	Spent a lot of time (with Chelsea) on technical problem-solving; especially getting timbres they wanted	"It’s fun to put your ideas to life" Spent considerable time technical problem-solving; copying and pasting; assigning timbres	"I kept on changing the colors because I am one short," technical problems; couldn’t figure out how to control it”	"It’s really hard to share when you’re making music;" "I like to make my own designs"	"Hacked" the software by using percussion window to increase timbres beyond eight simultaneous timbres	"I think it’s better if you find it out yourself" "You can learn on your own if you have a device, or a source"
	Sound are unrealistic		I have a lot of ideas in my head Wanted to ‘hack’ the software for more timbres”		Needs more sounds simultaneously	The “more capable peer” who helped others solve technical problems	Freedom to do whichever notes you’d like, anytime of instrument, any type of beat or drums

Table 44

Theme: Value; Category: Process (Return to document)

Bri	Brittany	Chelsea	Emily	Jeff	Josh	Draco	Ryan
More affective than cognitive; a joyful journey through “composer land;” body-syntonic and ego-syntonic	Freedom; "there’s so many choices;" there are no rules; "it’s kind of like a free for all"	Much more emphasis on learning and knowledge than creating something that sounded good; ego-syntonic; "it’s all about the process," upbeat and optimistic	Time-consuming process was good for her; challenged her to not give up	"Messing around" is fun but does not produce quality; higher quality requires time and effort	Valued composer qualities (e.g., "really thoughtful music that they put a lot of time into"); valued the intricacy of the process	Enjoyed having "complete and total control over" the process. Wanted to focus on one piece and "make it nice"	Thinking in sound was important Valued partner as “more capable peer” GarageBand is hard but provides more choice
Felt more like a composer in the end despite not learning specific composition techniques	Composition is expression without words It’s a long process; "I worked on this for a couple of weeks"	"There hasn’t been many challenges It’s easy to come up with ideas but hard to execute them;" spent a long time getting things to fit together	Appreciated "the harder part" trying to fit things together (hard fun) Preferred working alone	Autonomy; doesn’t like directions or lecture Likes working alone; did not enjoy collaboration	Individual process seemed strained and focused on his shortcomings Collaborative process was inspired; "we started exploring more"	Valued working in a mechanical way, more of a music editor or arranger than a composer; strong sense of self (ego-syntonic); always humming (body-syntonic)	"You can learn on your own if you have a device, or a source." "One of the fun things about composing music is you have the freedom to do whatever you’d like."

Table 45

Theme: Value; Category: Products (Return to document)

Bri	Brittany	Chelsea	Emily	Jeff	Josh	Draco	Ryan
Genuine, carefree, forthcoming comments about her products, excited about the end of her individual composition; collaborative ideas "did not get used a lot"	Proud of individual composition; felt collaborative composition needed more originality	Displayed visible satisfaction creating creepy music; especially making quasi *Harry Potter* and *Twilight Zone* themes (with Emily)	Often expressed pride in what she produced individually Started over when it didn't work out Focused on drumbeats	"I like it better because it took more effort" Audiences like to hear beats	Mostly critical of his individual work; "The ideas were there, but they just weren't developed;" more positive about collaborative composition	Valued compositions with good melodies	Expressed more dissatisfaction than satisfaction with his individual products, collaborative composition was "pretty good" because of his partner's ability to make it cohesive
Enthusiastic sharing of product impressions, although not fluent in musical terminology Occasionally critical: "It doesn't sound good. The instruments don't match;" "Everything about it was terrible…it doesn't have a rhythm, and nothing goes in harmony" "I'm not good at making these sounds but it still sounds good"		Highly critical of individual products but in a light-hearted way: "It sounds bad, but that's okay"	Displayed visible satisfaction creating creepy music; especially making quasi *Harry Potter* and *Twilight Zone* themes (with Chelsea)	Liked to keep it simple; proud of his five variations "Messing "around" is fun but does not produce quality Appreciated visual aspect of the quasi conductor's score he created with partner more than the sound of the piece.		Critical of individual compositions when the melody was not good; proud of collaborative composition; emphasized teamwork with partner	Abandoned many discrete melodies and drum patterns when they didn't fit together Hesitant to share individual composition Good beats were important Needed more melody

Figure 148. Value theme-related categories and sub-categories.
(Return to document)

Table 46

Salient Observed Instances of Affect-Cognition Variables of Interest (Return to document)

	Ego-Syntonic Expression or Display	Body-Syntonic Reasoning	Hard Fun	Metacognition	Cognitive Complexity	Socio-Cognitive Conflict
Bri	Strong sense of like and dislike; a joyful journey through "composer land"				"It was kind of hard to get all of this information at once"	"It was challenging to agree with my partner"
Brittany	"I'm a genius, I'm such a genius. I feel so accomplished."	Regularly used her singing voice to "find the right note, and I was really happy"	Displayed and expressed a process that was only somewhat hard but relatively fun (negative case)	Spent a great deal of time listening and reflecting on her piece, exhibiting a metacognitive tendency		"Sometimes hard to agree [but] two opposites can result in something cool in the end"
Chelsea	Focused on quality of her music; "Come listen to how horrible mine is;" expressed overall dissatisfaction with her individual work; felt strongly that using motives was not being original	Vocal percussion; "I think of a drumbeat and try to impersonate it"	"It's easy to come up with ideas but hard to execute them"	"So, I'd listen to one, then I would listen to the other, then I would listen to them together and like, tweak it" (reflexive)	"I just don't know how to build on it;" "I don't really know how to make a transition"	

(Table 46 continued) (Return to document)

	Ego-Syntonic Expression or Display	Body-Syntonic Reasoning	Hard Fun	Metacognition	Cognitive Complexity	Socio-Cognitive Conflict
Chelsea and Emily		Hummed, sang, and transcribed familiar themes; occasional air drawing (gesturing)	"Hard finding the right instruments;" found it challenging replicating familiar motives; "We have six entire lines (pride), but we worked really hard on them."	Collaborative composition was a through-composed, non-repetitive, programmatic piece of music emanating mostly from a reflexive process and thinking in and with sound.		Strongly disagreed about using pre-existing motives (loops)
Emily	Strong sense of her strengths and challenges; regularly expressed importance of self-expression; strong satisfaction or dissatisfaction with her work	Often attempted to hum and transcribe	"The harder part is when you're trying to figure out what will fit and what will co-exist together nicely. The great part is when you finally get that right combination;" "It's good to experience how hard and time consuming it (composition) is."	Occasionally used thinking aloud to reflect and come up with new ideas (i.e., reflexive); reflective about the purpose of composition	"Sometimes I need to have direction, I need someone else to lead;" "It's not the best but I don't know what to add." "I'm pretty good at setting up music in my head, but I don't know what makes those sounds"	

(Table 46 continued) (Return to document)

	Ego-Syntonic Expression or Display	Body-Syntonic Reasoning	Hard Fun	Metacognition	Cognitive Complexity	Socio-Cognitive Conflict
Draco	Expressed strong sense of self as a “mechanical guy;” good melody was his goal	Regular humming and singing; would have preferred tapping to drawing rhythm		Spent considerable time applying an iterative, think-sing-notate-playback cycle	Felt lack of structure made him more creative, but most people would prefer more structure so it’s not so overwhelming.	“We sometimes disagreed and just came up with a new idea [instead]”
Ryan	More of an intentional composer than exploratory. Expressed intention to compose ideas in his head in advance.	Occasionally used his singing voice, especially when explaining his thinking process aloud to me or Draco		Like Chelsea, exhibited compelling evidence of reflexivity, thought of ideas before class	“I really don’t think I am a composer because I am really struggling with a 30-second piece;” became overwhelmed	Usually deferred to Draco except on one occasion
Draco and Ryan	Planning and intention evident in conversations	Attempted singing, air drawing (gesturing), and transcribing solo section		Expressed extensive self-directed listening, discussing, planning, and reflecting.	Challenged themselves to think of a melody without writing it first, which led to lack of productivity	One incident of strong disagreement; occasionally disagreed on structure, but Ryan usually deferred

(Table 46 continued) (Return to document)

	Ego-Syntonic Expression or Display	Body-Syntonic Reasoning	Hard Fun	Metacognition	Cognitive Complexity	Socio-Cognitive Conflict
Jeff	Animated and engaged; strong sense of like and dislike; had a goal to "keep it simple"		"I like using Hyperscore [because] it's really easy and fun" (negative case)	"When you're planning you're thinking about it, when you're doing trial-and-error, you're not really thinking," "With Josh we really thought about our piece;" "Not really" thinking about it while composing individually.		"Need a plan with a partner, because the other person either won't like it or doesn't agree;" felt like he was sometimes composing the other person's piece
Josh	"I need to make more thoughtful pieces…a composer makes more thoughtful pieces;" "Get to make music that you like, you get to say, 'I made that'"		It's easy to make something but hard to make it sound "like the books in music class" (hard but did not express fun)	Engaged in a reflexive process when experiencing an impasse with Jeff; reflective about the purpose of composition	"Sometimes it gets so confusing and hard, and you just lose yourself." "I'm trying to use everything and it's so overwhelming;" "You helped us with technology but not really besides that"	Responded to socio-cognitive impasse with reflexivity (going back to previous compositions to resolve the impasse)

Table 47

Salient Examples of Constructionism-Instructionism Variables of Interest (Return to document)

	Bricolage vs. Planning	Scaffolding (peer or researcher)	Direct Instruction
Bri	Expressed interest in a few intentional ways of developing her compositions, but process was often carefree, playful, and unintentional (quasi-bricoleur): “If I don’t like it, I delete it and start over. Just wipe it out” (planner).	Occasionally asked others to listen, but they rarely gave suggestions.	
Brittany	“Sometimes I really don’t have anything in my mind that I can come up with, so then I just kind of have to play around;” “You have to try everything. Don’t limit to only what you see in the software. Play with everything.” “I feel like if I just start [without planning] it’s just easier.” “I’m gonna start with one sound and build off of that, so I don’t really have a plan.”	Had a reciprocal relationship with Hyperscore as “partner in cognition” (Goldman et al., 2012); called Hyperscore a robot (AI); felt “inspired” by listening to others. A few times gave feedback to others; technological scaffolding (i.e., classical setting on Hyperscore) inspired her.	I found it easy to provide direct instruction because she had a good command of musical terminology.
Bri and Brittany	SD: How did you figure out that ending chord? Bri: We fiddled!		

(Table 47 continued) (Return to document)

	Bricolage vs. Planning	Scaffolding (peer or researcher)	Direct Instruction
Chelsea	"It's not like notes and things; the whole thing is trial and error;" however, sometimes planned drumbeats with vocal percussion. Although she asserted that the Hyperscore composition process was mostly trial and error, her final composition revealed multiple intentional strategies and intentional form (planning). Melodic material distinctly "trial and error" overall. Tended to compose "circularly," and I scaffolded left-to-right approach.	"It would be nice if it would give you some things to build off" (i.e., technological scaffolding. (Comment before she knew about the Hyperscore loops library.). "It was pretty self-explanatory; you don't even need to do the tutorial in the beginning;" Her remarks and her reticence about asking for help underscored my suspicion that he might have felt she was supposed to problem-solve on her own.	Used one or more geometric strategies allowing me to interject direct instruction; thought more instruction at the beginning would have been helpful. "It would have been nice if it kind of told you like, it gave you a little bit of a guideline;" "More Hyperscore instruction would not have helped me."
Emily	Often erased and started over; "I kept restarting and restarting;" Thirty-five of the 44 motives I examined exuded structure and planning. Intentionally planned incorporating piano pieces she knew. Exhibited a process of refining notation over several minutes (planning)	Explicit evidence of using Hyperscore as "partner in cognition;" technological scaffolding (i.e., classical setting on Hyperscore) inspired her I scaffolded when she got stuck (e.g., suggesting thinking of each motive representing one hand of the piano).	Used one or more geometric strategies allowing me to interject direct instruction; Emily: I definitely thought composing was systematic. SD: Did you think you were going to learn a system? Emily: Yes…I thought it [composition] was kind of constrained Indicated a need for occasional direction, which could have meant direct instruction. "[Sometimes], I need someone else to tell me." I used Emily's apparent interest in theory and piano to provide some direct instruction (e.g., arpeggio)

(Table 47 continued) (Return to document)

	Bricolage vs. Planning	Scaffolding (peer or researcher)	Direct Instruction
Chelsea and Emily	C: "Right now, we're doing this strategy of trial and error…if they don't work, we are getting rid of them quickly because we don't have a lot of time." Sonic elements emanated from extensive planning, reflection, and discussion (planning); editing, adding, and building like bricoleurs as needed. C: "It's good we kept our old stuff" to build on. C: "I think we could build off of this. I feel like we could add."	I helped them transcribe Beethoven motive; Chelsea was often the mouse controller and Emily scaffolded with her aural and skills theory knowledge.	
Draco	Less bricoleur, (Lévi-Strauss, 1962; Papert, 1980, 1987) more planner (Stager, 2001; Turkle & Papert, 1990) who was "saying one's piece" (Turkle & Papert, 1990, p. 136) via Hyperscore rather than engaging in a metaphorical conversation with the software "I am just trying to figure out how I can plan out more complicated beats;" SD: Is that the exact tune you planned? "That's the exact tune I planned; planned to focus on one piece." Expressed intention to create "good" melodies.	Had a reciprocal relationship with Hyperscore as "partner in cognition;" "All I know is it sound the way I eventually wanted it in my head" (technological scaffolding). Draco was called on by peers for help more than anyone else in the class; assisted Jeff several times; Draco explained hacking and technical "tricks" to me and others.	I explained chords and overtones to him, but he never used chords: "People like me might be helped by some instruction." "Have the melody in your head not sure of the notes for writing them down."

(Table 47 continued) (Return to document)

	Bricolage vs. Planning	Scaffolding (peer or researcher)	Direct Instruction
Ryan	Tendency to abandon ideas when they did not work the first time resembled the response of a planner rather than a bricoleur: “For planners, mistakes are missteps; for bricoleurs they are the essence of a navigation by mid-course corrections” (Turkle & Papert, 1990, p. 136). “I didn’t really have a plan in the beginning. I think that would have helped me a lot.” Expressed feeling more successful later in the process when he made plans in advance. “Other [compositions] didn’t work out because I didn’t have a plan. It would have helped to have a plan. [For]this one I had a thing in my head.”	I scaffolded fitting things together; “I don’t know what I should do with this part to create more melody. It just doesn’t go with the rest.”	Harmony is "all together bouncing around" led to direct instruction “It’s better if you find it out yourself so you can remember it better.”
Draco and Ryan	More planners than bricoleurs, rarely spontaneous or extemporaneous; intentional “jazz-blues” style; focused on planning the form and creating melodies with inversions. D: “My theory is if you make them all harmonize by overlapping them." After the piece was done, Draco said, “I’m just kind of playing around with stuff right now.”	I helped them use Mr. Sandman for inspiration; Ryan viewed Draco as “more capable peer” (Vygotsky, 1978, p. 86); Draco often took on the lead role working with Ryan (e.g., “You need to think of melodies as well.” I encourage them to think in measures, but they ignored my advice. They taught me about the advantages of hacking the software.	Used numerous traditional composition and geometric strategies allowing me to interject direct instruction.

(Table 47 continued) (Return to document)

	Bricolage vs. Planning	Scaffolding (peer or researcher)	Direct Instruction
Jeff	"I'm just gonna try this. If it's bad, I'll fix it later. I'm just trying something;" thought his style conflicted with his partner's planning style; "It was all trial and error. I didn't plan any of it." "I just don't like to plan, even though I feel like you should. I just like to try." "It's hard to compose without a plan [when composing] with a partner. If you don't have a plan, you're both just fighting over the mouse." Expressed intent to develop extended compositions but did not. Intentionally developed variations of one composition.		Explicitly state disdain for teacher lecture; I used his emphasis on trial-and-error to instruct about aleatoric music. "In most classes they make you follow certain rules; in this you can just test and have fun" "I don't like how teachers lecture you about how to use the tools;" "I don't like instructions."
Josh	At first, "I didn't have a plan and went with what sounded best…adding to that or leaving it alone." As time went on, seemed to become overwhelmed and less of a bricoleur, more of a planner.	Demeanor and comments indicated he needed more support. For example, "I just need help…I almost kind of want to work with you because I don't understand how to make the long pieces." "I just don't know how to build on it;" needed my help to overcome "composer's block." Although I gave him some musical advice, at the end he commented, "You helped with the technical stuff but not actual music."	Rarely asked for help; demeanor and comments indicated a desire for more direct instruction; seemed slightly conflicted about the value of instruction; " I wish there was a better tutorial, and I also wish there wasn't 'cuz it let you explore more: "I didn't realize that I had harmony - I didn't really know what it was before."

(Table 47 continued) (Return to document)

	Bricolage vs. Planning	Scaffolding (peer or researcher)	Direct Instruction
Jeff and Josh	Jeff: "It sounds like we planned it out. I kind of wish we [actually] did." Jeff: "Try not to do so much trial and error because it takes up so much time." Struggled with contrasting styles; Jeff was more of a bricoleur and Josh was more of a planner.	Josh: "I'm learning so much right now I wish we did the partner stuff first."	

Table 48

Salient Examples of Epistemological Pluralism (Return to document)

	Epistemological Pluralism		
Bri	"What if we just made the dark blue quieter?"	"[I need] to get some yellow up in here; got it."	Used the concrete representation of her composition to point and explain how it has repetition and variety (abstract concepts).
Brittany	"Let's make the red a little bit softer." Did a lot of intentional work with dynamics by adjusting thickness of lines.	Sometimes hummed or set note names while placing them on the screen, looking for specific notes	"I am gonna add a little bit of blue so I can have a little bass." "I'm just gonna add some more beautiful dots" (chords). "I wish I had more colors to develop it."
Bri and Brittany	Brittany: The trumpet is too high. Bri: Which one is the trumpet? Brittany: The green.	Intentionally stretched notes to augment their motive.	Used tools to make dynamic changes regularly. Combined concrete and abstract to find their desired ending note and build a major chord.
Chelsea	"I think they're going to sound too much the same (comparing two melodic contours)"	"Okay, let's make this guy fat (louder)"	Combined air drumming or verbalizing sticking patterns with notating on sketchpad. "What if we did a really high one into a low one?" Moving from abstract idea to drawing concretely.
Emily	Sometimes hummed and tried to transcribe. "I tried to simulate a piano piece that I learned" using the tool	Used the tools (concrete) to build a major chord (abstract thinking)	Regularly alternated between abstract "music talk" (e.g., melody, drumbeat) and concrete "Hyperscore talk" (e.g., droplets, colors) "The droplets are just keys on the scale"

(Table 48 continued) (Return to document)

	Epistemological Pluralism		
Chelsea and Emily	Combined Hyperscore’s graphical user interface with their persistent singing to transcribe their quasi-*Twilight Zone*, Beethoven’s *Fifth Symphony*, and quasi-*Harry Potter* themes (i.e., sound *with* sight process; Hyperscore as “partner in cognition.”)	Emily sang to Chelsea while Chelsea transcribed	Used droplets as tools to adjust note size and space between notes (values and rests), which affected tempo and texture (staccato vs. legato) and created music that matched their inner hearing. Used the tools to create the footstep effect they were imagining.
Draco	Regular concurrent use of Hyperscore’s graphic notation tools to transcribe melodies he hummed or sang (i.e., sound *with* sight process; prevalent sing-notate-listen iterative process. Often equated droplets with standard notation. Used the cursor as a tracing tool to follow his voice; “This is the line that’s the problem, it’s going too up and down (curved)” (used concrete to explain the abstract) “The notation helps me remember what I composed.”	“[Composition] requires a lot of different types of thinking. It requires the mechanical, how does this work, how does this work? And then it also requires the really creative, abstract thinking. I’m really a mechanical kind of guy” (sequential thinking and drawing came together); could easily “see” what he wanted to edit by merging concrete (visual) with abstract (inner hearing) “I need to hum it out loud to build on it. It starts in the back of my head and then I bring it to the front where I can put the notes on the program.” Used the concrete tools to bring out abstract ideas.	“I’m gonna double this;” stretched a collection of notes to create augmentation. Used tools to make “faster” rhythms by shortening notes; “Trying to make it [drawing] sound as much like the tune in my head as possible.” “Sometimes it sounds better after I write it down even though it’s not what I was humming.” Changes note sizes to match the exact rhythm he is humming. Copied and pasted a motive, added to the end, then transposed the last two notes to create antecedent- consequent.

(Table 48 continued) (Return to document)

	Epistemological Pluralism		
Ryan	"Creativity, [is] easily being able to change things around in your head like, 'cuz you have to do a lot in your head rather than just placing everything down." He could hear his mistake when trying to duplicate a motive note-by-note and quickly corrected it (improved aural skills combined with concrete drawing).	His comments implied that composition required more abstract thinking than he believed he was capable of. At the end, believed he improved at abstract thinking in sound; used tools (concrete) to create antecedent-consequence phrase (abstract).	Concrete tools helped him describe his thinking: "It needs more intertwining melodies not just lines like that (pointing to the screen). Learned parallel and oblique motion using concrete tools to apply and explain his abstract idea.
Draco and Ryan	D: "I have an idea that's hard to explain in my words it's much easier to explain in my actions" Lots of listen-reflect-discuss-change quickly with the tools; ccopied part of their original motive (concrete) to include in the solo section (abstract thinking/development) Used tools to create bi-tonality Draco used the icons to explain note values and measures to Ryan	D: "This is where the coarse adjustment works" (transposes an entire collection of pitches) Inversion idea (abstract) easily accommodated by the tools (concrete). Using the concrete tools in the software to realize the abstract concept of inversion in music. Intentionally created standard note values with the tools and measures using the gridlines; Draco used the tools to show Ryan how he thinks of a melody holistically rather than separate motives.	Ryan sang, Draco repeated it and transcribed while making adjustments (sound *with* sight) Singing and pointing was common (e.g., "I don't like the duh, duh, duh, duh"); experimented with transposition a lot by quickly moving icons higher and lower. D: "I'm much better at the mechanical thinking (i.e., concretely making the music) and Ryan is much better at the abstract thinking."
Jeff	Worked briskly and fluidly with concrete tools to create his desired "simple" textures.	SD: "Jeff is an intuitive music maker who seems to be able to think abstractly in music and use the concrete tools simultaneously." Drew motives intently and quickly, and rarely changed them.	Seemed to work fluidly with the abstract and concrete combined; rarely changed or deleted material.

(Table 48 continued) (Return to document)

	Epistemological Pluralism		
Josh	Occasionally spoke in terms of standard notation while drawing droplets.	"What if they (notes) are all attached? (used concrete tools to quickly eliminate rests in between notes),	"A strategy I found was making the same thing (repeating) but one [with] shorter [notes] than the other" (diminution through drawing with tools).
Jeff and Josh	Jeff: "Could have a green line going the whole time and loop in the yellow line."		

REFERENCES

Ackermann, E. K. (1993). Tools for constructive learning: Rethinking interactivity. *Epistemology and Learning*, *15*(1), 1–12. Cambridge, MA: MIT Media Lab. Retrieved January 12, 2015 from http://web.media.mit.edu/~edith/publications/1993-tools%20for.const.%20E&L.pdf

Ackermann, E. K. (1996). Perspective-taking and object construction. In Kafai, Y., & Resnick, M. (Eds.), *Constructionism in practice: Designing, thinking, and learning in a digital world*. New York, NY: Routledge. [Kindle version]. Retrieved from Amazon.com

Ackermann, E. K. (2001). Piaget's constructivism, Papert's constructionism: What's the difference? *Future of Learning Group Publication*, *5*(3), 438–448. Retrieved from https://learning.media.mit.edu/content/publications/EA.Piaget%20_%20Papert.pdf

Ackermann, E. K. (2004). Constructing knowledge and transforming the world. In M. Tokoro and L. Steels (Eds.), *A learning zone of one's own: Sharing representations and flow in collaborative learning environments* (pp. 15–37). Washington, D.C.: IOS Press.

Ackermann, E., Gauntlett, D., & Weckstrom, C. (2009). Defining systematic creativity: Explaining the nature of creativity and how the LEGO system of play relates to it. Billund, Denmark: The LEGO Learning Institute. Retrieved February 2015 from https://davidgauntlett.com/wp-content/uploads/2013/05/LEGO_LLI09_Systematic_Creativity_PUBLIC.pdf

Ainley, J., Pratt, D., & Hansen, A. (2006). Connecting engagement and focus in pedagogic task design. *British Educational Research Journal, 32*(1), 23–38. doi:10.1080/01411920500401971

Airy, S. & Parr, J. (2001). MIDI, music and me: Students' perspectives on composing with MIDI. *Music Education Research, 3*(1), 41–49. doi:10.1080/14613800020029941

Andrews, R., Torgerson, C., Beverton, S., Freeman, A., Locke, T., Low, G., & Zhu, D. (2006). The effect of grammar teaching on writing development. *British Educational Research Journal, 32*(1), 39–55. doi:10.1080/01411920500401997

Applefield, J. M., Huber, R., & Moallem, M. (2000). Constructivism in theory and practice: Toward a better understanding. *The High School Journal, 84*(2), 35–53. Retrieved from www.jstor.org/stable/40364404

Auh, M. S. (2000). Effects of using graphic notations on creativity in composing music by Australian secondary school students. Paper presented at *Proceedings of the Australian Association for Research in Education Conference, 2000.* Brisbane, Australia. Retrieved November 20, 2019 from https://files.eric.ed.gov/fulltext/ED458188.pdf

Auh, M. S., & Walker, R. (1999). Compositional strategies and musical creativity when composing with staff notations versus graphic notations among Korean students. *Bulletin of the Council for Research in Music Education, 141*, 2–9. Retrieved from https://eric.ed.gov/?id=EJ628590

Azzara, C. D. (1993). Audiation-based improvisation techniques and elementary instrumental students' music achievement. *Journal of Research in Music Education, 4*1(4), 328–342.

Bamberger, J. (1977). In search of a tune. In D. Perkins and B. Lender (Eds.), *The arts and cognition* (pp. 284–319). Baltimore, MD: John Hopkins Press.

Bamberger, J. (2003). The development of intuitive musical understanding: A natural experiment. *Psychology of Music, 31*(1), 7–36. doi:10.1093/acprof:oso/9780199589838.003.0016

Bamberger, J. (2005). How the conventions of music notation shape musical perception and performance. In D. Hargreaves, R. MacDonald & D. Miell (Eds.), *Musical communication* (pp. 143–170). New York, NY: Oxford University Press. doi:10.1093/acprof:oso/9780198529361.003.0007

Bamberger, J. (2013). Action knowledge and symbolic knowledge: The computer as mediator. In J. Bamberger, *Discovering the musical mind: A view of creativity as learning* (pp. 1–28). Retrieved from Oxford Scholarship Online. doi:10.1093/acprof:oso/9780199589838.003.0012

Barbour, R. (2014). *Introducing qualitative research: a student's guide* (2nd ed.). Thousand Oaks, CA: SAGE. [Kindle version]. Retrieved from Amazon.com

Barrett, M. (1996). Children's aesthetic decision-making: An analysis of children's musical discourse as composers. *International Journal of Music Education*, (1), 37–62. doi:10.1177/025576149602800104

Barrett, M. (1997). Invented notations: A view of young children's musical thinking. *Research Studies in Music Education, 8*(1), 2–14. doi:10.1177/1321103x9700800102

Barrett, M. (2002). Invented notations and mediated memory: A case study of two children's use of invented notations. *Bulletin of the Council for Research in Music Education, 153*(4), 55–62. Retrieved from www.jstor.org/stable/40319141

Barrett, M. S. (2003). Freedoms and constraints: Constructing musical worlds through the dialogue of composition. In M. Hickey (Ed.), *Composition in the schools: A new horizon for music education* (pp. 3–27). Reston, VA: MENC

Barrett, M. (2006). Creative collaboration: An 'eminence' study of teaching and learning in music composition. *Psychology of Music, 34*(2), 195–218. doi:10.1177/0305735606061852

Barron, B., & Engle, R. (2007). Analyzing data derived from video records. In S. Derry (Ed.), *Guidelines for video research in education* (pp. 24–33). Chicago, IL: University of Chicago Data Research and Development Center.

Baumann, J. F., Seifert-Kessell, N., & Jones, L. A. (1992). Effect of think-aloud instruction on elementary students' comprehension monitoring abilities. *Journal of Reading Behavior, 24*(2), 143–172. doi:10.1080/10862969209547770

Baytak, A. (2009). *An investigation of the artifacts, outcomes, and processes of constructing computer games about environmental science in a fifth grade science classroom* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3399626).

Berkley, R. (2001). Why is teaching composing so challenging? A survey of classroom observation and teachers' opinions. *British Journal of Music Education*, *18*(2), 119–138. doi:10.1017/s0265051701000225

Berkley, R. (2004). Teaching composing as creative problem solving: Conceptualising composing pedagogy. *British Journal of Music Education, 21*(3). 239–263. doi:10.1017/s0265051701000225

Boardman, E. (2002). The relationship of musical thinking and learning to classroom instruction. In E. Boardman (Ed.), *Dimensions of musical learning and teaching: A different kind of classroom* (pp. 1–20). Lanham, MD: Rowman & Littlfield.

Bolden, B. (2009). Teaching composing in secondary school: A case study analysis. *British Journal of Music Education*, *29*(2), 137–152. doi:10.1017/s0265051709008407

Bolton, J. (2008). Technologically mediated composition learning: Josh's story. *British Journal of Music Education*, *25*(1), 41–55. doi:10.1017/s0265051707007711

Boyer, J. T. (2010). *Using Scratch for learner-constructed multimedia: A design-based research inquiry of constructionism in practice* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3436320).

Brandes, A. (1996) Elementary school children's images of science. In Kafai, Y., & Resnick, M. (Eds.), *Constructionism in practice: Designing, thinking, and learning in a digital world* (Ch. 3). New York, NY: Routledge. [Kindle version]. Retrieved from Amazon.com

Breeze, N. (2009), Learning design and proscription: How generative activity was promoted in music composing, *International Journal of Music Education, 27*(3), 204–219. doi:10.1177/0255761409335953

Bruner, J. S. (1977). *The process of education* (2nd ed.). Cambridge, MA: Harvard University Press.

Bruner, J., & Haste, H. (1987). *Making sense: The child's construction of reality*. New York, NY: Methuen & Co.

Burnard, P. (1995). Task design and experience in composition. *Research Studies in Music Education, 5*, 32–46. doi:10.1177/1321103x9500500104

Burnard, P. (2000). How children ascribe meaning to improvisation and composition: rethinking pedagogy in music education. *Music Education Research, 2*(1), 7–23. doi:10.1080/14613800050004404

Burnard, P. (2006). Understanding children's meaning-making as composers. In Deliège, I., & Wiggins, G. A. (Eds.), *Musical creativity: Multidisciplinary research in theory and practice* (pp. 111–133). East Sussex, UK: Psychology Press.

Burnard, P. (2007). Reframing creativity and technology: promoting pedagogic change in music education. *Journal of Music, Technology and Education, 1*(1), 37–55. doi:10.1386/jmte.1.1.37_1

Burnard, P., & Younker, B. A. (2002). Mapping pathways: Fostering creativity in composition. *Music Education Research, 4*(2), 245–261. doi:10.1080/1461380022000011948

Cage, J. (1961). *Silence*. Middletown, CT: Wesleyan University Press.

Carlin, J. L. F. (1998). *Can you think a little louder? A classroom-based ethnography of eight and nine year olds composing with music and language* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. NQ27143).

Carroll, D. (2007). *Children's use of personal, social and material resources to solve a music notational task: A social constructivist perspective* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. NR32162).

Chen, J. C. W. (2012). A pilot study mapping students' composing strategies: Implications for teaching computer-assisted composition. *Research Studies in Music Education*, *34*(2), 157–171. doi:10.1177/1321103x12465515

Christensen, C. B. (1992). *Music composition, invented notation and reflection: Tools for music learning and assessment*. (Doctoral dissertation) Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 9231370).

Cobb, Paul. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23*(7), 13–20. doi:10.3102/0013189x023007013

Cole, M., & Wertsch, J. V. (1996). Beyond the individual-social antinomy in discussions of Piaget and Vygotsky. *Human Development*, *39*, 250–256. doi:10.1159/000278475

Colley, A., Comber, C., & Hargreaves, D. (1997). IT and music education: What happens to boys and girls in coeducational and single sex schools? *British Journal of*

Music Education, *14*(2), 119–127. doi:10.1017/s0265051700003569

Collins, D. (2007). Real-time tracking of the creative music composition process. *Digital Creativity*, *18*(4), 239–256. doi:10.1080/14626260701743234

Collins, D., & Dunn, M. (2011). Problem-solving strategies and processes in musical composition: Observations in real time. *Journal of Music, Technology & Education*, *4*(1), 47–76. doi:10.1386/jmte.4.1.47_1

Couturier, R. L. (2000). *Computer microworld development adapted to children's conceptions: A case study* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Full Text. (Publication No. 9960744).

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand Oaks, CA: SAGE.

Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: SAGE. [Kindle version]. Retrieved from Amazon.com

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: SAGE.

Creswell, J. W., & Poth, C. N. (2017). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Thousand Oaks, CA: SAGE.

Csikszentmihalyi, M. (1991). *Flow: The psychology of optimal experience*. New York, NY: Harper & Row.

Daignault, L. (1996). *Children's creative musical thinking within the context of a computer-supported improvisational approach to composition.* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 9714572).

Dammers, R. (2013). Capitalizing on emerging technologies in composition education. In M. Kaschub & J. Smith (Eds.), *Composing our future: Preparing music educators to teach composition* (pp. 201–210). New York, NY: Oxford University Press.

Davidson, L., & Scripp, L. (1988). Young children's musical representations: Windows on music cognition. In J. Sloboda (Ed.), *Generative processes in music: The psychology of performance, improvisation, and composition* (pp. 195–230). New York, NY: Oxford University Press. doi:10.1093/acprof:oso/9780198508465.003.0009

DeLorenzo, L. C. (1989). A field study of sixth-grade students' creative music problem-solving processes. *Journal of Research in Music Education*, *37*(3), 188–200. doi:10.2307/3344669

Denzin, N. K., & Lincoln, Y. S. (2008). *The landscape of qualitative research* (Vol. 1). Thousand Oakes, CA: SAGE.

Derry, S. J. (Ed.). (2007). *Guidelines for video research in education: Recommendations from an expert panel.* Chicago, IL: University of Chicago, Data Research and Development Center. Retrieved November 21, 2019 from https://drdc.uchicago.edu/what/video-research-guidelines.pdf

DeVries, R. (1997). Piaget's social theory. *Educational Researcher 26*(2), 4–17. doi:10.2307/1176032

DeVries, R. (2000). Vygotsky, Piaget, and education: A reciprocal assimilation of theories and educational practices. *New Ideas in Psychology, 18*(2), 187–213. doi:10.1016/s0732-118x(00)00008-8

Dewey, J. (1910). *How we think: A restatement of the reflective thinking to the educative process.* Boston, MA: Heath.

Dick, W. (1992). An instructional designer's view of constructivism. In T. M. Duffy & D. H. Jonassen (Eds.), *Constructivism and the technology of instruction: A conversation* (pp. 91–98). Hillsdale, NJ: Lawrence Erlbaum

Dillon, J.T. (1982). Problem finding and solving. *Journal of Creative Behaviour 16*(2), 97–111. doi:10.1002/j.2162-6057.1982.tb00326.x

Dorfman, J. (2013). *Theory and practice of technology-based music instruction.* New York, NY: Oxford University Press.

Downton, M. P., Peppler, K. A., & Portowitz, A. (2010). *Building tunes block by block: Constructing musical and cross-cultural understanding through Impromptu*. Retrieved from https://eric.ed.gov/?id=ED521167

Downton, M. P. (2015). *The learner's intuition: Harnessing the power of intuitions during creative and collaborative activities* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Full Text. (Publication No. 3689714).

Duffy, T. & Cunningham, D. (1996). Constructivism: Implications for the design and delivery of instruction. *Handbook of research for educational communications and technology* (pp. 170–198). Retrieved November 20, 2019 from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.138.2455&rep=rep1&type=pdf

Duncan, R. M. (1995). Piaget and Vygotsky revisited: Dialogue or assimilation? *Developmental Review, 15*(4), 458–472. doi:10.1006/drev.1995.1019

Dye, J. F., Schatz, I. M., Rosenberg, B. A., & Coleman, S. T. (2000). Constant comparison method: A kaleidoscope of data. *The Qualitative Report*, *4*(1), 1–10. Retrieved November 20, 2019 from https://nsuworks.nova.edu/tqr/vol4/iss1/8

Emmons, S. E. (1998). *Analysis of musical creativity in middle school students through composition using computer-assisted instruction: A multiple case study* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 9825697).

Erickson, F. (2006). Definition and analysis of data from videotape: Some research procedures and their rationales. In J. L. Green, G. Cimilli, & P. B. Elmore (Eds.), *Handbook of complementary methods in education research* (pp. 177–191). New York, NY: Routledge.

Ericsson, K.A. & Simon, H.A. (1993). *Protocol analysis: Verbal reports as data* (Rev. ed.). Cambridge, MA: MIT Press.

Farbood, M., Kaufman, H., & Jennings, K. (2007). Composing with Hyperscore: An intuitive interface for visualizing musical structure. Paper presented at *Proceedings of International Computer Music Conference 2007*. Copenhagen, Denmark. Retrieved January 1, 2016 from http://hdl.handle.net/2027/spo.bbp2372.2007.133

Farbood, M. & Pasztor, E. (2004). Hyperscore: Harmony Line Music (Version 4.5) [computer software]. Retrieved January 20, 2015 from https://hyperscore.wordpress.com/

Folkestad, G., Hargreaves, D. J., & Lindström, B. (1998). Compositional strategies in computer-based music-making. *British Journal of Music Education, 15*(1), 83–97. doi:10.1017/s0265051700003788

Fosnot, C. T. (2005). *Constructivism: Theory, perspectives, and practice*. New York, NY: Teachers College Press. [Kindle version]. Retrieved from Amazon.com

Fox, E., & Riconscente, M. (2008). Metacognition and self-regulation in James, Piaget, and Vygotsky. *Educational Psychology Review, 20*(4), 373–389. doi:10.1007/s10648-008-9079-2

Franz, G., & Papert, S. (1988). Computer as material: Messing about with time. *The Teachers College Record, 89*(3), 408–417. Retrieved July 15, 2020 from http://dailypapert.com/computer-as-material-messing-about-with-time/

Gall, M. and Breeze, N. (2005), Music composition lessons: The multimodal affordances of technology, *Educational Review, 57*(4), 415–433. doi:10.1080/00131910500278314

Gass, S.M. and Mackey, A (2000). *Simulated recall methodology in second language research*. Mahwah. N.J.: Lawrence Erlbaum.

Gargarian, G. (1996). *The art of design: Expressive intelligence in music* (Unpublished doctoral dissertation). Massachusetts Institute of Technology, Cambridge, MA.

Retrieved December 12, 2015 from http://dspace.mit.edu/handle/1721.1/12559#files-area

Getzels, J.W. (1975). Problem-finding and the inventiveness of solutions. *Journal of Creative Behaviour, 16*(2), 12–18. doi:10.1002/j.2162-6057.1975.tb00552.x

Gilutz, S. (2009). *Young children's learning of novel digital interfaces: How technology experience, age, and design come into play.* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3388419).

Glassman, M. (1994). All things being equal: The two roads of Piaget and Vygotsky. *Developmental Review, 14*(2), 186–214. doi:10.1006/drev.1994.1008

Glesne, C. (2011). *Becoming qualitative researchers: An introduction.* New York, NY: Pearson.

Goldman, R., Black, J., Maxwell, J. W., Plass, J., & Keitges, M. J. (2012). Engaged learning with digital media: The points of viewing theory. In. W. Reynolds, G. Miller, & I. Weiner (Eds.), *Handbook of psychology* (Vol. 7, pp. 321–364). New York, NY: John Wiley & Sons.

Gunstone, R. (2000) Constructivism and learning research in science education. In D.C. Phillips (Ed.), *Constructivism in education, Ninety-ninth yearbook of the national society for the study of education*, (pp. 254–280). Chicago, IL: University of Chicago Press.

Guthmann, Susanna E. (2013). *Cycles of revision: A study of music compositions by students involved in the Vermont MIDI Project (Music-COMP).* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3595600).

Harding, J. (2018). *Qualitative data analysis: From start to finish*. Thousand Oaks, CA: SAGE Publications Limited. [Kindle version]. Retrieved from Amazon.com

Harel, I. R. (1988). *Software design for learning: Children's construction of meaning for fractions and Logo programming* (Unpublished doctoral dissertation). Massachusetts Institute of Technology, Cambridge, MA. Retrieved December 9, 2014 from http://dspace.mit.edu/handle/1721.1/75005

Hewitt, A. (2008). Children's creative collaboration during a computer-based music task. *International Journal of Educational Research, 47*(1), 11–26. doi:10.1016/j.ijer.2007.11.003

Hewitt, A. (2009). Some features of children's composing in a computer-based environment: the influence of age, task familiarity and formal instrumental music instruction. *Journal of Music, Technology & Education, 2*(1), 5–24. doi:10.1386/jmte.2.1.5/1

Hickey, M. (1995). *Qualitative and quantitative relationships between children's creative musical thinking processes and products* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 9614754).

Hickey, M. (1997). The computer as a tool in creative music making. *Research Studies in Music Education, 8*(1), 56–70. doi:10.1177/1321103x9700800106

Hickey, M. (2012). *Music outside the lines: Ideas for composing in K–12 music classrooms.* New York, NY: Oxford University Press.

doi:10.1177/1321103x9700800106

Hickey, M. (2013). What pre-service teachers can learn from composition research. In M. Kaschub & J. Smith (Eds.), *Composing our future: Preparing music educators to teach composition* (pp. 33–56). New York, NY: Oxford University Press. doi:10.1093/acprof:oso/9780199832286.003.0003

Hickey, M., & Lipscomb, S. D. (2006). How different is good? How good is different? In Deliège, I., & Wiggins, G. A. (Eds.), *Musical creativity: Multidisciplinary research in theory and practice* (97–110). East Sussex, UK: Psychology Press. Retrieved November 20, 2019 from http://www.lipscomb.umn.edu/docs/HickeyLipscombPrePress.pdf

Horst, S. W. (2016). *Cognitive pluralism.* Cambridge, MA: MIT Press.

Huang, C., & Yeh, Y. (2014). Graphical interface-based automated music composition use among elementary school students. *Musicae Scientiae, 18*(1), 84–97. doi:10.1177/1029864913514596

Illich, I. (1973). *Tools for conviviality.* New York, NY: Harper & Row.

Jennings, K. (2005). Hyperscore: A case study in computer mediated music composition. *Education and Information Technologies, 10*(3), 225–238. doi:10.1007/s10639-005-3003-x

Jennings, K. (2009). Composing with graphical technologies: Representations, manipulations, and affordances. In J. Finney & P. Burnard (Eds.), *Music education with digital technology* (pp. 76–94). London: Continuum International Publishing

Johnson, C. (2014). *'I liked it, but it made you think too much': A case study of computer game authoring in the Key Stage 3 ICT curriculum.* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 10082039).

Jonassen, D. H. (1999). Designing constructivist learning environments. In Reigeluth, C. M. (Ed.), *Instructional design theories and models: A new paradigm of instructional theory,* (pp. 215–239). New York, NY: Routledge.

Jonassen, D. H. (2006). *Modeling with technology: Mindtools for conceptual change.* Saddle River, NJ: Prentice Hall.

Kafai, Y. B. (1995). *Minds in play: Computer game design as a context for children's learning.* New York, NY: Routledge.

Kafai, Y. B. (1996). Learning design by making games. In Kafai, Y., & Resnick, M. (Eds.), *Constructionism in practice: Designing, thinking, and learning in a digital world* (Ch. 4). New York, NY: Routledge. [Kindle version]. Retrieved from Amazon.com

Kaschub, M. E. (1999). *Sixth grade students' descriptions of their individual and collaborative music composition processes and products initiated from prompted and unprompted task structures* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 9932187).

Kaschub, M., & Smith. J. (2009). *Minds on music: Composition for creative and critical thinking.* New York, NY: Rowman & Littlefield Education. [Kindle version]. Retrieved from Amazon.com

Kendall, S. (1986). The harmony of human life: An exploration of the ideas of Pestalozzi and Froebel in relation to music education. *British Journal of Music Education*, *3*(1), 35–48. doi:10.1017/s0265051700005118

Kennedy, M. A. (1999). Where does the music come from? A comparison case-study of the compositional processes of a high school and a collegiate composer. *British Journal of Music Education, 16*(2), 157–177. doi:10.1017/s0265051799000248

Kennedy, M. A. (2002). Listening to the music: Compositional processes of high school composers. *Journal of Research in Music Education, 50*(2), 94–110. doi:10.2307/3345815

Kincheloe, J. L. (2005). On to the next level: Continuing the conceptualization of the bricolage. *Qualitative Inquiry*, 11(3), 323–350. doi:10.1177/1077800405275056

Kirkman, P. (2011). Exploring contexts for development: Secondary music students' computer-mediated composing*, Journal of Music, Technology & Education 3*(2), 107–124. doi:10.1386/jmte.3.2-3.107_1

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. doi:10.1207/s15326985ep4102_1

Kitchener, R. F. (1980). Piaget's genetic epistemology. *International Philosophical Quarterly, 20*(4), 377–405. doi:10.5840/ipq198020437

Kosak, P. D. (2014). *Intrapersonal, interpersonal, and cultural influences in collaborative composition* (Doctoral dissertation). Retrieved from ProQuest

Dissertation and Theses Full Text. (Publication No. 3581050). https://open.bu.edu/handle/2144/11108

Kratus, J. (1989). A time analysis of the compositional processes used by children ages 7 to 11. *Journal of Research in Music Education, 37*(1), 5–20. doi:10.2307/3344949

Kratus, J. (2012). Nurturing the songcatchers: Philosophical issues in the teaching of music composition. In W. Bowman & L. Frega (Eds.), *The Oxford handbook of philosophy in music education* (pp. 367–385). Oxford, England: Oxford. doi:10.1093/oxfordhb/9780195394733.013.0020

Ladanyi, K. S. (1995). *Processes of musical composition facilitated by digital music equipment* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 9543638).

Lamberty, K. K. (2007). *Getting and keeping children engaged with a constructionist design tool for craft and math* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3261675).

Lévi-Strauss, C. (1962). *The savage mind.* Chicago, IL: University of Chicago Press.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Newbury Park, CA: Sage Publications

Lourenço, O. (2012). Piaget and Vygotsky: Many resemblances, and a crucial difference. *New Ideas in Psychology, 30*(3), 281–295. doi:10.1016/j.newideapsych.2011.12.006

Louth, P. (2013). Examining instruction in MIDI-based composition through a critical theory lens. *Philosophy of Music Education Review, 21*(2), 136–155. doi:10.2979/philmusieducrevi.21.2.136

Major, A. E. (2007). Talking about composing in secondary school music lessons. *British Journal of Music Education*, *24*(2), 165–178. doi:10.1017/s0265051707007437

Martinez, S. & Stager, G. S. (2013). *Invent to learn: Making, tinkering, and engineering in the classroom*. Torrance, CA: Constructing Modern Knowledge Press. [Kindle version]. Retrieved from Amazon.com

mathematic. (n.d.). In *Online Etymology Dictionary.* Retrieved July 12, 2014 from https://www.etymonline.com/search?q=mathematic

Mavrou, K., Lewis, A., & Douglas, G. (2010). Researching compute-based collaborative learning in inclusive classrooms in Cyprus: The role of the computer in pupils' interaction. *British Journal of Educational Technology*, *41*(3), 486–501. doi:10.1111/j.1467-8535.2009.00960.x

Maxwell, J. A. (2013). *Qualitative research design: An interactive approach* (3rd ed.). Thousand Oaks, CA: SAGE. [Kindle version]. Retrieved from Amazon.com

Mellor, L. (2008), Creativity, originality, identify: Investigating computer based composition in the secondary school, *Music Education Research, 10*(4), 451–472. doi:10.1080/14613800802547680

Menard, E. (2009). An investigation of creative potential in high school musicians: Recognizing, promoting, and assessing creative ability through music composition. (Doctoral dissertation). Retrieved from ProQuest Dissertation and

Theses Full Text. (Publication No. 3451495).

Menard, E. (2015). Music composition in the high school curriculum: A multiple case study. *Journal of Research in Music Education*, *63*(1), 114–136. doi:10.1177/0022429415574310

Merriam, S. B. (2014). *Qualitative research: A guide to design and implementation.* San Francisco, CA: John Wiley & Sons.

Mevarech, Z. R., & Kramarski, B. (1993). Vygotsky and Papert: Social-cognitive interactions within LOGO environments. *British Journal of Educational Psychology, 63*(1), 96–109. doi:10.1111/j.2044-8279.1993.tb01044.x

Meyer, L.B. (1956). *Emotion and meaning in music*. Chicago, IL: Chicago University Press.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2013). *Qualitative data analysis: A methods sourcebook.* Thousand Oaks, CA: SAGE. [Kindle version]. Retrieved from Amazon.com

MIT Media Lab. (n.d.). *Hyperscore overview.* Retrieved from https://www.media.mit.edu/projects/hyperscore/overview/

National Coalition for Core Arts Standards. (2013). *National core arts standards.* Retrieved from http://nationalartsstandards.org/

Nelson, S. L. (2007). *The complex interplay of composing, developing musicianship and technology: A multiple case study* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3256395).

Nicolopoulou, A. (1993). Play, cognitive development, and the social world: Piaget, Vygotsky, and beyond. *Human Development, 36*(1), 1–23. doi:10.1159/000277285

Nilsson, B. & Folkestad, G. (2005). Children's practice of computer-based composition. *Music Education Research, 7*(1), 21–37. doi:10.1080/14613800500042042

NVivo (Version 12.0) [Computer software]. Accessed February 13, 2015 from https://www.qsrinternational.com/nvivo/home

Noss, R., & Clayson, J. (2015). Reconstructing constructionism. *Constructivist Foundations*, *10*(3), 285–288. Retrieved August 2, 20202 from http://www.kvccdocs.com/ss-department/psychology/constructionism/Noss.pdf

Noss, R., & Hoyles, C. (2017). Constructionism and microworlds. In E. Duval, M. Sharples, & R. Sutherland (Eds.), *Technology enhanced learning* (pp. 29–35). New York, NY: Springer.

Papert, S. (1972a). Teaching children to be mathematicians versus teaching about mathematics. *International Journal of Mathematical Education in Science and Technology, 3*(3), 249–262. doi:10.1080/0020739700030306

Papert, S. (1972b). Teaching children thinking. *Programmed Learning and Educational Technology, 9*(5), 245–255. doi:10.1080/1355800720090503

Papert, S. (1980a). *Mindstorms: Children, computers, and powerful ideas*. New York, NY: Basic Books.

Papert, S. (1980b). Computer-based microworlds as incubators for powerful ideas. In R. Taylor (Ed.), *The computer in the school: Tutor, tool, tutee* (pp. 203–210). New

York, NY: Teacher's College Press.

Papert, S. (1987) *A critique of technocentrism in thinking about the school of the future.* Paper presented at Children in an Information Age: Opportunities for Creativity Innovation, and New Activities, Sofia, Bulgaria. Retrieved July 15, 2020 from http://dailypapert.com/a-critique-of-technocentrism-in-thinking-about-the-school-of-the-future/

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer.* New York, NY: Basic Books.

Papert, S. (1996) *The connected family.* Atlanta, GA: Longstreet Press.

Papert, S. (1999a). Child psychologist Jean Piaget. *Time 100: Scientists and thinkers, 153(*12), 104–109. Retrieved November 20, 2019 from http://content.time.com/time/magazine/article/0,9171,990617,00.html

Papert, S. (1999b). *The eight big ideas of the constructionist learning laboratory*. Unpublished internal document. South Portland, Maine. Retrieved June 9, 2014 from http://stager.org/articles/8bigideas.pdf

Papert, S. (2005). You can't think about thinking without thinking about thinking about something. *Contemporary Issues in Technology and Teacher Education, 5*(3), 366–367. Retrieved November 20, 2019 from https://www.learntechlib.org/p/21845/

Papert, S. & Harel, I. (1991). Situating constructionism. In S. Papert & I. Harel, *Constructionism* (pp. 1–11). New York, NY: Ablex Publishing Corporation.

Parry-Jamieson, M. (2006). *From play to potential: Composition pedagogy in music education* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. NR30737).

Paynter, J. (2000). Making progress with composing. *British Journal of Music Education, 17*(1), 5–31. doi:10.1017/s0265051700000115

Paynter, J. (2002). Music in the school curriculum: Why bother? *British Journal of Music Education, 19*(3), 215–226. doi:10.1017/s0265051702000311

Perkins, D. N. (1981). *The mind's best work*. Cambridge, MA: Harvard University Press.

Perkins, D. N. (1992). What constructivism demands of the learner. In T. M. Duffy & D. H. Jonassen (Eds.), *Constructivism and the technology of instruction: A conversation*, (pp. 161–165). Hillsdale, NJ: Lawrence Erlbaum

Piaget, J. (1951). *Play, Dreams and Imitation in Childhood.* (C. Gattegno & F.M. Hodgson, Trans.). Florence, KY: Routledge. (Original work published 1945)

Piaget, J. (1973). *To understand is to invent: the future of education*. (G. Roberts, Trans.). New York, NY: Grossman Publishers.

Piaget, J. (1997). *The moral judgement of the child*. (M. Gabain, Trans.). New York, NY: Simon and Schuster. (Original work published 1932)

Pike, P. D. (2011). Using technology to engage third-age (retired) leisure learners: A case study of a third-age MIDI piano ensemble. *International Journal of Music Education, 29*(2), 116–123. doi:10.1177/0255761410396965

Pirie, S. E. (1996). *Classroom video-recording: When, why and how does it offer a valuable data source for qualitative research?* Retrieved November 20, 2019 from https://eric.ed.gov/?id=ED401128

Pitts, A., & Kwami, R. M. (2002). Raising students' performance in music composition through the use of information and communications technology (ICT): a survey of secondary schools in England. *British Journal of Music Education*, *19*(1), 61–71. doi:10.1017/s0265051702000141

Reese, S. (2001). Tools for Thinking in Sound. *Music Educators Journal, 88*(1), 42–53. doi:10.2307/3399776

Reimer, B. (2003). *A philosophy of music education: Advancing the vision*. Upper Saddle River, NJ: Prentice Hall.

Reybrouck, M., Verschaffel, L., & Lauwerier, S. (2009). Children's graphical notations as representational tools for musical sense-making in a music-listening task. *British Journal of Music Education, 26,* 189–211. doi:10.1017/s0265051709008432

Riley, P. E. (2009). Pre-service music educators' perceptions of the national standards for music education. *Visions of Research in Music Education, 14,* 1–23. Retrieved November 20, 2019 from http://users.rider.edu/~vrme/v14n1/vision/Riley%20Final2.pdf

Reimer, B. (1989). Music education as aesthetic education: Toward the future. *Music Educators Journal, 75*(7), 26–32. doi:10.2307/3400308

Richardson, L., & Whitaker, N. (1994). Writing. A method of inquiry. In K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 345–371). Thousand Oaks, CA: SAGE.

Robinson, A. G., & Stern, S. (1997). Three simple principles that dramatically boost corporate creativity. *National Productivity Review*, *17*, 43–52. doi:10.1002/npr.4040170108

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context.* New York, NY: Oxford University Press.

Rosenbaum, E. E. R. (2015). *Explorations in musical tinkering* (Doctoral dissertation). Retrieved from http://dspace.mit.edu/handle/1721.1/97970

Ruitenberg, C., & Phillips, D. C. (2012). *Education, culture and epistemological diversity: Mapping a disputed terrain.* Dordrecht: Springer. doi:10.1007/s11191-012-9509-x

Salomon, G., & Perkins, D. N. (1998). Individual and social aspects of learning. *Review of Research in Education, 23,* 1–24. doi:10.2307/1167286

Savage J., & Challis, M. (2001). Dunwich revisited: Collaborative composition and performance with new technologies. *British Journal of Music Education, 18*, 139–149 doi:10.1017/s0265051701000237

Savage, J. (2005). Working toward a theory for music technologies in the classroom: How pupils engage with and organize sounds with new technologies. *British Journal of Music Education, 22*(2), 167–180. doi:10.1017/s0265051705006133

Schiff, M. S. (2015). *A qualitative study of music teachers' beliefs about the teaching of composition* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3668098). https://open.bu.edu/handle/2144/15437

Scholz, R. W. & Tietje, O. (Eds.). (2002). *Embedded case study methods: Integrating quantitative and qualitative knowledge.* Thousand Oaks, CA: SAGE.

Screencast-O-Matic (Version 2.0) [Computer software]. Retrieved February 13, 2015 from http://screencast-o-matic.com/

Seddon, F. A. (2006). Collaborative computer-mediated music composition in cyberspace. *British Journal of Music Education, 23*(3), 273–283. doi:10.1017/s0265051706007054

Seddon, F. A., & O'Neill, S. A. (2001). An evaluation study of computer-based compositions by children with and without prior experience of formal instrumental music tuition. *Psychology of Music, 29*(1), 4–19. doi:10.1177/0305735601291002

Seddon, F. A., & O'Neill, S. A. (2003). Creative thinking processes in adolescent computer-based composition: An analysis of strategies adopted and the influence of instrumental music training. *Music Education Research, 5*(2), 125–137. doi:10.1080/1461380032000085513

Shaw, A. C. (1995). *Social constructionism and the inner city: Designing environments for social development and urban renewal* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Full Text (Publication No. 0576373).

Shayer, M. (2003). Not just Piaget; not just Vygotsky, and certainly not Vygotsky as alternative to Piaget. *Learning and Instruction, 13*(5), 465–485. doi:10.1016/s0959-4752(03)00092-6

Shayer, M., Kuchemann, D. E., & Wylam, H. (1976). The distribution of Piagetian stages of thinking in British middle and secondary school children. *British Journal of Educational Psychology, 46*, 164–173. doi:10.1111/j.2044-8279.1976.tb02308.x

Shayer, M., & Wylam, H. (1978). The distribution of Piagetian stages of thinking in British middle and secondary school children II: 14–16 year-olds and sex differentials. *British Journal of Educational Psychology, 48*, 62–70. doi:10.1111/j.2044-8279.1978.tb02370.x

Smith, J. P. (2004). *Music compositions of upper elementary students created under various conditions of structure* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3132610).

Stager, G.S. (2001, July). Constructionism as a high-tech intervention strategy for at-risk learners. Proceedings of *National Educational Computing Conference.* Chicago, Illinois. Retrieved November 20, 2019 from https://eric.ed.gov/?id=ED462949

Stager, G.S. (2005, August). Papertian constructionism and the design of productive contexts for learning. Proceedings of *EuroLogo 2005 Conference on Digital Tools for Lifelong Learning.* Warsaw, Poland. Retrieved from November 20, 2019 http://www.stager.org/articles/eurologo2005.pdf

Stake, R. (2005) Qualitative case studies. In N. K. Denzil & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (3rd ed., pp. 443–465).

Stauffer, S. L. (2001). Composing with computers: Meg makes music. *Bulletin of the Council for Research in Music Education, 150,* 1–20. Retrieved from https://www.jstor.org/stable/40319096

Stauffer, S. L. (2002). Connections between the musical and life experiences of young composers and their compositions. *Journal of Research in Music Education, 50*(4), 301–322. doi:10.2307/3345357

Strand, K. D. (2003). *Nurturing young composers: Exploring the relationship between instruction and transfer in 9- to 12 -year -old students.* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3087983).

Swanwick, K., & Tillman, J. (1986). The sequence of musical development: A study of children's composition. *British Journal of Music Education, 3*(3), 305–339. doi:10.1017/s0265051700000814

Tarricone, P. (2011). *The taxonomy of metacognition.* New York, NY: Psychology Press.

Tobias, E. (2010). *Crossfading and plugging in: Secondary students' engagement and learning in a songwriting and technology class* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Full Text (Publication No. 3402496).

Tobias, S., & Duffy, T. (2009). The success or failure of constructivist instruction. In S. Tobias, & T. Duffy (Eds.), *Constructivist instruction: Success or failure?* (pp. 3–10). New York, NY: Routledge. [Kindle version]. Retrieved from Amazon.com

Tudge, J., & Rogoff, B. (1989). Peer influences on cognitive development: Piagetian and Vygotskian perspectives. In M. Bernstein & J. Bruner (Eds.), *Interaction in human development* (pp. 17–40). New York, NY: Lawrence Erlbaum.

Tudge, J. R., & Winterhoff, P. A. (1993). Vygotsky, Piaget, and Bandura: Perspectives on the relations between the social world and cognitive development. *Human*

Development, 36, 61–81. doi:10.1159/000277297

Turkle, S. (2017). *Alone together.* New York, NY: Basic Books.

Turkle, S., & Papert, S. (1990). Epistemological pluralism: Styles and voices within the computer culture. *Signs*, 128–157. doi:10.1086/494648

Turkle, S., & Papert, S. (1991). Epistemological pluralism and the revaluation of the concrete. In I. Harel & S. Papert (Eds.), *Constructionism* (pp. 161–191). New York, NY: Ablex Publishing.

Upitis, R. (1989). The craft of composition: Helping children create music with computer tools. *Psychomusicology: A Journal of Research in Music Cognition, 8*(2), 151. doi:10.1037/h0094241

Upitis, R. (1990). *This too is music.* Portsmouth, NH: Heinemann Educational Books.

Upitis, R. (1992). *Can I play you my song? The compositions and invented notations of children.* Portsmouth, N.H.: Heinemann Educational Books.

Van Ernst, B. (1993). A study of the learning and teaching processes of non-naive music students engaged in composition. *Research Studies in Music Education, 1*(1), 22–39. doi:10.1177/1321103x9300100104

Vanderwall, A. L. (2008). *Musical successes and challenges: The impacts of a keyboard lab program on public schools, music teachers, and students* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 3327071).

von Glassersfeld, E. (1982). An interpretation of Piaget’s constructivism. *Revue internationale de philosophie, 36*(142/143), 612–635. Retrieved from https://www.jstor.org/stable/23945415

von Glassersfeld, E. (1997). Homage to Jean Piaget (1896–1982). *The Irish Journal of Psychology, 18*(3), 293–306. doi:10.1080/03033910.1997.10558148

Vygotsky, L. S. (1978). *Mind in Society: The development of higher psychological processes* (14th ed.). (M. Cole, V. John-Steiner, S. Scribner, E. Souberman, Trans.). Cambridge, MA: Harvard University Press.

Ward, C. J. (2009). Musical exploration using ICT in the middle and secondary school classroom. *International Journal of Music Education, 27*(2), 154–168. doi:10.1177/0255761409102323

Webb, N. (1984). Sex differences in interaction and achievement in co-operative small groups. *Journal of Educational Psychology, 76*, 33–44. doi:10.1037//0022-0663.76.1.33

Webster, P. R. (1977). *A factor of intellect approach to creative thinking in music* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 7726619).

Webster, P. R. (1987). Conceptual bases for creative thinking in music. In Peery, J.C., Peery I.W., Draper T.W. (Eds.). *Music and child development* (pp. 158–174). New York, NY: Springer.

Webster, P. R. (2002a). Computer-based technology and music teaching and learning. In R. Colwell & C. Richardson (Eds.), *The new handbook of research on music teaching and learning* (pp. 416–439). New York, NY: Oxford University Press.

Webster, P. R. (2002b). Creative thinking in music: Advancing a model. In T. Sullivan & L. Willingham (Eds.), *Creativity and music education* (pp. 16–34). Edmonton, Canada: Canadian Music Educators' Association.

Webster, P. R. (2006). Some cautions about constructivism. *The Mountain Lake Reader*, *4*, 92–93. Retrieved November 20, 2019 from ProQuest. (Document ID 1578768).

Webster, P. R. (2011). Construction of music learning. In R. Colwell and P. Webster (Eds.), *MENC handbook of research on music learning* (Vol. 1, pp. 35–83). New York, NY: Oxford University Press.

Webster, P. R. (2012). Key research in music technology and music teaching and learning. *Journal of Music, Technology & Education, 4*(2–3), 115–130. doi:10.1386/jmte.4.2-3.115_1

Webster, P. R. (2013). Music composition intelligence and creative thinking in music. In M. Kaschub & J. Smith (Eds.), *Composing our future: Preparing music educators to teach composition* (pp. 19–32). New York, NY: Oxford University Press.

Wiggins, J. (1994). Children's strategies for solving compositional problems with peers. *Journal of Research in Music Education, 42*(3), 232–252. doi:10.2307/3345702

Wiggins, J. (1999). Teacher control and creativity: Carefully designed compositional experiences can foster students' creative processes and augment teachers' assessment efforts. *Music Educators Journal, 85*(5), 30–44. doi:10.2307/3399545

Wiggins, J. (2003). A frame for understanding children's compositional processes. In M. Hickey (Ed.), *Why and how to teach music composition: A new horizon for music* *education* (pp. 141–165). Reston, VA: The National Association for Music Education.

Wiggins, J. (2007). Compositional process in music. In Liora Bresler (Ed.), *International handbook of research in arts education* (pp. 453–476). Dordrecht. NL: Springer

Wiggins, J. (2009). *Teaching for musical understanding.* New York, NY: McGraw-Hill.

Wiggins, J. & Medvinsky, M. (2013). Scaffolding student composers. In M. Kaschub & J. Smith (Eds.), *Composing our future: Preparing music educators to teach composition* (pp. 109–125). New York, NY: Oxford University Press.

Wilson, B. G. (1996). *Constructivist learning environments: Case studies in instructional design.* Englewood Cliffs, NJ: Educational Technology Publications.

Winters, M. (2012). The challenges of teaching composing. *British Journal of Music Education, 29*(01), 19–24. doi:10.1017/s0265051711000489

Wise, A. & O'Neill, K. (2009). Beyond more versus less: A reframing of the debate on instructional guidance. In S. Tobias, & T. Duffy (Eds.), *Constructivist instruction: Success or failure?* (pp. 82–105). New York, NY: Routledge. [Kindle version]. Retrieved from Amazon.com

Wise, S. (2016). Secondary school teachers' approaches to teaching composition using digital technology. *British Journal of Music Education, 33*(3), 283–295. doi:10.1017/s0265051716000309

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89–100. doi:10.1111/j.1469-7610.1976.tb00381.x

Yin, Robert K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: SAGE. [Kindle Version]. Retrieved from Amazon.com

Yin, R. K. (2011). *Qualitative research from start to finish*. New York, NY: Guilford Press.

Younker, B. A. (1997). *Thought processes and strategies of eight, eleven, and fourteen-year-old students while engaged in music composition* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Full Text. (Publication No. 9814345).

Younker, B. A., & Smith, W. H. (1996). Comparing and modeling musical thought processes of expert and novice composers. *Bulletin of the Council for Research in Music Education*, 25–36. Retrieved from https://www.jstor.org/stable/40318786

CURRICULUM VITAE

Steven P. Dziekonski

Education

Boston University, Boston, MA
Doctor of Musical Arts (Music Education)

California State University, Northridge, CA
Master of Arts (Music Education)
Graduated with honors

Berklee College of Music, Boston, MA
Bachelor of Music (Dual Major in Music Education and Film Scoring)
Graduated magna cum laude

Experience

Director of Arts Programs
Pacific Ridge School, Carlsbad, CA (2009–present)

Graduate Teaching Assistant (2008–2009)
West Virginia University, Morgantown, WV

Music and Drama Teacher (2007–2008)
Winchester Thurston School, Pittsburgh, PA

Music Teacher (2002–2006)
Brentwood School, Los Angeles, CA

Performing Arts Department Chair (1995–2002)
Windward School, Los Angeles, CA

Music Department Chair (1988–1995)
Oakwood School, North Hollywood, CA

Music Teacher (1986–1988)
Wellesley Public Schools, Wellesley, MA

Music Teacher (1984–1986)
Silver Lake Regional High School, Kingston, MA

Music Director for Educational, Community, and Regional Theaters

Experience (continued)

Guest Conductor
PMEA District 1 Elementary SingFest, Pittsburgh, PA

Choir Director (former)
Church of The Visitation, Los Angeles, CA

Choir Member (former)
Mendelssohn Choir, Pittsburgh, PA
Angeles Chorale, Los Angeles, CA

Business Owner (current)
G&S Works Music (www.gsworks.com)

Certifications

K–12 Music in Massachusetts and Pennsylvania (currently inactive)
Orff-Schulwerk Level I certification

Professional Memberships

Member of National Association for Music Education
Southern California Vocal Association
California Music Educators Association.

Special Interests and Skills

Musical Theater
Music Technology
Animal Rescue