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Collaborative and Creative Thinking Skill Development Through the Design of Wearable Technologies

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2014

Abstract

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by

Laurie E. Korte

MA, University of Wisconsin, 2002

BS, Butler University, 1989

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Skills inherent in the creative thinking process such as reflecting and collaborating are needed for success in many careers. However, a focus on standardized testing in K-12 schools in the United States has resulted in the restructuring, reduction, and in some cases, elimination of arts in the curriculum to the detriment of students' creative thinking process. The purpose of this study was to discover whether creative thinking and collaborative skills were positive unintended consequences of a curriculum that includes the design of wearable technologies. Jonassen's modeling using Mindtools for conceptual change and Rosen's culture of collaboration provided the conceptual framework. This qualitative case study explored students' and teachers' perceptions of collaborative and creative thinking skill development while designing wearable technologies. The data analysis used interviews with 3 students and 1 teacher and an evaluation of participant wearable technology artifacts. Rich themes and patterns were determined through open coding. The themes identified to explain the perceived development of creative thinking skills were divergent thinking, stimulation of the imagination, generation of new knowledge, and creative climate. The themes identified to explain the perceived development of collaborative skills were diverse membership, culture of collaboration, and community building. The design of wearable technologies as a Mindtool showed promise as a new way to integrate art with science, technology, engineering, and math (STEM). This study may effect positive social change by informing educational policy and influencing school budgetary consideration toward including art as a value-added benefit to STEM curriculum.

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Dedication

My efforts are dedicated to my husband, Don, and to my parents. Without their encouragement and understanding, this endeavor would not have been possible. Thank you for all your love and support.

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I would like to thank Dr. MaryFriend Shepard for her guidance and support throughout my studies at Walden University. She inspired me to learn for the future. Her mentorship grew into more than just an academic relationship, but a true friendship. I wish to thank Dr. Amar Almasude for his unwavering willingness to share knowledge and insights. I would also like to acknowledge my immediate and extended family for putting up with me during this journey. Along with family, there were friends, Christine and Jeriann, in particular, without whom I would not have become a Doctor of Philosophy. The people involved in my efforts along the way mean more to me than any award or recognition I could ever receive.

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Chapter 1: Introduction to the Study

An innovation gap exists related to collaborative and creative thinking skill development in terms of students being prepared to enter careers following high school (Partnership for 21st Century Skills, 2010). Business leaders acknowledged a need for knowledge gained through other areas than what is currently the standard of education, noting that schools are not producing students prepared for the workforce (Apollo, 2012). The problems facing the future success of today's learners are multifaceted (Falk-Krzesinski et al., 2010). The need to address these problems is surmountable through cross-disciplinary, collaborative, and constructivist-learning environments.

The STEM subjects of Science, Technology, Engineering, and Math are associated with a focus on building future success (Guimerans, 2012). The importance of creative thinking as a developed skill is increasing. Creativity is not something just a few are born with; it can be fostered, built, and gained through learning (Katz-Buonincontro & Phillips, 2011). The arts need to be considered in cooperation with the STEM subjects to better prepare students to be successful in the workforce of tomorrow.

The No Child Left Behind Act (NCLB) had a detrimental effect on learners receiving the benefits of the arts as a core subject (Americans for the Arts, 2012). A proposal by the Republican Study Committee suggested continued decreases of arts and cultural funding on a national scale (Campoy-Leffler, 2011). According to Mardell, a researcher with Project Zero at Harvard University, "kids learn through all their senses" (Cleaver, 2013). Creative thinking is developed through learners' hands working with their minds toward knowledge building (Katz-Buonincontro, 2011).

Many believe that the world became economically integrated through continual increases in trade and financial flows. Zande (2011) calls this *value creation*, which means developing organizational structures that go beyond traditional forms and processes, collaborating to create new kinds of wealth. These extended networks are expanding the workplace around the globe to increase creativity and collaboration. Katz-Buonincontro (2011) found that creative thinking skills were enhanced by participating in a range of artistic areas, from drama to ceramics. Businesses are finding avenues through artistic resources to build learner skill development in sought after employee abilities (Americans for the Arts, 2012). Continued exploration of these changes resulted in discussions on the changing nature of work and how to shape and adapt to these latest findings (Apollo, 2012).

This study adds to the knowledge base by focusing understanding on participants' perceptions of the value of designing wearable technologies to the development of collaborative and creative thinking skills. A lack of research on students' and teachers' perceptions of collaborative and creative thinking skill development through the design of wearable technologies, directed the review of literature found in Chapter 2. A historically growing need to develop learner skills in collaboration and creative thinking for future business innovation and the global economy is evident.

Two theories were used as the conceptual framework for this study. Jonassen's (1996) modeling using Mindtools for conceptual change supported creative thinking as it relates to Mindtools. Rosen's (2009) culture of collaboration provided support for art in education and the development of collaboration and creative thinking skills through the design of wearable technologies.

This chapter includes a description of the topic of study, why this study needed to be conducted, and potential social implications. A background section summarizes research related literature, thus establishing a gap in knowledge that this study addresses. Evidence that the problem this study addressed is emerging to the field of educational technology is shared along with a rationale for the case study research approach. Logical connections are made as to how the information led to the research questions.

Background

Rosen (2009) described how the culture of collaboration affects the workforce and changes the standard of business today toward tomorrow. He explored the significance of collaboration in sparking innovation. An industry inclination is to establish simultaneous work environments towards an enhancement of interaction (p. 9). Parts, products, and manufacturing processes can be designed at the same time, rather than designing parts individually and assembling them into an end product. People from multiple functions can be included in developing services and processes. Participation can be simultaneous, instead of passing instructions through levels and functions for others to implement (p. 11). In a survey of 2,800 executives on global innovation, 92 % indicated, “Innovation is the main lever to create a more competitive economy” and 86 % agreed that, “Investing in innovation is probably the best way to create jobs in my country” (Seifter, 2012).

Involvement with the environment happens with all our senses (Steed, 2010). The appeal to offering many interpretations is to enrich understanding. For instance, almost all experience possesses visual-spatial dimensions. Within almost all experiences, learners can utilize visual-spatial dimensions to build knowledge. Steed stated that visual-spatial dimensions necessitate personal perspective to foster imaginative connections for creative thinking. A learning ecology to explore the arts allows an avenue to integrate technology (Steed, 2010). This taps a collective knowledge through collaboration (Hwang, Chu, Lin, & Tsai, 2011).

A new vision is developing of the skills necessary for success in the modern era. The core of the essential skillset for the future is creativity (Americans for the Arts, 2012). Batey (2011) showed creativity as being a vital skill from the level of the individual to the organization as a whole. Along with creativity, it was reported in National Endowment for Science, Technology & the Arts (NESTA) that capabilities sought after for enhanced workforce innovation are organizational culture, leadership, and value (Patterson, Kerrin, Gatto-Roissard, & Coan, 2009). Despite the growing need to foster creative thinking for an innovative workforce, best practice implementation has not been determined. The avenue for attainment seems to be a significant challenge (Patterson et al., 2009).

Phillips (2012) listed 10 skills children learn from the arts. She explored leadership skills taught through the arts and explained why learners need these skills to succeed in business. Among the skills are creativity and collaboration. Along with the other eight listed, these skills are crucial as they help develop integrity of character, which employers are seeking. Innovation requires an ability to constantly adapt to change. Phillips (2012) emphasized creative thinking skill development as promoted through arts education.

A broad societal and educational problem that needs addressing is the lack of understanding for the value of art in education. Through integration with the arts, STEM subjects may benefit from diversifying knowledge domains to create more ideas (Lovell, 2011). E-textiles have shown promise as a new way to introduce STEM to students in such a way that can broaden the appeal of engineering (Lovell & Buechley, 2010).

The potential development of collaborative and creative thinking skills through the design of wearable technologies needed exploration to determine the value of the arts through facilitated technological projects. Research on student and teacher perceptions regarding collaborative and creative thinking skill development through facilitated technological projects was not evident, confirming that a gap in research existed. Integration with the arts offers the opportunity to increase creativity and innovation across the workforce.

Problem Statement

The perception of many school administrators is that desired skills are not lessened or harmed through the elimination of the arts (Americans for the Arts, 2012). Mandated, standardized tests in mathematics, reading, and language arts are conducted each year (West & Bleiberg, 2013) focusing schools on strengthening scores in these subjects. The result of an increased focus on these assessments meant less support for the arts. The principal benefits to studying the arts needs to be addressed (Linton, 2009). In fact, Linton (2009) stated a “silo effect” in learning and the isolation it causes goes against human nature. Linton indicated that learner collaboration with others and ideas from different disciplines can increase knowledge and creativity leading to more productive and effective results.

Storksdieck (2011) provided two key arguments for increased arts in education. The first point discussed art as a means of knowing and learning. He proposed that art provides a useful tool to individuals challenged to make outcomes and products more interesting and valuable. The study indicated that art offers a different way of seeing the world leading to a broader understanding. Storksdieck stated that art affords a way to open minds and offer an avenue to creativity (2011). He claimed that the arts add value to understanding concepts beyond limited disciplines. The findings supported art-infused learning allows understanding and application of concepts toward other endeavors.

Further findings indicated many connected their art explorations with their scientific creativity. Root-Bernstein (2011) demonstrated links between people who became Nobel laureates because of their works in the sciences and engagement in the arts. The 1968 Nobel Prize for Physics was won by Luis Alvarez. The ability to utilize visual-spatial dimensions for constructing his visions gained Alvarez his success (1987). Einstein’s creative thinking ability is attributed to his improvisational talent with musical instruments. As Einstein put it, “The theory of relativity occurred to me by intuition, and music is the driving force behind this intuition. My parents had me study the violin from the time I was six. My discovery is the result of musical perception” (Suzuki, 1969, p.

90). Einstein credited many of his greatest scientific discoveries to musical thinking (Root-Bernstein & Root-Bernstein, 2013).

In addition, multiple studies have identified positive connections between the arts, creativity, and workplace readiness. A survey administered to 244 executives and superintendents found that companies were looking for employees that display creativity (Lichtenberg, Woock, & Wright, 2008). Results indicated that companies want employees who can identify problems and new patterns, integrate knowledge across fields, are original, and possess basic curiosity (Lichtenberg et al., 2008). However, most schools and employers provided little relative education and training. Employers want collaborative and creative thinking skills that they assume schools provide to learners (Apollo, 2012). Seventy-two percent of business leaders polled listed creativity as one of the five most important applied skills wanted in new hires (Lichtenberg et al., 2008).

In summary, the arts are important to the future of workforce success toward innovation. Steve Jobs, creator of Apple, attributed his ability to link technology with creative thinking and artistic design (Wynn & Harris, 2012). If there are arts providing opportunities toward the development of skills employers are looking for, then the value of arts in curriculum needs to be reinstated and increased (Baker, 2012). Research was needed to explore how students and teachers perceive collaborative and creative thinking skills are developed as a result of the artistic design of wearable technologies through art-technology projects.

Purpose of the Study

The purpose of this qualitative case study was to explore student and teacher perceptions on how engagement in digital artistic design of wearable technologies affects collaborative and creative thinking skill development in learners.

Research Questions

1. What are students' perceptions regarding the development of creative thinking skills while designing wearable technologies?
2. What are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?
3. What are students' perceptions regarding the development of collaborative skills while designing wearable technologies?
4. What are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?

Conceptual Framework

The conceptual framework included Jonassen's (1996) model using Mindtools for conceptual change and Rosen's (2009) culture of collaboration. Conceptual frameworks supportive of constructivism suggest using student-centered, technology-supported, problem-based learning environments with open-ended solutions. Jonassen's modeling using Mindtools for conceptual change is useful in explaining the research questions because participants consider knowledge expanded through connections, inquiry, and reflection in spite of institutional challenges and opportunities.

Mindtools are defined by Jonassen (1996) as learning environments designed with technology that adapts to function intellectually with learners. During the construction of knowledge a Mindtool serves as a cognitive tool. Cognitive technology tools are emphasized in inquiry frameworks (Jonassen & Reeves, 1996, p. 700). Jonassen further explained:

> Constructivist-learning environments provide a question or issue, a case, a problem or a project that learners will attempt to solve. Ownership of the problem or learning goal is the key to meaningful learning. Students must be provided with interesting, relevant, and engaging problems to solve. (p. 718)

A constructivist-designed learning environment was found by Jonassen to support learning through the active creation of knowledge across domains. A Mindtool provides learning within a context-rich, experience-based activity that builds knowledge through construction.

The objective in designing constructivist-learning environments is skill development through problem solving. These environments are intended for open-ended solutions requiring knowledge gained across multifaceted domains (Reigeluth, 1983, p. 216). Jonassen's theory values problems that are owned by the learner. Learner engagement toward ownership of a problem is built through relevant interests. A context-rich, visual-spatial environment that engages learners through knowledge construction provides an instructional design that is both active and authentic. Building representative examples enables reasoning and cognitive flexibility. The constructivist-learning environment design should offer meaning making through information. Cognitive tools that support skill development toward problem solving, modeling, and knowledge building should be included in learning environments (Hirumi, 2005). Social conversation and collaboration tools support discourse in the learning community for knowledge building and sharing.

Constructivist-learning environment design supports knowledge building by modeling performance and cognitive processes. Instructional activities coach learning by providing motivation, monitoring, and reflective opportunities. The constructivist-learning environment design supports knowledge building by adapting to learner level. Five elements were identified to support such instruction from determining a common goal, continual assessment, active and authentic information avenues, communication, to adjustments in responsibility (Puntambekar & Kolodner, 2005). A Scaffolding Connected Knowledge Framework (SCKF) for problem-based learning environments was proposed as supportive to open-ended solution activities (Jacobson, 2008). Another framework was proposed to examine technological scaffolding to aid in problem solving, which included ‘‘task understanding and planning, monitoring and regulation, and reflection’’ (Quintana, Zhang, & Krajcik, 2005, p. 237). Constructivist learning theory suggests that assigning students to design wearable technologies using collaborative and creative thinking skills will facilitate the development of decision-making, problem solving, and communication skills.

Everyday attire embedded with electronic programmable components is known as e-textiles, wearable technologies, or smart clothing (Olsson, 2012, p. 6). This merger enables computing, digital components, and electronics to be incorporated through the design of wearable technologies. These e-textiles become intelligent clothing or smart clothing. Examples include touch buttons that are constructed using a sensor and conductive thread, which are then activated to control programmable elements such as LEDs mounted on clothing to form displays (p. 11). Through this construction, students build knowledge from experiences during the learning, not solely from prior facts.

Rosen (2009) concentrated his research on the relationship of culture, environment, and technology to support collaboration. The culture of collaboration dissolves the obstacles of time and space, produces outcomes, and generates value. These benefits require an understanding of the possibilities and the impossibilities of tools involved. Rosen defined collaboration as "working together to create value while sharing virtual or physical space" (p. 9). A few individuals with a common goal, engaging through collaboration, create added value to something (p. 10).

Technological, economic, and cultural trends have changed the ways people collaborate. Rosen explained what he calls rich, real-time collaboration: "Rich, real-time collaboration lets people with a variety of skills and talents in multiple fields and functions come together spontaneously and create value" (2009, p. 22). This creates a group ability to build upon energy heightened by the culture of collaboration (p. 70).

Companies today are seeking this shared creation of value. Enhanced value is created when collaboratively designing products concurrently. The economic trend is to search for the best talent at the best price, regardless of geography. As organizations explore globalization, the desire to innovate and build value drives the need to collaborate (Fawcett, Jones, & Fawcett, 2012).

Organizations are driven by technology, progress, and the need to share information. In this global economy, collaboration is important and has become an essential norm (Rogers-Brown, 2010). Groups are working synchronously and/or asynchronously, virtually and/or face-to-face on tasks. Sharing experiences speeds up the design process. This is of benefit to the organization as concerns can be resolved quicker. An important characteristic of collaboration is the tools used to enable progress. Effective collaboration can produce many benefits for individuals or organizations. The collaborating group needs a common goal. The group must be made up of people with appropriate skills. Individuals need readily accessible and applicable resources, and an environment conducive to collaboration (Rogers-Brown, 2010).

Constructivism is an educational theory that suggests learning is the building of knowledge structures (Jonassen, Carr, & Yueh, 1998). A key issues coming out of this theoretical stance is that learners construct their own knowledge. Jonassen (1998) believed that the opportunities for pedagogic design are far more interesting for the future because emerging technologies have extended opportunities for learning. Opportunities to solve problems are provided and built upon in a constructivist-designed learning environment (1998, p. 215). Authenticity and motivation toward solving a problem is the key to student owned learning.

Knowing this, Jonassen (1996) specialized in taking knowledge from unrelated fields, using technology, and applying it to information being learned. He discussed ways that Mindtools enhance learning to engage interactivity toward willingness to build on knowledge. Using computers, he transformed constructivism theory to include technology in ways previously inconceivable. Constructivism builds upon prior knowledge and experiences. He believed Mindtools enhance collaborative and cooperative efforts in the learning community. Jonassen believed accomplishing this necessitated intertwining instructional design with various instructional technologies.

To solve complex problems, a collaborative diverse group of individuals offers a greater knowledge base of perspectives (Rosen, 2009). Solutions may be seen completely differently from one individual to the next. Building on collective knowledge, differences are beneficially highlighted through collaboration adding value to a group solution. Bringing people together simultaneously to share spontaneous input solves problems through more efficient decisions (Rosen, 2009). If individuals perceive belonging to a collective knowledge, the likelihood of creating value through a collaborative tool is increased (p. 12).

Anticipating all of the solutions to a problem is not possible due to individual differences in backgrounds, knowledge, and imagination. Wearable technology provides opportunity to innovate on a personal platform. This relates to new kinds of value-added that fulfills individual needs. Rosen (2009) defined the culture of collaboration as "working together to create value while sharing virtual and physical space" (p.9). He explained that collaboration is central to creating wealth. People working collaboratively achieve greater success than individuals working alone. This led to the last two research questions for this study and helped the development of the interview questions (Appendix A) on how teachers and students perceive collaborative skill development when designing wearable technologies.

Through the designing of wearable technologies as the Mindtool, collaborative and creative thinking skill development can be explored. Wearable technologies allow for the embedding of built-in electronic programmable components with everyday attire (Hwang, Shi, & Chu, 2011). Emerging technologies involving mobile and wireless devices have opened new opportunities for learning in which students combine their non-digital real-world with digital-world activities. This allows sharing of knowledge or experiences with others through collaborative skill development. These opportunities promote creative thinking. This study proposes the design of wearable technologies as the Mindtool for innovative ubiquitous learning. Jonassen's (1996) idea of Mindtools guided the design of research questions 1 and 2 and helped determine the interview questions (Appendix A) to collect data on how students and teachers perceive development of creative thinking when designing wearable technologies.

Nature of the Study: Qualitative Case Study

The qualitative case study design provided a means of gathering teacher and student perceptions about collaborative and creative thinking skill development through the design of wearable technologies. This study was designed to explore student skill development experiences in a particular classroom rather than to evaluate the constructivist-learning environment. This design allowed the researcher to explore individual experiences, from simple to complex learning, relationships, communities, or activities. The approach permitted deconstruction and reconstruction of various phenomena (Yin, 2011). Qualitative case study research is consistent with developing an understanding of how students approach the work of designing wearable technologies and its influence on collaborative and creative thinking skill development. This research study derived a deep, rich interpretation of a single case set in a real-world context of a classroom. The purpose was to produce an invaluable and deep understanding of the collaborative and creative thinking skill development resulting in new learning and its meaning. This was an exploration of a particular phenomenon set within a real-world classroom context, "when the boundaries between phenomenon and context are not clearly evident" (Yin, 2009, p. 18). My study explored whether students engaged in wearable technology design developed collaborative and creative thinking skills. Data were collected from teacher and student interviews as a means to finding out perceptions of collaborative and creative thinking skill development through the design of wearable technologies.

A homogeneous study on perceived collaborative and creative thinking skill development through the design of wearable technologies with teachers and students was undertaken. The conceptual framework involved an interpretation of constructivism with Mindtools (Jonassen, 2005) and a culture of collaboration (Rosen, 2009) as the foundations for the exploration of skill development. The research included Skype or telephone audio-recorded interviews as the data collection technique. Also examined were participant shared artifacts of art-technology collaboration and creative thinking.

The method of data analysis included descriptors of collaborative and creative thinking skill development. Data collected included Skype or telephone audio-recorded teacher and student interviews. Additional Skype or telephone audio-recorded teacher follow-up interviews were based on reflections from all previous participant responses.

Analysis involved selections from the initial teacher and student Skype or telephone audio-recorded interviews, and teacher follow-up selections to add validity to interpretations. From the interviews and artifacts, a coding system was developed to determine rich themes and patterns through the analysis of data. Perceptions of big ideas about collaborative and creative thinking skill development through the design of wearable technologies were grouped. The organization of data collected helped explain how to enhance learner skill development in these two areas. Investigations included teacher and student Skype or telephone audio-recorded interviews, with additional teacher follow-up Skype or telephone audio-recorded interviews based on the analysis of responses from all previous participant interviews.

Acknowledging multiple possibilities in qualitative case studies involves distinguishing various perceptions (Yin, 1994). To interpret shared experiences explored for research, a case study approach was chosen. Rich detail from the depth of context is possible when a focused number of similarly shared experiences are analyzed. Yin stressed that data collected from multiple sources provides opportunity to consider a variety of perspectives (1994). I analyzed collected data to determine key patterns and themes.

Definitions

Collaboration: “Working together to create value while sharing virtual and physical space” (Rosen, 2009, p. 9).

*Creative Thinking: “*Going beyond accepted knowledge to generate new knowledge” (Jonassen, 1996, p. 237).

*E-textile: "*Designing of programmable garments, accessories, and costumes that incorporate elements of embedded computing, novel materials, sensors, and actuators, in addition to traditional aspects of fabric crafts" (Kafai & Peppler, 2011, p. 25).

*Mindtool: "*Computer-based tools and learning environments adapted or developed to function as intellectual partners with the learner in order to engage and facilitate critical thinking and higher order learning" (Jonassen, 1996, p. 9).

*Wearable Technology: "*Having to do with the combining of fashion and technology, wearable technologies are technology-enhanced garments or pieces of technology that can be worn on the body" (Olsson, 2012, p. 5).

Assumptions

1. Participants perceive and develop strategies to develop collaboration and creative thinking skills similarly to others in different locations.
2. A limited, bounded study is essential to acquire the depth and description of the perceptions from the participants.
3. Participants will interpret each interview question similarly and the interview stimulus will be equally presented to the participants (Mishler, 1991, p. 5).
4. Teachers and students will participate willingly and respond honestly to the interview questions.

Scope and Delimitations

The purpose of this qualitative case study was to discover student and teacher perceptions on how engagement in digital artistic design of wearable technologies affects collaborative and creative thinking skill development in learners. Collaborative and creative thinking skill development research as it relates to technological art or wearable technologies is limited. This study explored the impact of designing wearable technologies on collaborative and creative thinking skill development as perceived by teachers and students. As this was an exploration into the effects of the inclusion or elimination of arts in education, the exploration is restricted by certain criteria in order to discover relevant perceptions regarding collaborative and creative thinking skill development while designing wearable technologies. A sample of two teachers and eight students who participated in a wearable technology integrated curriculum in a Rocky Mountain state was the population from which participants were drawn for this study. Certain criteria directed purposeful sampling to teachers and students who were involved in a wearable technology integrated curriculum. Participants were residents of a Rocky Mountain State.

Transferability of the results from this study may affect future educational decisions toward wearable technologies as an integrated curricular art and STEM practice. The information added to the field from this study will share perceptions from a certain group on collaborative and creative thinking skill development through design of wearable technologies. As the study participants were in an educational setting, relevance of the findings may be relatable to other similar institutions. Insights from this study may also help to develop educational policy by informing upon the value of arts. The scope is delimited to teachers who are self-directed in their teaching practice to connect learners with wearable technology design and their students. To meet the study's criteria, teachers were invited to participate who offered to students an integrated curricular experience designing wearable technologies. An exploration into the perceptions of teacher and student participants supported further understanding of the skill development of collaboration and creative thinking. This study explored attributes of the identified gap for workforce preparation purposes of collaborative and creative thinking skill development.

Limitations

Case studies, by definition, are not generalizable. Inferring a generalization from case study results is cautioned against by Yin (2009) stating, "cases are not 'sampling units' and should not be chosen for this reason" (p. 38). The results of this study, therefore, are of greatest use to those in the educational and business community who may choose to transfer the findings to their environment.

Limitations may arise when the collected data, determined themes and patterns, and interpretations are analyzed. The possibility exists that "everyday contextual understandings are reintroduced" (Mishler, 1991, p. 5). Other limitations may be found due to inconsistencies in individual opinions and the environment of qualitative research that is "exploratory and inductive in nature" (Trochim, 2006, p. 20). This study's primary limitation was the specific criteria chosen to select participants. Due to the narrow population of participants available for the study, results may not be transferable beyond the specific population from which the sample is drawn.

The importance of incorporating "correct operational measures for the concepts being studied" was documented by Yin (1994). Processes successfully implemented in previous comparable studies should be repeated where possible. Familiarization with the participating environment should be achieved before any data collection begins. Preliminary documents and consulting communications will build familiarization.

The results of this study could advocate social change in other areas to promote understanding of the value of art in education. Due to the narrow participant selection, transferability of results to a similar institution may not be feasible. However, the findings may indicate necessity for further studies. For this study, the concentration was on the depth of data analyzed from the perceptions of the participants (Moustakas, 1994).

An additional limitation was that only teacher and student perceptions were included in the data collection for this study. Additional possibilities for data could aid in building a more comprehensive knowledge of the participants. Further interviewing with parents or peers could provide more perceptive insights regarding development of collaborative and creative thinking skills. However, such additions could also diminish clearer findings from the experience of selected participants. A rich description provided by a narrower population could promote transferability with a more significant sampling. Demographic information beyond what is shared through Skype or telephone audio-recorded interviews was not collected, but may yield implications. These interviews were completed remotely and, aside from gender, no knowledge of socioeconomic status or ethnicity was gained.

Significance

The results of this study provided much-needed insights into collaborative and creative thinking skill development through the design of wearable technologies in the art curriculum. New knowledge was added to the field of educational technology by determining additional value offered through exploration of this artistic aesthetic endeavor toward employer-sought skills for future workplace pursuit. The national push to engage students in the exploration of science, technology, engineering, and math may be enhanced with the continued and reinstated inclusion of artistic integrations that strengthen the STEM curriculum. This may advance practice and policy in educational technology by clearly indicating the value of the arts in STEM. The high stakes testing focus is driving budget-cutting decisions. Insights from this study may aid in decision making for school budgets to include the arts or integrate the arts through other aspects within existing curricula if it is shown that the design of wearable technologies adds value to skill development of collaborative and creative thinking.

Positive social change that might be brought about is enhanced substantially through the design of wearable technologies. Global economic needs in demand for future innovation and success may be better addressed with the results from this study. Education is a force for social change by addressing the needs of future employers. Because the global economy is seeking these skills, supporting student attainment of collaborative and creative thinking skill development is important. If the arts are facilitating the development of these skills that employers are assuming schools are providing, then the value of arts in curriculum needs to be reassessed and the arts reinstated and increased in public schools.

Summary

This study is unique because it addressed a societal issue to find out if curriculum enhanced through designing of wearable technologies develops collaborative and creative thinking skills in learners. The integration of Mindtools such as the design of wearable technologies in constructivist-learning environments could lead toward global economic success. If it can be shown that the designing of wearable technologies as a Mindtool impacts developmentally on the learning of collaborative and creative thinking skills, then findings from this study may enhance decisions to expand and implement the arts into STEM areas.

The designing of wearable technologies affords educational opportunity for students to develop collaborative and creative thinking skills otherwise significantly unavailable for a number of reasons. What is known about the designing of wearable technologies as a Mindtool seems specific toward outside of school experiences. A significant gap exists in how classroom learners in an integrated curricular experience respond to this Mindtool. To clearly realize the potential possible through such an art, participants were interviewed to determine what perceptions they have about their development of collaborative and creative thinking skills through the design of wearable technologies.

Chapter 2 is organized around a review of research in four sections: (a) an analysis of the conceptual framework based on Jonassen's (2006) modeling using Mindtools for conceptual change and Rosen's (2009) explorations in collaborative culture changing business models, (b) research on workforce preparedness and the nature of creativity, (c) research on development of collaboration and creative thinking in other curricular areas, (d) research on collaboration and creative thinking through art. From this literature review, research questions were designed to focus this inquiry on the specific

Mindtool of wearable technology design. A literature search strategy description is also provided to allow for future duplication of this study. The chapter summary synthesizes studies related to the research questions, highlighting gaps, and why the approach selected is meaningful.

Chapter 2: Literature Review

The purpose of this qualitative case study was to discover student and teacher perceptions on how engagement in the digital artistic creation of wearable technologies affects the development of collaborative and creative thinking in learners. These results address whether the arts should be reinstated, included, or increased within STEM education. This literature inquiry provides an invaluable and deep understanding on the development of collaborative and creative thinking skills resulting in new learning about real-world behavior and its meaning. New knowledge has been added to the field of educational technology by determining the value gained through the creation of wearable technology toward employer sought skills for future workplace pursuit.

Involvement with the environment happens with all our senses (Steed, 2010). The appeal to offering many interpretations is to enrich understanding. For instance, spatial dimensions are in most experiences (2010). Those experiences can build knowledge toward collaborative learning. Steed stated that visual-spatial forms of expression require inquiry and critical perspective to foster innovative insight and understanding. A learning ecology uses a dimensional environment integrated with technology to explore the arts as part of the natural world. (Nardi & O'Day, 1999; Zhao & Frank, 2003). Brown described this as an "open, complex, adaptive system comprising elements that are dynamic and interdependent" (2000, p. 19), where Barron defined a learning ecology as the "set of contexts found in physical or virtual spaces that provide opportunities for learning" (2006, p. 195). Learning is interpreted through a collaborative collective knowledge building environment (Lin, 2011).

Each of the three global editions of the New Media Consortium Horizon Report (2013) – higher education, K-12 education, and museum education – emphasizes six emerging technologies expected to find mainstream use over the next 5 years. On this list of emerging technologies, set at 4 or 5 years away, is wearable technology (p. 5). Wearable technology is referred to as the integration of devices and related electronics into clothing and accessories (p. 32). An increasing array of wearable technology has become available, hinting at the potential for teaching and learning, though there remains to be seen many concrete education examples (p. 6).

The focus of this study provides research into the design of wearable technologies as a Mindtool for conceptual change to consider its impact on the development of collaborative and creative thinking skills in learners. In addition, the research may support educators' adoption, implementation, and practice of modeling with technology. Stakeholders may use these research findings to plan professional learning driven by the desire to develop collaborative and creative thinking skills.

Chapter Organization

Chapter 2 is organized into four sections: (a) an analysis of the conceptual framework based on Jonassen's (2006) modeling using Mindtools for conceptual change and Rosen's (2009) explorations in collaborative culture changing business models, (b) research on workforce preparedness and the nature of creativity, (c), research on the development of collaborative and creative thinking in other curricular areas, and (d) research on collaborative and creative thinking through art. The findings of the literature review were used to design research questions that focused this inquiry on the possibility of wearable technology design as a Mindtool to develop collaborative and creative thinking skills.

Literature Search Strategy

Relevant literature of both digital and printed material from the last 5 years, from varied resources and research databases was reviewed. Dawidowicz (2010) stated that to build academic rigor, framing questions to locate current and related literature might be necessary to successfully narrow the topic. The searches were designed with the research questions as the primary focus.

I accessed the following databases through Walden University's Thoreau Library as part of this search: ABI/INFORM, ACM Digital Library, Academic Search Complete, Academic Search Premier, Business Source Complete, Computers and Applied Sciences Complete, Dissertation and Theses Database, EBSCOhost, Education Resource Complete, ERIC, IEEE Digital Library, ProQuest, ProQuest Central, PsychINFO, SAGE, ScienceDirect, and the Thoreau Multiple Databases tool. Current peer-reviewed scholarly journals were searched using the above databases and Google Scholar. Beyond these resources, a variety of online and printed peer-reviewed journals and relevant field publications were explored for current information relating to skill development in the arts: *Arts Education*, *American Educational Research Journal*, *THE Journal*, and *Educational Researcher*. Journals were confirmed as peer reviewed using Walden University's Thoreau Library services included access to Ulrich's Periodicals Directory.

Through discoveries of relatable information, adjustments to search terms and limiters became necessary to locate additional literature. Search terms included the following keywords: *technology, collaboration, teamwork, cooperation, creative thinking, e-textiles, wearable technology, Mindtools, culture, constructivism, entrepreneurship, workforce, leadership, aesthetic, cognitive tools, David H. Jonassen, Evan Rosen, Maxine Greene, John Dewey, experiential learning, inquiry, learning-by-doing, art, education, problem-based-learning, authentic, conceptual change, business models, innovation, 21st century learning, wearable computing, human-computer interaction, smart textiles, modeling, fashion, digital design, electronics, circuitry,* and *programming.* The search terminology evolved as new keywords, combinations, truncations, roots, and different perspectives were discovered. Some of these added search terms were: *student attitudes, arts education, technology education, creativity, digital arts, Internet, active learning, constructiv*, collaborat*, cooperative learning, team learning, problem solving, electronic textiles, electro textiles, wearable comput*, smart clothing, smart clothes,* and *smart fabrics*. Lists of term strings were also explored as search points: *e-textiles* or *electronic textiles* or *electro textiles* or *wearable comput** or *smart textiles* or *smart clothing* or *smart clothes* or *smart fabrics, art education* or *technology education* or *digital arts,* and *collabor** or *cooperative learning* or *teamwork* or *team learning.*

Conceptual Framework

Maxwell (2005) explained conceptual frameworks as a blend of a researcher's wisdom and experiences. This study's conceptual framework included Jonassen's (2006) modeling using Mindtools for conceptual change and Rosen's (2009) culture of collaboration. These theories were used to build a comprehensive interpretation as to the value for art education to include a Mindtool (Jonassen, 2006), such as the design of wearable technologies, as well as the benefits perceived to enable learner success. Constructivist-learning environment design as it relates to Mindtools was used to explain the development of collaborative and creative thinking skills when students are engaged with the design of wearable technologies.

To shape an understanding of collaboration, Rosen’s theory (2009) on the culture of collaboration was used to categorize the needs facing workforce success. Individuals simultaneously make decisions to solve problems more efficiently (p. 2). Today, information can be gathered, exchanged, and interacted with whenever, wherever, and however desired. The culture of collaboration allows primary source information on demand with analysis of the implications in real-time with others of similar interest.

Rosen’s (2009) assumptions on the culture of collaboration and Jonassen’s (1996) work on Mindtools highlight technology as a cognitive tool that provides insight into the interpretations of each participant. These theories guided the design of research for this study. Maxwell (2005) cautioned relying too much on relevant literature might sway the analysis of a study. The theories used as a framework for this study helped with the identification of themes and patterns.

Jonassen: Mindtools for Conceptual Change

Harvard University’s Project Zero researchers suggested that conceptual frameworks based in constructivism are increasingly understood to steer the design of technology-integrated, student-centered learning environments for open-ended problem solving pursuits (Cleaver, 2013). Constructivist-learning environment design was useful in explaining this study's research questions because participants were asked to consider knowledge expanded through connections, inquiries, and reflections. Inquiry frameworks highlight technology as a cognitive tool (Jonassen & Reeves, 1996, p. 700). Jonassen further explained:

> Constructivist-learning Environments provide a question or issue, a case, a problem or a project that learners will attempt to solve. Ownership of the problem or learning goal is the key to meaningful learning. Students must be provided with interesting, relevant, and engaging problems to solve. (p. 718)

Multifaceted opportunities to perceive and interpret authenticity support the learning process by actively creating knowledge through integrated experiences. (p. 710). These experiences build knowledge through construction. This study focused on a particular case. The phenomenon Jonassen saw as enabling knowledge construction in a specific context was explored through the design of wearable technologies.

Skill development through problem solving is the objective in designing constructivist-learning environments. These environments are intended for open-ended solutions requiring knowledge gained across multifaceted domains (Reigeluth, 1983, p. 216). Learner engagement toward ownership of a problem is built through relevant interests. The problem should be interesting, relevant, and engaging to foster learner ownership (Jonassen, 1999). The constructivist-learning environment and instructional design should address context, representation, and space to facilitate knowledge construction and meaning making. Cognitive tools that support skill development toward problem solving, modeling, and knowledge building should be included (Hirumi, 2005).

The constructivist-learning environment design should offer applicable and easily accessible information. Social conversation and collaboration tools will support discourse in the learning community for knowledge building and sharing.

A constructivist-learning environment design supports learning by modeling performance and cognitive processes. Instructional activities coach learning by providing motivation, monitoring, and reflective opportunities. The constructivist-learning environment design should support knowledge building by adapting to learner level. Five elements were identified to support such instruction from determining a common goal, continual assessment, active and authentic information avenues, communication, to adjustments in responsibility (Puntambekar & Kolodner, 2005). A Scaffolding Connected Knowledge Framework (SCKF) for problem-based learning environments was proposed as supportive to open-ended solution activities (Jacobson, 2008). Another framework was proposed to examine technological scaffolding to aid in problem solving, which included ‘‘task understanding and planning, monitoring and regulation, and reflection’’ (Quintana, Zhang, & Krajcik, 2005, p. 237).

When students apply skills toward decision-making, problem solving, and communication through the design of wearable technologies, collaborative, and creative thinking skills may develop. Embedding electronic programmable components into everyday attire is known as e-textiles, wearable technologies, or smart clothing (Olsson, 2012, p. 6). This merger enables computing, digital components, and electronics to be incorporated through the design of wearable technologies. These e-textiles become intelligent clothing or smart clothing. Examples include touch buttons that are constructed using a sensor and conductive thread, which are then activated to control programmable elements such as LEDs mounted on clothing to form displays (p. 11). Students build knowledge from experiences during the learning, not solely from prior facts.

According to Wagner, when a learner's role is that of designer, tools are utilized effectively for interpretation to support knowledge building (2012, p. 142). "Technologies should not support learning by attempting to instruct the learners, but rather should be used as knowledge construction tools that students learn with, not from" (Jonassen et al., 1998, p. 1). Therefore, to assist learners in interpreting knowledge in a constructivist-learning environment, it is important to offer Mindtools. Jonassen (1999) described Mindtools as "a way of using a computer application program to engage learners in constructive, higher-order, critical thinking about the subjects they are studying" (p. 9). To cope with this problem, this study investigated the design of wearable technologies as a Mindtool for learning, based on the constructivist approach, to determine whether creative thinking and collaborative skills are enhanced by the activity. Design of wearable technologies is an innovative learning activity (Kafai & Peppler, 2011).

The use of several Mindtools such as databases, spreadsheets, computer conferencing, hypermedia construction, and micro world environments have been demonstrated as effective constructivist-learning models (Jonassen et al., 1998). Mindtools have shown effectiveness in some practical applications. The Mindtool of a concept map was used in a study for context-aware knowledge building (Hwang et al., 2011). As stated by Trochim, “concept mapping is a structured process, focused on a topic or construct of interest, involving input from one or more participants, that produces an interpretable pictorial view of their ideas and concepts and how there are interrelated” (2006). This practical application of a Mindtool required visual connecting of knowledge using a computer-based tool to draw. The concept mapping represented a spatial interpretation of idea building from existing knowledge (Jonassen, Beissner, & Yacci, 1993). As noted by Jonassen et al. (1998), a Mindtool can be used to support learners to experience creative thinking necessary for meaningful learning.

Robotics is thought to be an approach to educational technology that fits constructivism. During the process of robotics study, learners explore problems through design, creative thinking, manipulation, reflection, and collaboration (Mikropoulos & Bellou, 2013). Mikropoulos and Bellou think that the educational contribution becomes more effective when an approach to constructivism involves cognitive tools or “Mindtools” as proposed by Jonassen (2000). The Mindtool of robotics engages the learner to build a physical object while problem solving (Chambers & Carbonaro, 2003). Mikropoulos and Bellou found positive learning results from two case studies on physics and programming teaching. Their findings indicate that educational robotics can be used as Mindtools supporting knowledge construction through the design of meaningful authentic projects. In this study of educational robotics as Mindtools, learning is by doing in both the virtual and real world, facing cognitive conflicts and knowledge building by reflection and collaboration.

Constructivism is an educational theory that suggests learning is the building of knowledge structures by the learner through interaction with the environment (Jonassen et al., 1998). A key issue coming out of this theoretical stance is that learners learn best when they construct their own knowledge. Jonassen (1998) believed that the opportunities for pedagogic design are far more interesting for the future because emerging technologies have extended opportunities for learning. Opportunities to solve problems are provided and built upon in a constructivist-designed learning environment (1998, p. 215). Authenticity and motivation toward solving a problem is the key to student owned learning.

Jonassen (1996) specialized in taking knowledge from unrelated fields using technology, and in applying it to information being learned. He discussed ways that Mindtools enhance learning to engage interactivity toward willingness to build upon knowledge. Using computers, he transformed constructivism theory to include technology in ways previously considered inconceivable. Constructivism builds upon prior knowledge and experiences. He believed Mindtools enhance collaborative and cooperative efforts in the learning community. Jonassen believed accomplishing this necessitated intertwining instructional design with various instructional technologies. Through his substantial body of learning research, Jonassen believed Mindtools enhance collaborative and cooperative efforts in the learning community, but his studies focused on semantic organization tools (1996, p. 25).

Through the designing of wearable technologies as the Mindtool, collaborative and creative thinking skill development can be explored. Wearable technologies allow for the embedding of built-in electronic programmable components with everyday attire (Hwang, Shi, & Chu, 2011). Emerging technologies involving mobile and wireless devices have opened new opportunities for learning in which students combine their non-digital real-world with digital-world activities. This allows sharing of knowledge or experiences with others through collaborative skill development. These opportunities promote creative thinking.

This study proposed the design of wearable technologies as an innovative Mindtool for learning. Jonassen's (1996) idea of Mindtools guided the design of research questions 1 and 2 to discover how students and teachers perceive development of creative thinking when designing wearable technologies. The concept of Mindtools was used as a guide to develop interview questions to collect data based on inquiry of these research questions. The methodological approach of a qualitative case study allows for the focus to be on the situation rather than on individual experiences.

Creative thinking is associated with interpretation of life experiences in an imaginative way (Zande, 2011). Skill development is accomplished through perception, and manipulation of elements through a problem solving process (Kafai & Peppler, 2011). Creative thinking is developed when a concept is designed in a context that inspires the learner (Steed, 2010). Wearable technology involves reflecting on the manipulation of elements to create a cultural message. The development of creative thinking requires a problem solving process using a combination of technical skill and motivation toward solution. Jonassen (2011) explored problem-based learning environments and found knowledge building required collaborative and creative thinking for problem solving.

Mishra and Henriksen (2012) explored how to rethink technology and creativity in the 21^{st} century. In the examination of "in-disciplined learning" (p. 19), they discussed findings and research conducted in the field of creativity. According to their study, "in-disciplined learning" occurs when creativity happens in a discipline, or within content. The conclusion supported open-ended, action-oriented instruction that allows students to incorporate technology, creativity, collaboration, and problem solving.

Rosen: Culture of Collaboration

Rosen (2009) concentrated his research on the relationship of culture, environment, and technology to support collaboration. The culture of collaboration dissolves the obstacles of time and space, produces outcomes, and generates value. These benefits require an understanding of the possibilities and the impossibilities of the tools involved. Rosen defined collaboration as "working together to create value while sharing virtual or physical space" (p. 9). It takes a few individuals with a common goal engaging through collaboration to create added value to something (p. 10).

Technological, economic, and cultural trends have changed the ways people collaborate. Rosen explained what he calls rich, real-time collaboration: "Rich, real-time collaboration lets people with a variety of skills and talents in multiple fields and functions come together spontaneously and create value" (2009, p. 22). This is an inherent ability to tap into positive energy that is created by the relationship of the group (p. 70).

Companies today are seeking this shared creation of value. Enhanced value is created when collaboratively designing products concurrently. The economic trend is to search for the best talent at the best price, regardless of geography (Carey, 2008). As organizations explore globalization, the desire to innovate and build value drives the need to collaborate (Fawcett, Jones, & Fawcett, 2012).

Organizations are driven by technology, progress, and the need to share information (Rosen, 2009, p. 7). In this global economy, collaboration is important and an essential norm (Rogers-Brown, 2010). Groups are working synchronously and/or asynchronously, virtually and/or face-to-face on tasks. This is of benefit to the organization as concerns may be resolved more quickly.

A top executive search firm, Egon Zehender (EZI) has internally built cross-border collaboration (Peshawaria, 2011). They eliminated employee competition and encouraged collaboration by not paying any individual selling bonuses or commissions based on fees generated; but rather operated with a single, firm wide, profit center (p. 21). The result of this collaboration effort was effective. During the last decade of economic turmoil, 25 of the largest search firms in the US declined on average by about 30%, whereas EZI's decline was only 7% (p. 22). Furthermore, while the average turnover among partners in the search industry was about 30%, at EZI it was between 2% and 5% (p. 22). Another company, American Express, shows effective collaboration growth as well.

In the 1990's, every employee at American Express was encouraged to work on ideas and projects that could benefit the company in some way with one condition: They had to form a cross-functional team and participate as a team (Peshawaria, 2011). All submitted projects were evaluated each year (p. 22). The company generated numerous process improvements, new revenue or cost-saving opportunities through such self-regulated teams (p. 22). Despite the turmoil during the last decade for the financial industry, both of these companies were proven long-term players. Both attributed a large part of their survival to their strong culture of teamwork and collaboration.

A characteristic of collaboration is the tools used to enable progress. Organizations may utilize collaboration tools, common processes, and systems to reduce geography and time zones barriers. With the expectation of overcoming these obstacles, companies adopt processes, systems, strategies, and tools to enable collaboration. The culture of many organizations does not include collaboration, yet employees are expected to collaborate (Rosen, 2009, p. 3). Effective collaboration can produce many benefits for individuals or organizations. The collaborating group needs a common goal. The group must be made up of people with appropriate skills. Individuals need readily accessible and applicable resources, and an environment conducive to collaboration (Rogers-Brown, 2010).

To solve complex problems, a collaborative diverse group of individuals offers a greater knowledge base of perspectives (Rosen, 2009). Solutions may be seen differently from one individual to the next. Building on collective knowledge, differences are beneficially highlighted through collaboration adding value to a group solution. Bringing people together simultaneously to share spontaneous input solves problems through more efficient decisions (Rosen, 2009). If individuals perceive they belong to collective knowledge, the likelihood of creating value through a collaborative tool is increased (p. 12).

Anticipating all of the solutions to a problem is not possible due to individual differences in backgrounds, knowledge, and imagination. Wearable technology provides opportunity to innovate on a personal platform. This relates to new kinds of value-added that fulfill individual needs. Rosen (2009) defined the culture of collaboration as "working together to create value while sharing virtual and physical space" (p.9). He explained that collaboration is central to creating wealth. People working collaboratively achieve greater success than individuals working alone.

In a recent international exhibition of "Technosensual," creative thinking for the future was showcased as a collaborative innovation between fashion and technology (NMC, 2013, p. 33). The exhibition brought together a diverse combination of artists and engineers who displayed interactive smart clothing, offering a glimpse into the future of wearable technology (p. 34). Wearable technology has emerged from decades of studies embedded in military, medical, and sports research to inspire the collaborative imaginations of future learners (Berzowska, 2013, p. 171).

Berzowska set up the XS Labs design research studio to concentrate on the emergence of wearable technologies (Berzowska, 2013, p. 171). Interest grew from a concern about the absence of softness in Human Computer Interaction (HCI). Berzowska's aspiration was to explore material properties through the design of physical interfaces. Within a design research environment, innovation often involves the development of new ideas. Material combined with technology steered investigations to new forms and processes (p. 173). This demanded a collaborative approach to fulfill the creative process. The material qualities of constantly emerging components affected knowledge building. This knowledge building brought together research, construction, and design through the development of a culture of collaboration (p. 174).

Skill development and innovation are lacking in learners who find they need better preparation for the future (Partnership for 21st Century Skills Framework, 2013). These skills include collaboration. Obtaining diversity, in learning through collaborative efforts builds respect in contexts that increase global awareness (Patterson, Carrillo, & Salinas, 2011). This led to the last two research questions for this study on perceptions about learner collaborative skill development through the design of wearable technology by students and their teachers. Subsequently, the need for collaboration as a learning and innovation skill helped determine interview questions for data collection to this research study.

Historical Perspective on Workforce Preparedness and the Nature of Creativity

This is a “visual age” (NAEA, 2010). According to the *New York Times Magazine*, a typical individual sees approximately 5,000 images and advertisements a day in addition to the many hours expended on video games, television, devices, or computers (Story, 2007). “The prevalence of visual images and demand for new abilities is transforming the workplace” (NAEA, 2010, p. 3). Corporate and professional fields are not depending on knowledge based abilities, skills, and degrees; rather, they are seeking aptitudes such as creative thinking, imagination, and collaboration. Sclafani, from the Bush Administration’s Department of Education stated, “Corporate leaders in America believe that success is going to depend on a flow of innovative ideas. They [corporate leaders] believe innovative ideas will come because students have the opportunity to engage in the arts" (2010, p. 2). President Obama acknowledged the significance of art education and contends for reinvesting in and revitalizing this attribute of American education for the economy.

The President's Committee on the Arts and Humanities (PCAH) conducted an 18-month study to examine art education. Findings arose, from an abundance of data, reinforcing the advantages of art education in preparing students for workforce demands (2011). The research highlighted the abilities necessary for today's global economy and the value corporate leaders place on these skills (p. 29). "In order to effectively compete in a global economy, business leaders are increasingly looking for employees who are creative, collaborative and innovative thinkers" (p. 30). President Obama expressed concern about the future when he indicated that 10 countries have passed the United States in college completion. It is not that other countries have smarter students; it is that these nations are being smarter about how to teach students (U.S. Department of Education, 2010). Art helps to develop skills and tackle imaginative innovative solutions. Today's business successes, such as desired products created by Apple and the most popular search engine, Google, succeed and grow in this economy due to the creative thinking of their collaborative workforce (Tillander, 2011, p. 44).

Leaders in China have acknowledged the value integration of the arts in order to develop creative thinking (Friedman, 2006). Bronson and Merryman (2010) confirmed the education reform happening in China, where they are replacing the "drill and kill teaching style" with problem-based learning approach. This idea has also been recognized as happening across Europe where countries are making creativity a national priority. 2009 was declared "European Year of Creativity and Innovation" (Bronson & Merryman, 2010). The goal was to heighten appreciation for the value of creative thinking toward innovation to promote development and connect ideas (Europa, 2009). The key message was that creativity and innovation contribute to economic prosperity as well as to social and individual wellbeing. One such event was the "Imagine A New World" photo competition (Creativity and Innovation, 2009). Any and all photographers were invited to share an original work expressing their vision of a "new world." This was an opportunity to deliver their own image of what creativity and innovation means to them for the future.

The Obama Administration revealed its version of NCLB in 2010, the *Blueprint for Reform* (U.S. Department of Education, 2010), to mixed reviews. It seemed to promote a more comprehensive education, even placing the idea in context of today's global economy, stating:

> Students need a well-rounded education to contribute as citizens in our democracy and to thrive in a global economy – from literacy to mathematics, science, and technology to history, civics, foreign languages, the arts, financial literacy, and other subjects. We will support states, districts, school leaders, and teachers in implementing a more complete education through improved professional development and evidence-based instructional models and supports. (p. 4)

Yet, it seems the end result of this blueprint is encouraging of more testing in more subjects more often. Peterson (2010) articulated apprehension that policy energized by "data-drenched obsession" would create learning environments "uninhabitable for young learners and compassionate teachers" (p. 5). As America continues to feed its preoccupation toward testing, other countries test once in elementary, once in middle, and once in high school (Neill, 2010).

The three-year British university model was transformed to a four-year American model in Hong Kong (Gordon, 2012, p. 45). Rather than dictating the added education with specific courses, they highlighted choices through a liberal arts education. The significance of liberal arts education for economic innovation requires consideration of the historical economy based on assembly line thinking in comparison to an economy based on creative thinking. Liberal arts courses are defined as providing information of general cultural concern and being intensely useful to knowledge building. They are academics that are distinct from professional and technical subjects.

Research on college majors in relation to earnings found liberal arts being below most other course concentrations (Gordon, 2012, p. 42). Upon closer inspection, the research showed that while liberal arts subject choices do not usually steer learners straight into high-income jobs, these courses do inspire lifelong learning and professional adaptability – qualities that yield interest long term (p. 42). The liberal arts prompt learners who are encouraged by former successes to develop creative thinking. Learners who develop their creative potential may be more successful and bring distinct value to an organization (p. 47).

In another recent study, findings showed that many learners make insignificant cumulative advancement, with the exception being liberal arts students (Arum & Roska, 2011). It was noted by Arum and Roska, "students majoring in traditional liberal arts fields demonstrated significantly higher gains in critical thinking, complex reasoning, and writing skills over time (p. 205)." As liberal arts students show improvement through advanced learning, they are being prepared to change for new demands in economic environments. They tend to be sought after by employees for work that necessitates life-long learning. With the U.S. unemployment rate at 9% and other countries educational reform efforts showing signs of success, there is a strong financial argument for pursuing liberal arts (Gordon, 2012, p. 42). When discussing the potential value of this choice in education, it is worthy to consider those highlighting its innovative impact, such as Michael Dell, Founder and CEO of Dell, as well as Michael Eisner, CEO of the Walt Disney Company (p. 42).

Jobs and Gates are college dropouts. Each has different thoughts as to the value of their college experiences. Gates' learning experiences at Harvard University included math and computer science but he does not feel the knowledge gained shaped his global perspective (Gates, 2011). Jobs shared his belief that by dropping out of Reid College, he was permitted to "drop in" on courses that impacted his life (Jobs, 2005). These two examples challenge the belief that students select a field as a forecaster to monetary success (Gordon, 2012, p. 44).

The objective of education in a democracy is to prepare caring, sensible, and knowledgeable citizens for future capability. Zande (2011) shared ways that design education develops skills to help students seek creativity for themselves and collaboration with their community. Zande's findings indicated the discovery of benefits to integrating STEM with the arts through a multidisciplinary environment (p. 27). In Zande's study (2011), learners found significance through the exploration of design because it is an integral component of life. The results of his study implied the development of creative thinking through design guides problem solving. This perspective challenges assumptions about existing knowledge and its connection toward what can be imagined. (p. 33). Results confirmed that knowledge had been expected from multiple avenues to make connections, build quality, and solve problems (p. 29). In contrast, subject-area content is taught in segmented and separate classes. Zande concluded that integrating design helps learners to connect experiences toward more comprehensive knowledge building (p. 33).

Social, as well as aesthetic, viewpoints on experience are significant to educational technology (Hausman, Ploof, Duignan, Brown, & Hostert, 2010). Creating and responding to knowledge becomes a standard practice in the cultures of everyday life. Educators should acknowledge these changes and work collectively to encourage creative thinking and collaboration toward challenges. Collectivity involves consensus on shared objectives for the profession and an understanding of a comprehensive education (p. 4).

Educational technology is more than just the use of computers and devices in schools; it is about using technology for learning (Jonassen, 1996). By seeing a bigger picture of learning and technology, an enticing vision for instructional design can be imagined (Eisenberg, 2010). Designing worthwhile activities for children requires attention to details in the bigger picture of a successful future. Details provide learners the environment to develop creative thinking and collaboration, and to cultivate lifelong learning. Opportunities can be created that fit into learning environments and engage meaningful interests in student lives.

Rather than inserting technology into the environments where learners have to be, it might be engaging to offer technologies that can be manipulated that inspire imaginative problem solving (Lovell, 2011). Educational technology can weave challenges into learning environments offering customization with innovative learning opportunities. Those pursuing further education in the field of technology should possess a resilient interest toward building attitudes of personal pride through intellectual challenges (Eisenberg, 2010). Learning explorations together with peers has the potential to develop collaborative and creative thinking skills through research, construction, and design (Lovell & Buechley, 2010). Emerging innovations in wearable technologies present an opportunity to reimagine learning for the future.

Development of Collaborative and Creative Thinking in Other Curricular Areas

The Partnership for 21st Century Skills (2010) suggested that students should not only learn math, writing, and reading, but also creativity, collaboration, problem solving, innovation, communication, and critical thinking. Singer, (2011) highlighted the importance of creativity in education, saying:

> Education that is not creative and generic, a form of indoctrination that descends mechanically upon everyone subjected to it, initially by the teacher but finally by the pupils whose differences of mentality and potential growth are systematically

> thwarted or neglected. In contrast, effective learning is basically creative; and the creativity we revere may itself be thought of as an extension and application of the learning process. (p. 61)

To clarify effective learning, a study by Pelfrey (2011) found that when teachers facilitate student choice, inquiry, imagination, and collaboration in a failure-friendly constructivist-learning environment, student creativity is enhanced.

Within the context of a classroom, Waite (2013) studied how creativity is exhibited in children. She believed mathematics needed be thought of as a subject for which all the answers have not already been discovered (2013, p. 5). Instead, it needed to be regarded as an environment from which knowledge has yet to be gained. Waite defined creativity as moments of discovery where knowledge becomes connected (p. 13). The research explains how an inquiry methodology increased creativity and allowed students to explore mathematics from constructivist-learning environment (p. 40). The results suggested a change in thinking about what it means to be mathematical and how students develop skills and gain knowledge (p. 74). The importance of collaboration and context, to the culture of not knowing, is explored. The culture of not knowing is significant to the development of mathematical understanding and confidence in learners (p. 80). Ambiguity, frustration, and perseverance are necessary elements in creative thinking (p. 75)). The findings influence thinking on how knowledge is created from experience. This study suggests creativity in mathematics is possible if students collaboratively use dialogue and reflection to explain how their thinking is changing, or what new things they are discovering about mathematics (p. 91). It was found that students must develop the attitude that they are in control of their mathematical learning; they are the creators of this knowledge and skill (p. 100).

Another study examined evolving instructional practices that encourage creative and critical thinking in learners (Adams, 2013). The study was created to identify the elements that affect the instruction of creative and critical thinking skills. The mixed method approach highlighted results through environments that further creative and critical thinking that develop collaboration and creativity (p. 8). Teachers recognized the following learning environment factors as being beneficial to creative and critical thinking: experiences that foster learner ownership and personal value; environments that are safe and failure-friendly; and activities where students are engaged in distinct knowledge building constructivism (p. 140). They defined creativity as thinking outside the box, doing something different than expected, going beyond expectations, or putting things together in a new or different way (p. 28). The teachers understood creativity as demonstrating knowledge building in a new way. Adams' study identified the strategies most frequently identified by teachers to encourage creativity as engaging, chosen, collaborative, inquiry, higher level reasoning, constructive and integrated (p. 34). The findings indicated a need for further investigation on the development of creative thinking skills in students (p. 83). Professional development was suggested to involve building teachers' knowledge about creative and critical thinking, and providing practical, proven, easily implemented ideas (p. 143).

Educational robotics was considered to be an approach to educational technology that fits constructivism in a study by Mikropoulos and Bellou (2013). During the design process of the educational robotics, learners considered problems through creative thinking, construction, collaboration, and reflection. Mikropoulos and Bellou thought that the contribution became more effective when the educational robotics was regarded as cognitive tools or “Mindtools” as proposed by Jonassen (2000). The context of robotics as a Mindtool requires synchronously manipulating components while connecting knowledge for problem solving decisions to accomplish tasks (Chambers & Carbonaro, 2003). The goal of the study by Mikropoulos and Bellou (2013) was to connect educational robotics as constructivist-learning with Mindtools, by highlighting particular Mindtools’ characteristics through learning. Findings from this study indicated positive learning results that educational robotics can be used as Mindtools (p. 8). A key characteristic was that learners used design knowledge to connect learning and solve their problems. Educational robotics integrated constructivist principles (p. 5). Results showed learners acquired necessary skills during their project integrating educational robotics (p. 10).

Another study on the constructivist Mindtool of educational robotics used problem-based learning (PBL) as an approach to build knowledge (Savage, Sánchez, O’Donnell, & Tangney, 2003). It examined constructivist-learning environment design, Mindtools as instruments, and learning from collaboration and reflection as a methodology. It was found that student understanding through design evolution of artifacts within a community promoted knowledge building through collaboration and creative thinking (Savage et al., 2003). Student understanding was acknowledged by Norman (1993) who proposed experiential and reflective thinking as a dual approach to learning. Experiential thinking develops from personal experiences when knowledge is demonstrated as reflective. Norman explained that external support builds reflective thinking through a "mental effort to think of and contrast the various courses of action" (1993). Features that describe Mindtools include knowledge depiction, reflection, and external support (Jonassen, 2000). The results of this study using educational robotics as a constructivist Mindtool in knowledge building found that this kind of learning experience offers promising potential to develop collaborative and creative thinking skills (Savage et al., 2003).

Collaboration and Creative Thinking Through Art

The reality of collaborative and creative thinking today is that people across the globe whose paths might never have crossed can weave thoughts together to create unique ideas. Multimedia collaborations are now, and growingly, more possible for individuals to make the most of others' ideas creatively. From generating ideas to financing them, producing content to exploring where to take it next, collaborative and creative thinking is expanding in new and different ways. For everyday functionality, not knowing how something works might be acceptable, yet for educational purposes transparency might be of more benefit to skill development in promoting better understanding of operation and opportunity (Buechley, 2010). Wearable technologies are changing perceptions of what creating a piece involves and taking ideas to places never thought of before.

Collaboration Through Art

Teams of educators are crossing curricula to integrate the arts, particularly through design of technological innovation (Fleischmann & Hutchison, 2012, p. 23). Branching from exploration that focuses on the advantages of multidisciplinary collaboration in the School of Creative Arts at James Cook University, Creative Exchange (2012) integrated a multidisciplinary exercise within a post-secondary learning environment (p. 23). They expanded collaborative engagement within the arts to include non-arts subjects, such as, Information Technology, Business, and Journalism (p. 24). This School of Creative Arts experienced a reinvention of the curriculum. Results highlighted an increase in student preparedness for the challenges and demands of the future workplace.

Fundamental to these changes was the development of new emerging technologies that position learners not only at the heart of new media arts practice, but as adaptable skilled contributors seeking networked relationships, within and external to, creative arts (Fleischmann & Hutchison, 2012, p. 23). In advertising, topic expertise was sought to achieve a shared result. As an idea takes shape and grows toward realization, input is gathered, adding to, forming, and developing the project. Game design and technology integrated art showcases intersections between Information Technology (IT) and the arts. These types of mergers have expanded since emergence of Web 2.0 tools (p. 23). Technological applications, electronics, mathematics, robotics, led installations, and sensors, in relationship with the arts, are used as part of a collaborative interactive dialogue toward future innovation (Ahmed, Camerano, Fortuna, Frasca, & Jaccheri, 2009, p. 580).

However, new workers are often unprepared for team relationships. Their educational experience having supplied them with little empathy for, or understanding of, other professionals with whom they need to collaboratively work (Fleischmann & Hutchison, 2012, p. 24). They are unskilled in collaborative actions of team and group dynamics. This is significant to the configuration of networking based on participant skills and meeting the expectation of evolving industries. New hires are lacking experience as to the benefits of teamwork. Many businesses are listing collaboration, community-minded, and experience with groups, as desirable attributes from graduates, in some cases rating these over subject-directed skills (p. 24).

Within a university environment, across departments and schools, collaboration can be difficult. A recurring concern in literature is the “silo” thinking of disciplines that makes collaboration challenging (Linton, 2009). Research confirmed that arts educators are enthusiastic about collaborative opportunities stretching across disciplines.

For example, the Creative Exchange was the first subject in the School of Creative Arts that was planned fundamentally on the POOL Model, an alternative learning and teaching approach that integrated multidisciplinary collaboration in the arts (Fleischmann & Hutchinson, 2012). Business and community relationships are an integral factor of the learning environment (p. 25). Creative Exchange guided subject learning by engaging students in multidisciplinary collaboration as a component of the curriculum. Groups of learners dialogued thinking across disciplines leading to effectively contributing to their teams. This developed an understanding of professional abilities in other fields (p. 29). As a result, learners are better prepared for their future collaborative work environments. Research is ongoing at the Creative Exchange. Findings continue to be suggestive of high levels of student involvement and appreciation of the skill development toward multidisciplinary collaboration for future success. Future study highlighted a need for collaborative opportunities to be extended (p. 29).

School standards require the arts to merge historical and cultural context, critical analysis, and aesthetic judgment into learning (Green & Kindseth, 2011). A study of the Manchester Craftsmen's Guild (2011) distinguishes student development through arts learning experiences within and outside of school environments. Student appeal for arts continues beyond the school experience through personal exploration. A learner, through working with his art teacher, developed interests in cultures. This student's perception of future potential changed. It was noticed that other learners placed value on this individual's aspiration and passion to learn (p. 339).

Schools aim the outcome of instruction on assessing. In traditional arts education, assessment seeks quantifiable data collected from normative rubrics (Green & Kindseth, 2011, p. 338). The Manchester Craftsmen's Guild study (2011) assessed unquantifiable accounts of uniqueness, community, and personal pride in the art-making processes of its students. The artistic process is specifically favorable to skill development and knowledge connection due to its integration of communication and reflection in context (p. 338). An artistic process is inherently learner-centered. The Manchester Craftsmen's Guild arts program encouraged individualized learning through experiences that emphasize relationships, and involve learners in their own knowledge building. The arts provided avenues for learners to develop creative thinking, toward a personal sense of action and vision in their lives (p. 339).

Students collaborated with community organizations to create a piece for a public space that engaged the community. The experience included learners in every step of creation. Students made soles of green chalk that would leave temporary traces of paths walked from cultural sites to a gathering place in a public park (Green & Kindseth, 2011, p. 339). From mixing pigmentation into the chalk medium to forming molds and stitching Velcro bands, students faced design choices, discovered solutions, and improved upon skills. For Julia Mandle, a cooperating artist, she witnessed creative thinking from students' collaboration with their community (p. 340).

Such experiences offer transformative opportunities by engaging learners as active participants in a collaborative culture. Their role shifts from that of a student to that of a leader. Leadership happens when learners develop a skill and willingly share the knowledge they gained with others. Harriger, Harriger, Offner, Marrero, and Saysinger (2013) collaborated with businesses to connect STEM learners through competition. The students responded positively. Harriger et al. concluded that these partnerships could result in more students entering STEM related fields.

The existing view of the 21st century workforce is of employees expected to innovate by collaborating with other individuals of diverse professions, interests, educational backgrounds, and cultures (Siler, 2011, p. 417). Collaboration requires practiced "interdisciplinary thinking" and "integrative thinking," which connects knowledge innovatively (p. 418). Established in 1994 at MIT, the ArtScience Program integrated the arts and sciences, applying creative thinking, critical inquiry, problem solving and collaborative skills to learning challenges. Using arts-based tools through hands-on workshops, students learned to create and investigate models. The process connected and transformed knowledge in personally meaningful ways (p. 419). The models served as shared artifacts to help foster a culture of collaborative understanding between learners. Student and teacher perceptions regarding the development of collaboration through design endeavors needs to be explored to better understand how this skill can be enhanced.

Creative Thinking Through Art

For over 50 years, researchers have tried to measure creativity. In the 1960's, Torrance designed the *Torrance Tests of Creative Thinking* (TTCT). Torrance (as cited by Kim, 2002) defined creativity as follows:

> [It is] a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solution, making guesses, or formulating hypotheses about the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results. (p. 3)

He developed this test to measure "fluency, flexibility, originality, and elaboration" (Kim, 2002, p. 3).

McTighe and Seif (2010) reviewed research and found indications that a constructivist-designed learning environment has an influence on creative thinking and collaborative skill development. McTighe and Seif pointed out that the current focus on high-stakes testing in education has been a factor in the decrease of creative thinking skills. Their conclusion encouraged moving away from this focus to integrate more meaningful learning experiences. They suggested problem-based learning. This would enhance development of skills such as collaboration and creative thinking (p. 150).

Barell (2010) indicated that facilitation of problem-based learning experiences resulted in higher engagement and better inquiries, leading to knowledge connecting. He believed that problem-based learning environments “help our students build upon their intrinsic curiosities about nature and our living, working, playing creating and surviving therein” (p. 197). Barell also suggested the use of technology to enhance problem-based learning and to encourage students to collaborate.

Duffy and Cunningham (1996) maintained that the role of an educator is not to disseminate knowledge, but to offer a learning environment that will support collaborative and creative thinking skill development through problem-based learning. When educators acted as facilitators and offered guidance, Duffy and Cunningham found that the learning experience is transformed for learners and resulted in more meaningful learning. In a case study about nurturing creativity and innovation, Beyers (2010) found that students need engagement that results in a meaningful learning experience to develop collaborative and creative thinking skills. Because problem-based learning is focused on the problem to be solved, Jonassen (2011) argued that content is mastered through problem-based learning and that knowledge is built in and applied.

In another study about constructivist-learning environments, Loyens, Rikers, and Schmidt (2009) shared findings of students' perceptions about their problem-based learning environment positively engaging knowledge gaining strategies forming connections. Hung, Jonassen, and Liu (2008) stated that problem-based learning provides learners opportunities to collaborate in failure-friendly environments that require creative thinking. They suggested problem-based learning as a way to improve creative thinking skills and collaboration. A Mindtool can offer ways to provide the type of problem-based learning environment that would help to prepare learners for a future in a workforce that is seeking collaborative and creative thinking skill abilities (2008).

Kafai and Peppler (2011) recently studied learner digital practices in remixing, reworking, and repurposing media designs. They found that digital media offers a networked environment that encourages creative thinking in context (2011, p. 90). It embeds technical skill learning within the design environment (p. 89). Digital media design opportunities are fostering life-long learning through innovative content creating (p. 99).

Creativity and innovation have been listed as desired skills that may require attention toward development in the near future (Kim, 2011). In a study by Kim, data collected on the *Torrance Test of Creative Thinking* from 1966 through 2008 was compared. Results found a decrease in creative thinking skills since 1990, as defined by the *Torrance Creativity Scale*. The No Child Left Behind Act of 2001 placed an emphasis on high-stakes testing in education. This has resulted in a reluctance of educators to design activities for learners to develop skills measured in the *Torrance Test of Creative*

Thinking (2011). Exploring student and teacher perceptions on creative thinking skill development through a Mindtool, such as the design of wearable technologies, encourages educational change to enhance life-long learning towards the goal of each learner's future success.

Summary

This chapter included a review of literature related to collaborative and creative thinking through art and other disciplines, as well as an evolution showing a decrease in the development of these skills. Recent attention to standardized testing in education has restricted schools' abilities to include creativity in the curriculum. Based on research, the importance of collaborative and creative thinking was evident as sought after skills in the workforce today. Studies indicated value learned through art as beneficial to the future of economic innovation. It is the skills inherent in the creative thinking process, such as reflecting and collaborating, which are needed for success in careers and in life. Several studies that have focused on teaching collaborative and creative thinking skills cite the need for improved professional development in this area.

This literature inquiry provided an invaluable and deep understanding on the development of collaborative and creative thinking skills resulting in new learning about real-world behavior and its meaning. These results showed a need to encourage art to be reinstated, included, and increased within STEM education. Research supported educators' adoption, implementation, and practice of modeling with technology.

The focus of this study provided research into the design of wearable technologies as a Mindtool for conceptual change to consider its impact on the development of collaborative and creative thinking skills in learners. Knowledge about Mindtools is limited due to the rapid growth of its emerging possibilities. It was found that Mindtools fostered needed skill development through cultures of collaboration. Researchers have also determined that the theory of constructivist-learning environments, which are inherent to Mindtools, helped promote collaborative and creative thinking skills. Stakeholders may use these research findings to plan professional learning driven by the desire to develop collaborative and creative thinking skills in learners.

Wearable technologies are referred to as the integration of devices and related electronics into clothing and accessories (NMC Horizon Report, 2013). This emerging field is growing exponentially, hinting at the potential for knowledge building through design. At the time of this study, no research was identified that examined student and teacher perceptions on collaborative and creative thinking skill development through the design of wearable technologies.

Collaborative and creative thinking skill development has been difficult to measure. This case study allows exploration of student and teacher perceptions on the development of collaborative and creative thinking skills through the design of wearable technologies. The next chapter details the research design and rationale for this study. This includes description on the role of the researcher, methodology, and issues of trustworthiness.

Chapter 3: Research Method

The purpose of this qualitative case study was to explore student and teacher perceptions on how engagement in digital artistic design of wearable technologies affects collaborative and creative thinking skill development in learners. A large body of knowledge exists indicating employers seek collaborative and creative thinking skills in employees, yet little is known about the value of experiences learners have through the use of Mindtools and how art education contributes to the development of these two areas. A review of the literature produced scholarly studies linking art education in general with collaborative and creative thinking skill development.

This chapter provides a description of the research design and rationale for the chosen approach. The Role of the Researcher is explained in relation to the procedures of data collection and analysis. A Methodology section identifies the participant selection logic, recruitment, and the process for data collection and analysis. A description of appropriate strategies to establish transferability follows under the next section, Issues of Trustworthiness. Dependability, confirmability, and ethical procedures are all addressed before a summary is provided.

Research Design and Rationale

Perceptions from participant experiences are essential for informing educational policy and budgetary consideration in decisions to educate learners for success of future workforce endeavors. A case study approach was selected to build a rich understanding of how the participants perceive the development of collaborative and creative thinking skills through the design of wearable technologies. The concentration of this exploration was on perceptions from both teacher and student experiences on the development of these skills. As such, the role of the researcher was to use knowledge of Mindtools to help understand the participants' perceptions of how they developed collaborative and creative thinking skills through the design of wearable technologies.

Research questions that directed this inquiry were:

1. What are students' perceptions regarding the development of creative thinking skills while designing wearable technologies?
2. What are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?
3. What are students' perceptions regarding the development of collaborative skills while designing wearable technologies?
4. What are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?

A qualitative case study approach was selected for the research design, as outlined by Yin (2011). This design was selected to gather teacher and student perceptions about collaborative and creative thinking skill development through the design of wearable technologies. Student skill development during a particular course experience was explored. A case study approach allowed for exploration of individual experiences through interactions, relationships, and environment. It supports analysis and the interpretation of particular phenomena (Yin, 2011, p. 6).

This research study developed an in-depth interpretation of a single case set in a real-world context of a classroom in the Rocky Mountain region of the United States. The intention was to yield an important and deep understanding into the development of collaborative and creative thinking skills resulting in new learning about authentic situations and their impact on knowledge building. This is an empirical exploration about a modern phenomenon set within an authentic context, when the parameters of the experience and environment are new (Yin, 2009, p. 18). Using a qualitative case study approach to the research for this inquiry is consistent with exploring an understanding of how learners approach the work of designing wearable technologies and its influence on collaborative and creative thinking skill development. The research questions from this study required an understanding of relationships in context. The aim was to build an understanding of these relationships that was based on collected perceptions from the participants. Qualitative research explores insights into experiences and environments where there is limited prior knowledge (p. 5). As such, this method was used to provide rich descriptions of the perceptions from respondents about particular issues.

Recognizing possibilities in qualitative case studies involves discerning multiple perceptions (Yin, 1994). Case studies are interpretive research explorations into details and meanings of experiences. The richness is in the detail possible when a small number of cases are analyzed. Various data points in qualitative case studies permit attention to multiple perspectives (Yin, 1994). A case study approach allows for exploration of details and meanings in an experience to determine patterns and themes.

I considered several research paradigms in addition to case study as a possible methodology during the planning phase of this study. These included three qualitative traditions including ethnography, grounded theory, and heuristic inquiry, as well as a quantitative questionnaire. The choice of research approach was based on the purpose of the study, the types of data to be collected, and the focus of the research questions.

Ethnographic research involves investigation into the cultural behavior in groups of individuals to interpret meaning and understanding. Behavior was not a focus of this study. Observation is a major data collection method used in ethnographic studies. It would have been limiting for this study because I was interested in the perceptions of the participants who engaged in the design of a wearable technologies experience (Patton, 2002). Furthermore, this study was not meant to interpret the culture of any group of persons. For these reasons, ethnographic approach for this study would have been limiting.

Grounded theory research is concerned with the formation of a new theory. This methodology utilizes analysis of data to establish findings toward the development of a new theory (Patton, 2002). Creating a theory was not the purpose of this study. Instead the exploration was to interpret and understand the phenomenon being studied and make investigated assertions on collaborative and creative thinking skill development through the design of wearable technologies as perceived by participants.

Heuristic inquiry is an isolated research approach, discernable by its recognition of a researcher's personal experiences, opinions, and interactions with participants (Patton, 2002). Using a heuristic method a researcher will become "one" with the subject matter and circumstances, and is a participant in the experience(s) (Patton, 2002). A heuristic research approach encounters frequent threats to bias and validity that need to be expertly countered and alleviated. This level of expertise requires a more seasoned researcher. Heuristic researchers typically have more experience. A heuristic investigation “is characterized by the personal role of the researcher with the participants being studied” (Patton, 2002). A heuristic inquiry could have met the goals of this study if I had chosen to conduct a workshop in this area. As this would not have occurred within a curricular setting this choice was rejected. Attentive research toward the discovery of the significance and meaning of phenomena is a heuristic inquiry (Patton, 2002, p. 107). As this study sought to understand skill development through the design of wearable technologies integrated within existing curricular opportunities, a heuristic research approach would be obtrusive and too difficult to control biases, and was rejected.

A quantitative questionnaire was considered as an approach to data collection for this study, but was rejected as unsuitable. While a questionnaire provides the advantage of reducing a researcher’s bias (Singleton & Straits, 1999, p. 205), it would be more difficult for further probing of the proposed research questions as clarification would not be an immediate option. A questionnaire was not selected because it would necessitate the use of variables taken from existing theory to investigate a hypothesis. A single theory did not exist to make testing a hypothesis possible in this study. Utilizing a questionnaire would also not yield the rich data required to analyze perceived development of collaborative and creative thinking skills through the design of wearable technologies. The design of wearable technologies as a Mindtool is new and there was the need to explore the outcomes of this experience in order to understand its value beyond the art experience. The researcher needed to learn from participants’ experiences in order to represent their perceptions. Also, with the use of a quantitative questionnaire, data would have to be acknowledged at face value, as there would be no opportunity to review (Nachmias & Nachmias, 1987).

The method selected for this inquiry was case study. Yin (1994) defined case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident…[and] relies on multiple sources of evidence" (p. 13). Case study was favored to ethnography, grounded theory, heuristic inquiry, and a quantitative questionnaire survey in relation to the purpose of this study and the type of data necessary for analysis. Case study permits a dynamic study of a phenomenon from a broader scope restricted by time, events, activities and/or individuals. This qualitative approach is rich in detail and pulls information from multiple sources (Yin, 1994). Case study is a method most suited for the investigation of a selected context (Trochim, 2006), because it relies on various points of data to develop a comprehensive interpretation of what is being researched (Jacelon & O'Dell, 2005). Science, Technology, Engineering, and Math (STEM) are gaining as an initiative in educational institutions across the United States. By narrowing this study the potential data that could be collected would be limited. A case study is an appropriate research approach where the questions that guide the investigation are about the content and context of the experience (Tellis, 1997).

Role of the Researcher

I first obtained a letter of cooperation to carry out the study from a university department located in the Rocky Mountain region of the United States (see Appendix B).

I next obtained approval from the Walden University Institutional Review Board (IRB) prior to approaching participants. Upon receipt of IRB approval (# 03-21-14-0162090), a teacher was contacted about participating in the study (Appendix C) sharing the scope of the study to acquire informed consent. Once a signed consent form (Appendix D) was received from a teacher, students were contacted about participating in the study (Appendix E). The scope of the study was shared with each student to acquire informed consent (Appendix F). Next, Skype or telephone audio-recorded interviews were arranged at convenient times. Interview questions provided data for collection on the perceptions from each participant. Interviews were structured to encourage a natural flow and provide participants time to consider their thoughts (Smith, Flowers, & Larkin, 2009).

Prior to the initiation of each audio-recorded Skype or telephone interview, rapport was established through casual conversation to ease any anxiety and reassure participants to feel comfortable talking about their experience (Smith et al., 2009). To minimize bias as an educational technology specialist, bracketing of thoughts throughout the data collection process occurred. Bracketing is used to note biases and refer to them throughout a study (Van Manen, 1990). The role of the researcher was to interview and ask follow-up questions about participants' perceived development of collaborative and creative thinking skills through the design of wearable technologies.

The analysis of the three separate audio-recorded Skype or telephone interviews required detailed coding and interpreting of data. By bracketing thoughts throughout the data collection process, this minimized inaccurate findings as the research evolved

(Fischer, 2009). Participants were provided with questions in advance to give time to reflect upon their experiences (Patton, 2002; Van Manen, 1990) and to build transparency (Smith et al., 2009). Public record information on my position as an educator and my affiliations within education were available to participants.

Methodology

This section identifies the sampling strategy and provides a rationale for its selection logic. Procedural description for data collection through interviewing of participants is included. Connection of data to specific research questions is shared. Additional information to build credibility, transferability, dependability, and confirmability follow to allow for duplication of this study. A comprehensive data analysis plan concludes this section.

Data collection includes audio-recorded Skype or telephone teacher and student interviews, and audio-recorded Skype or telephone follow-up teacher interviews based upon analysis of initial data collection from all participants. The method of data analysis includes descriptors of collaborative and creative thinking skill development. The data collection for this study was determined by the need to analyze responses within the conceptual framework. Such an analysis requires comparison across participants to isolate patterns and be able to observe links between them. This study sought to elaborate on the contextual influences on relations observed, explore relevant associations, and provide for the emergence of connections. Therefore, the collection of responses on the questions of interest was necessary, and also that data be collected across a range within the organization. Analysis involved selections from the transcripts of the three sets of audio-recorded Skype or telephone interviews to validate findings.

Through constant comparisons from this collected data, rich themes and patterns were developed providing a code scheme for the analysis of data (Yin, 2011). Immersion into the data collected produced initial findings of important concepts (p. 143). Big idea perceptions about collaborative and creative thinking skill development were grouped. These constant comparisons led to the initial codes (Glaser & Strauss, 1967). Data immersion sought to reach saturation, where no additional meanings or insights emerge. Ideas were derived from the data in abstraction through this iterative nature of explanation building (Yin, 2011, p. 143). Initial codes were further grouped with similar ideas to form categories. These categories and codes were "compared and contrasted" to develop new insights, forming additional codes. This gradual building of an explanation was akin to the process of refining a set of ideas. The organization of data collected helped explain how learner skill in these two areas develops. Investigations required initial audio-recorded Skype or telephone teacher and student interviews, and additional audio-recorded Skype or telephone follow-up teacher interviews based on the analysis of accumulated responses and reflections.

Participant Selection Logic

Teachers and students of a wearable design technology integrated curricular component in education were purposively selected for this study. "To uncover the meaning of a phenomenon, individuals who have experienced the event must be included in a study and carefully interviewed to allow meaning to surface" (Van Manen, 1990, p.

30). Selecting participants using predefined logic, while ensuring their confidence by protecting rights, are both equally important to consider (Moustakas, 1994).

Participation in this study was voluntary. Participants were interviewed at a convenient agreed upon time outside of school hours via audio-recorded Skype or telephone. To ensure analysis validity from collected perceptions, teacher participants were asked follow-up questions. For the teacher follow-up interviews, audio-recorded Skype or telephone was again used. Participants who have experienced a wearable design technology integrated curricular component in education from teachers in the Rocky Mountain region were selected. Each student participant was selected from a class roster provided by the course facilitator. Smith et al. (2009) recommended a sampling of three participants to collect relevant data for analysis by beginning researchers. This suggestion offered a basis from which to determine an appropriate number for this study. A minimum of 3 and a maximum of 10 participants was the chosen sampling to ensure depth and detail of data collection. Reasoning for the selection logic was justified by the availability of participants, quality assurance for data analysis, and considerations of participation willingness.

To ensure quality and depth of collected perceptions for analysis, each participant interview was attentively interpreted. Participant familiarity and sufficient homogeneity within the study was assured by following predetermined selection criteria and the conceptual framework (Miles & Huberman, 1994, p. 27). The details obtained from researcher analysis of initial interviewing, followed up by further clarifying and probing, increase transferability of the findings to suggest the design of wearable technologies for collaborative and creative thinking skill development in educational curricula.

Instrumentation

The audio recording of three sets of Skype or telephone interviews provided the primary source of data collection: teachers, students, and teacher follow-up interviews. A "semi-structured flexible interview protocol" (Appendix G) was used (Smith et al., 2009, p. 80). The participants were asked related follow-up questions to all responses. The initial audio-recorded Skype or telephone interviews lasted approximately 30-45 minutes each, depending on the comfort of each participant. Rapport was established before beginning the actual questioning. The interviews were "structured to provide the interviewee with sufficient time to answer questions and expand upon them when prompted by the interviewer" (Smith et al., 2009, p. 80). The audio-recorded Skype or telephone teacher follow-up interviews were shorter in time as the additional questioning was framed by the initially collected data.

Procedures for Recruitment, Participation, and Data Collection

Data were collected through audio-recorded Skype or telephone interviews with each participant outside of school hours. Teacher participants had an audio-recorded Skype or telephone follow-up interview based on researcher analysis of all initial responses. Data collection through audio recordings using Skype or telephone was conducted over the course of seven weeks. A Confidentiality Agreement (Appendix H) to transcribe recordings was provided by the professional transcriptionist service. After the initial recordings were transcribed, the transcripts were checked for accuracy, verified line-by-line by listening to each audio file while coding. The teacher participants were contacted for follow-up questioning based on initial analysis of collected responses. No interviews were scheduled for more than 45 minutes unless a participant requested additional time. Participant comfort was respected to foster detailed sharing of perceptions. This provided greater depth for analysis of their experiences. Interviews were audio recorded using Skype or telephone and QuickTime Player and then transcribed verbatim.

The potential participant population was narrow due to the recent emergence of wearable technologies into educational curricula. If less than three participants could be interviewed, the study would have to consider using outside course participants who have experienced wearable technology design in a group learning scenario. Although participants outside of an educational curricular wearable technologies course boundaries were not the focus of this study, their perceptions could add deeper understanding into collaborative and creative thinking skill development through the design of wearable technologies. All of the participants had been involved in an integrated curricular experience on the design of a wearable technology.

Upon reaching the exit point for each interview, individuals were thanked for their willingness to participate in the study and also reminded of their right to withdraw at any time. Contact information as presented on the Consent Form (Appendix D, F) was readdressed with each participant.

Data Analysis Plan

Data were analyzed at two levels. At the first level, the initial student and teacher interviews were coded for each case, and then categories were constructed from these codes. A process of line-by-line coding, recommended by Charmaz (2006), was followed to remain immersed within the data. The process of line-by-line coding involved naming each line and provided focused insight regarding details (2006).

At the second level, data were examined across the student and teacher interviews to determine emerging themes and discrepant cases. Key findings were developed from these themes and discrepancies. These findings were presented in relation to the research questions for this study.

Interview Questions

Research Question 1: What are students' perceptions regarding the development of creative thinking while designing wearable technologies?
Student Interview Questions • What do you think creative thinking means? • How did your creative thinking change as you moved through the design of your wearable technology? • How did creative thinking influence the design of your wearable technology? • How do you think creative thinking is learned? • Is there anything I have not asked you that you feel is important to add to our conversation about the designing of your wearable technology?

Research Question 2: What are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?
Initial Teacher Interview Questions • How would you define creative thinking? • What evidence of creative thinking did you see in the students while they were designing wearable technologies? • How did the students' creative thinking change as they moved through the designing of wearable technologies? • How did the development of creative thinking affect the students' designing of wearable technologies? • How do you think creative thinking is developed? • Is there anything I have not asked you that you feel is important to add to our conversation about the students' designing of wearable technologies?
Research Question 3: What are students' perceptions regarding the development of collaborative skills while designing wearable technologies?
Student Interview Questions • What do you think collaboration means? • How did your collaboration change as you moved through the design of your wearable technology? • How did collaboration influence the design of your wearable technology?

• How did your collaboration with others help or hinder the designing of wearable technologies? • How do you think collaboration is learned? • Is there anything I have not asked you that you feel is important to add to our conversation about the designing of your wearable technology?
Research Question 4: What are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?
Initial Teacher Interview Questions • How would you define collaboration? • What evidence of collaboration did you see in the students while they were designing wearable technologies? • How did the students' collaborative abilities change as they moved through the designing of wearable technologies? • How did the development of collaboration affect the students' designing of wearable technologies? • How do you think collaboration is developed? • Is there anything I have not asked you that you feel is important to add to our conversation about the students' designing of wearable technologies?

Teacher Follow-up Interview Questions

Research Question 1: What are students' perceptions regarding the development of

creative thinking while designing wearable technologies?
When I examined all of the student interviews I discovered that • Students shared thoughts about creativity as having developed at home or through academic experiences. Where did you see your students' creativity coming more from, academic knowledge or extracurricular knowledge? Why?
Research Question 2: What are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?
• Did you see participants from particular colleges/domains as showing/having more creative thinking tendencies over the duration of the course? • The syllabus suggested, thinking creatively, taking risks, and doing something new. Can you share examples of how students making "hybrid creations that cross domains" showcased these suggestions?
Research Question 3: What are students' perceptions regarding the development of collaborative skills while designing wearable technologies?
When I examined all of the student interviews I discovered that • Students shared about your encouragement of learning avenues for finding help. Can you share some examples of how far you saw that extended?
Research Question 4: What are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?
• Did you see participants from particular colleges/domains as showing/having

more collaboration tendencies over the duration of the course?

- Did you feel there was more collaboration regarding the technology knowledge building or craft knowledge building domain of the learning?
- What differences could you see in the development of collaboration in students between the two course offerings because of the additional recruitment outside of your own department?
- Looking at the syllabus, a question was asked in the introduction. "Why are computing-related professions among the least diverse in society?" How do you think your course addressed this issue?

Coding

The audio recordings were transcribed and coded following the educational institution's Staff and Student Rights and Responsibilities Code that protects the rights of individual students and employees in regards to educational records. "Verbatim transcription provides a way for the researcher to interpret the words of the participant outside the context of the interview, while also facilitating the process of coding" (Smith et al., 2009, p. 100). To enhance interpretation of the experiences, "raw data were coded as each transcript is read to let the themes emerge" (Miles & Huberman, 1994, p. 11). The coding process required reading and re-reading of a transcript, initial noting from individual participant data, developing emergent themes from perceptions, searching for connections across themes, and repeating these steps with next transcripts (Smith et al., 2009).

Microsoft Office Suite was used to manage and code the collected data for analysis. This comprehensive tool offered convenience to review or audit findings. Several layers of coding within multiple categories were permitted, subsequently allowing theme and pattern representation of the data to be generated. This tool supported the data analysis process.

Conspicuous information that would identify the participants was removed to further ensure confidentiality. To provide support to educational policy decision makers, certain information obtained through inquiry may be relevant to current initiatives. Findings and interpretations of the data analysis were shared with stakeholders. The results were shared according to ethical research procedures, respectful of the confidentiality and trust of the participants.

Discrepant Cases

As themes emerged and connections began to form, data that was significantly different from other participants' perceptions was used in contrast and as a way to broaden the perspective of collaborative and creative thinking skill development through the design of wearable technologies. "Discrepant cases were identified and explored through the follow-up interviews as a way to check for possible bias" (Maxwell, 2005, p. 244). The discrepant information helped form the follow-up questions with the teachers to aid in creating a broader understanding of the perceptions on collaborative and creative thinking skill development through the design of wearable technologies. This increased confirmability of this study.

Issues of Trustworthiness

This section addresses credibility, transferability, dependability, and confirmability of this study. In addition, the ethical procedures for the treatment of participants and their rights are discussed. Following is a summary of all the elements for qualitative research in regards to the study of student and teacher perceptions on collaborative and creative thinking skill development through the design of wearable technologies.

Credibility

Data from each participant were explored to reveal a rich understanding of his or her perceptions. Through the depth of detail, internal validity was enhanced (Miles & Huberman, 1994) as each transcript was examined (Maxwell, 2005). To enhance the validity of the researcher's interpretation, the collected data were triangulated. Moustakas (1994) suggested participant information be reviewed and probed further to clarify and validate the data. "Each participant may also feel more valued by being provided with the opportunity to be an active part of the research process" (p. 110). The credibility of the study was increased by teacher participant opportunity to clarify initial analysis through follow-up interviewing.

Triangulation occurred through the compilation of personal perceptions from each participant interview, the multiple perceptions of two types of participants, and the inclusion of follow-up teacher interviews based on researcher analyzed initial responses from all participants. The inclusion of multiple data sources enabled each participant's responses to be confirmed in different contexts and at different times.

Transferability

Yin (2009) argued that transferability is contingent on the conceptual framework of the case study research rather than the quantity of cases. Yin noted replication could be achieved with only a few cases. Merriam (2009) suggested several strategies to enhance transferability of a qualitative study: (a) thick description, (b) maximum variation in the sample, and (c) generally characteristic of the sample.

A strategy to enhance the transferability of this study was the use of rich, thick description. This type of description was used to find rich themes that provided insight to others. To increase transferability, individual participant data were explored and described to add depth of understanding. As themes and commonalities were identified, data were explained within the context of the individual responses and in contrast to other participants' perceptions within the study. If a theme emerged describing a preconceived idea of influence to a participant in perceiving collaborative and/or creative thinking skill development that contrasted pointedly from other data collected, contextualization within the selected participant interview offered connection of emerging themes in a meaningful manner (Smith et al., 2009).

Dependability

Dependability was enhanced through triangulation and verbatim transcription. Accurate records of procedural dates and times, with any additional details, were maintained. This increased transparency and possible duplication of study. The secure access and use of Microsoft Office Suite, for managing and coding of data, added to the integrity of the study.

Confirmability

According to Lincoln and Guba (1985), “confirmability is similar to objectivity in that the outcomes of an investigation are not the result of a researcher’s biases and are instead informed by the context of the research” (p. 124). Bracketing of researcher thoughts pertaining to collection of data during interviews ensured confirmability. These collected thoughts were reviewed during the coding. By using a repetitive process for analysis of all collected data, findings were informed by the perceived experiences of each participant.

Ethical Procedures

The Rocky Mountain region state educational institution approved access to the participants. A Letter of Cooperation (Appendix B) was obtained from the department head giving permission to conduct this study. IRB approval was obtained prior to collecting data for the study (# 03-21-14-0162090). Potential participants were screened by contacting their teacher from the shared course on design of wearable technologies.

Teachers were purposively selected and invited (Appendix C) to participate in the study. They were asked to sign a Consent Form (Appendix D) addressing the study and their part in the research, should they wish to participate. Teachers received a copy of their signed Consent Form, which included the scope of the study and contact information.

Students were invited to participate in the study (Appendix E). These students were informed of their rights and asked to sign a Consent Form (Appendix F). Each student received a copy of his or her signed Consent Form, which included the scope of the study and contact information. Student Consent Form responses were collected and participants purposively selected from the collection. If a student wished to withdraw from the study before or during data collection, another purposively selected student from the Consent Form responses, if available, was added.

All data were collected and analyzed within Microsoft Office Suite. Upon completion of research, information was stored digitally in a secured file on a separate drive accessed through a password protected computer and on a USB drive backup copy that is locked in a filing cabinet in my home. The professional transcriptionist provided a Letter of Confidentiality (Appendix H) and assured that all data will be returned after transcription. Any and all paper records produced during data analysis were shredded. All Consent Forms were kept digitally in the secure file on the separate drive accessed through a password protected computer and on a USB drive backup copy that is locked in a filing cabinet in my home. There will be no additional access to the data, and all the files will be deleted and destroyed after 5 years.

Summary

Qualitative research credibility throughout the inquiry was established and maintained through rigor and meticulous attention to detail. In order to allow researchers to build upon this work further, the research protocols were managed and followed throughout this study. This was a case study exploring student and teacher perceptions of collaborative and creative thinking skill development through e-textile activities. Teachers and students were interviewed to determine their perceptions on the development of collaborative and creative thinking skills through the design of wearable technologies. The experiences and perceptions of the participants were the core of this study, inclusion of their ideas and reflections enhanced understanding of collaborative and creative thinking skill development through the design of wearable technologies. Chapter 4 will include a comprehensive analysis of each participant's perceptions and the results from the study related to each research question.

Chapter 4: Results

The purpose of this qualitative case study was to understand teacher and student perceptions regarding the development of collaborative and creative thinking skills through the design of wearable technologies. This study explored personal experiences with e-textiles within a curricular setting. In order to develop an understanding of the shared experiences from the participants, the responses from each participant were explored using a conceptual framework based on Jonassen's (1996) modeling using Mindtools for conceptual change, Rosen's (2009) culture of collaboration, and the following research questions:

1. What are students' perceptions regarding the development of creative thinking skills while designing wearable technologies?
2. What are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?
3. What are students' perceptions regarding the development of collaborative skills while designing wearable technologies?
4. What are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?

Conceptual frameworks supportive of constructivism suggest using student-centered, technology-supported, problem-based learning environments with open-ended solutions for knowledge building. Jonassen's (1996) modeling using Mindtools for conceptual change supported creative thinking through the design of wearable technology as a Mindtool. As part of the conceptual framework, this was useful in explaining the research questions because participants considered knowledge expanded through connections, inquiry, and reflection in spite of institutional challenges and opportunities. To shape an understanding of collaboration, Rosen's (2009) theory on the culture of collaboration was used to categorize the needs facing workforce success. Rosen's assumptions on the culture of collaboration and Jonassen's work on Mindtools highlight technology as a cognitive tool that provides insight into the interpretations of each participant.

Chapter 4 includes sections describing Setting, Demographics, Data Collection, Data Analysis, Evidence of Trustworthiness, Results by Research Question, and Summary of the Data. Results by Research Question are organized by the determined themes from inquiry focusing on student or teacher perceptions. The open-ended inquiries outlined themes on collaborative and creative thinking skill development through the design of wearable technologies.

Setting

I conducted all of the interviews for this study using Skype or telephone calls from a private location in my home using a password-protected secure desktop computer. The interview participants were in quiet secluded locations, and the audio from these calls was recorded with QuickTime Player. Three students and one teacher responded to the invitation with their consent to be contacted for interviewing via Skype or telephone. A total of five interviews were conducted over the course of seven weeks with three of them being student interviews, one teacher interview, and one follow-up interview with the teacher. While these participants were willing to provide data to the study, they also had personal and school responsibilities that made scheduling convenient interviews a challenge. The interviews were scheduled on evenings, weekends, and during non-academic times.

The interview times were arranged at the participants' convenience, with one student selecting Skype on a Saturday morning. Another student scheduled a Tuesday evening Skype call. The third student arranged for a Thursday midday telephone call. The teacher initial interview was recorded midday on a Tuesday via Skype. The follow-up teacher interview took place on a Thursday evening after being rescheduled from earlier that morning. The student interview that took place on a Tuesday evening was a reschedule from a missed chosen time the Sunday evening before. All participants were interviewed independently in order to elicit personal perceptions without any influence or knowledge of the others. Participants were each in a quiet secluded location where they were free to talk. Each seemed willing and eager to share their experiences for the study. Comfort and confidentiality were always a priority for each interview.

I followed my interview protocol (Appendix G) for each data collection opportunity. I used my home desktop computer to eliminate distractions and disturbances, where the interviews could not be overheard. The first interview participant on Saturday morning received an incoming call after 30 minutes, electing to mute our conversation for a few moments. The offer to continue another time was presented but turned down. Upon his return to our interview, I indicated that the time allotted was reached with an invitation to wrap up or continue. He eagerly chose to continue, saying that he was enjoying sharing for my study. At this point, he located his final reflection paper for the course and voluntarily sent the file through Skype. He felt this would provide a fuller picture for data collection than just the interview. This artifact was unexpected, but provided an additional data detail for depth of analysis and review.

The initial teacher interview on Tuesday morning was next and occurred without interruption. A course syllabus was voluntarily shared as an additional data artifact to enhance depth of analysis and review also. A second student interview followed that Tuesday evening, having been rescheduled from the originally arranged time Sunday evening. Early on during our time, this student posted a link in Skype to her course reflection blog as a voluntary artifact to better contribute toward the interview questions. This interview was interrupted by her FaceTime application ringing about a half an hour into the interview. The offer to continue another time was presented but turned down. The other call went unanswered and she continued sharing in response to the interview questions. Indication of the time allotted was reached with an invitation to wrap up or continue. She wished to continue also saying our time was enjoyable. Her artifact was unexpected as well, but also provided more additional data detail for depth of analysis and review.

A third student interview took place midday on a Thursday, via telephone. After first attempting to contact her on my phone with no success, I sent a text indicating my name so she would associate the phone number with my call. She then phoned me to apologize for not being in an area with good cell reception. Once she was settled in a quiet location, we proceeded with the interview. There were no interruptions.

The follow-up teacher interview was that same Thursday but in the evening. Our originally scheduled Skype call earlier that day went unanswered. Following up via an email and a voice message to her office prompted a new time and telephone number for the evening. The teacher connected with me from within a coffee shop. This follow-up teacher interview was shorter as its purpose was to clarify and probe further from all the initial interview interpretations. This interview took less than half an hour.

My research process focused on the rich detail of experiences provided by participants through the initial interviewing. The follow-up interview conducted with a teacher clarified interpreted results from the initial data collection analysis. Additional artifacts were voluntarily offered by some participants and contributed to the understanding and interpretation of results. The themes that surfaced reflect the personal perceptions of the participant experiences on collaborative and creative thinking skill development when students are engaged in the design of wearable technologies.

Demographics

The selected population for this study was a sample of two teachers and eight students who participated in a wearable technology-integrated curriculum in a Rocky Mountain state in the United States. Four participants were recruited from a state educational institution in this region. Data for analysis were based on experiences and not on individuals or groups. Therefore, seeking further participants from alternative environments was unnecessary. Smith et al. (2009) recommended a sampling of three participants to collect relevant data for analysis by beginning researchers. This suggestion offered a basis from which to determine the appropriate number for this study. A minimum of 3 and a maximum of 10 participants was the chosen sampling to ensure depth and detail of data collection. Reasoning for the selection logic was justified by the availability of participants, quality assurance for data analysis, and considerations of participation willingness.

Each of the three global editions of the New Media Consortium Horizon Report (2013) – higher education, K-12 education, and museum education – emphasizes six emerging technologies expected to find mainstream use over the next 5 years. On this list of emerging technologies, set at 4 or 5 years away, is wearable technology (p. 5). An increasing array of wearable technology has become available, hinting at the potential for teaching and learning, though there remains to be seen many concrete education examples (p. 6).

The Rocky Mountain Region state educational institution department head agreed to serve as a community partner for the study to identify potential participants from their organization for interview consideration. The teacher participant provided potential student candidates to consider for data collection. Participants were purposively chosen through the selection criteria, and an email invitation was sent. "To uncover the meaning of a phenomenon, individuals who have experienced the event must be included in a study and carefully interviewed to allow meaning to surface" (Van Manen, 1990, p. 30).

The names of participants were coded to prevent identification. The three student participants were coded as S followed by a number. The teacher participant was coded as T followed by a number. For confidentiality, gender obvious pseudonyms beginning with the letter S were used for student participants (Sally, Sarah, and Scott), and the letter T for the teacher participant (Tiffany).

The first student interviewee was a male college student in a communications program. The second student interviewee was a female college student in an instructional technology program. The third student interviewee was a female art major college student. The teacher was a college professor in the instructional technologies and learning sciences department.

Data Collection

A case study on perceived collaborative and creative thinking skill development through the design of wearable technologies with teachers and students was undertaken. Constructivism with Mindtools (Jonassen, 2005) and the culture of collaboration (Rosen, 2009) provided a conceptual framework for this study and were the foundations for the analysis of skill development. The research included Skype or telephone audio-recorded interviews as a data collection technique. Additional data were provided when participants voluntarily shared additional artifacts of wearable art-technology that demonstrated collaboration and creative thinking.

After the selection process, potential participants were emailed an invitation to participate in the study including an introduction of the research scope. Contact was initiated via email, as this form of contact was made available by the cooperating educational institution department. I collected data from one teacher and three students for this study over seven weeks in the form of interviews. A copy of the Consent Form (Appendix D, F) was emailed to each participant for review and consent before interview scheduling. I obtained permission from each participant via email CONSENT responses prior to arranging for interviewing. In my initial interviewing, I discussed and reviewed the Consent Form with each participant.

Once consents were collected, arrangements for the interviews were determined Arrangements included agreeing upon a date, time, and method of communication at the convenience of the participants. The researcher sent reminders of the agreed arrangement to participants to help keep the appointment in focus. Participants were busy people, and reminders helped check on the status of the appointment. Reminders of the agreed arrangements allowed for prompt rescheduling if circumstances changed. Expressing a willingness to cooperate built a trust with participants.

The purpose of the study and a brief profile of the researcher were primary interests of the participants. Participants agreed with the value of the study and were willing to share their experiences. The initial interviews and teacher follow-up interview were semi-structured with open-ended questions. Questions prepared in advance guided the interviews. The prepared questions were then adapted for clarification and further information depending on the responses from the participant being interviewed. QuickTime Player Audio Recording was used to capture the interview, and a printed copy of the interview questions was used for note-taking to ensure each interview was captured accurately. Researcher notes were kept throughout data collection to remember thoughts as the study progressed. Validation of the findings was enhanced through analysis of multiple sources of data. Rich, thick description emerged. Confidentiality of information shared for use with this study was assured to each participant. Two of the three student participants and the teacher voluntarily contributed additional artifacts to enhance understanding of the data collected. These included a syllabus, a blog, and a final paper. Each was asked if there was anything else they would like to share pertaining to their experiences with the design of wearable technologies and they all felt the recorded responses and offered artifacts were sufficient. At the end of each interview, the audio was reviewed, additional notes taken, and the recordings were reviewed to determine if the audio was clear for transcription.

For the initial interviews, a printed copy of the Interview Protocol was used to keep notes of any feelings or thoughts in the margins during the course of data collection. After each interview, the recordings were listened to with any additional notes being added to the margins of the printed copy of the Interview Protocol. The files were then transferred from the password-protected computer to a password protected external storage device. Once the files were transferred, they were uploaded to the transcription service through a secure connection. The transcription service had a turnaround time of 2 to 3 business days after which they emailed the text file(s). Automatic Sync Technologies was chosen to transcribe recordings. A Confidentiality Agreement (Appendix H) was provided by this professional transcriptionist service.

Upon receipt of each transcript, the text files were reviewed against the original recordings to ensure the accuracy. The teacher interview was deemed inaudible by the transcription service and returned. Researcher review of the original audio file found it as clearly audible. Therefore, the researcher completed a transcription of the teacher interview. Each audio recording was listened to while reading the transcript to ensure accurate transcription. Initial coding followed this review. The initial interviews were coded to identify areas for further probing and clarification in teacher follow-up interviews.

The teacher follow-up interview questions were chosen to add richness and depth to the detail and as a way to add validity to the interpretations and themes from the student interviews and the initial teacher interview. The teacher follow-up interview began with a review of interpretations from the initial interviews. The teacher participant provided additional follow-up feedback, which helped to refine the data analysis further.

Data Analysis

The findings in this chapter consist of an analysis of three sets of data: initial teacher and student interviews, and a teacher follow-up interview. Participants' volunteered offerings of additional artifacts were also included in the data analysis. Among these were a reflective blog, a final review paper, and a syllabus. All of these primary documents were grouped according to each participant level. For each document, the selections were read and coded for the two broad categories that related to the research questions, creative thinking and collaboration. This process gave a structure to determine themes and patterns through a second reading of the transcripts. Additional notes were made during the second reading. Personal quotes and artifact details highlighted the captured perceptions of the experiences. As coding continued, recurring perceptions helped determined themes for each research question. Quotations from the transcriptions were preliminarily sorted within these determined themes. The highlighted personal quotes and artifact details were used to enrich interpretations of the themes and patterns discovered during data analysis. To review my note taking from the initial interviews, the audio recordings of the participants were listened to while reading the transcripts as a way to contextualize all the parts as a whole. This initial interpretation helped form the interview questions for the follow-up teacher interview. A multifaceted examination ensued of collected data derived from all interviews and artifacts.

Themes and patterns began to emerge during the second review of all the collected data. Additional note taking in the margins of any feelings and thoughts associated with any participant or verbalization was continued. At the second level, data were examined across the student and teacher interviews, and the additional artifacts to determine emerging themes and discrepant cases. Key findings were developed from this examination. These findings were presented in relation to the research questions for this study. The subsequently determined themes and patterns were then organized under each research question in the following section.

As themes emerged, and connections began to form, data that was significantly different from other participants' perceptions were used in contrast and as a way to broaden the perspective of collaborative and creative thinking skill development through the design of wearable technologies. "Discrepant cases were identified and explored through the follow-up interviews as a way to check for possible bias" (Maxwell, 2005, p. 244). The discrepant information helped form the follow-up questions with the teacher to aid in creating a broader understanding of the perceptions on collaborative and creative thinking skill development through the design of wearable technologies. This information increased the confirmability of this study.

Discrepant Cases

Sampling in this qualitative study was small. One of the limitations was that only three students and one teacher chose to participate. A sample of two teachers and eight students who participated in a wearable technology integrated curriculum in a Rocky Mountain state was the population from which the participants were drawn for this study. Because I had a small group of participants, it is difficult to make generalizations. Throughout the analysis and reflection of collected data, no difference in perceptions on creative thinking and collaborative skill development through the design of wearable technologies of students was noted within themes and patterns. No discrepant cases were found within this small group. Participant accounts were consistent given exploration of only one teacher and three student experiences. Insights can be gained, but further study will be needed. As an emerging educational Mindtool, wearable technologies are expected to find mainstream use in 4 or 5 years (NMC Horizon Report, 2013, p. 5). These participants could be considered an outlier representation of wearable technologies potential. Through analysis, within and between all collected data, transferability of the findings for future studies was increased.

A difference was revealed between the pre-existing knowledge bases of the student participants. Backgrounds ranged from programming ability, artistic aesthetic expertise to traditional crafting upbringing. This difference was used to highlight the range of student and teacher perceptions through their experiences. While each student perceived the improvement of collaborative and creative thinking abilities, the development of these skills varied with individual’s needs and prior experiences. Whereas Scott was a communications student with an affinity for computer programming, Sally shared roots in traditional crafting talents encouraged throughout childhood, and Sarah had academic knowledge and expertise in artistic aesthetics. When compared, the incongruities became clear as each recognized the expanding needs of their collaborative and creative thinking skill based upon necessities for knowledge growth. Similarities and differences among the participant responses and artifacts added a richness of detail and depth to the exploration of their experiences.

Evidence of Trustworthiness

Credibility

Collected data from each interview were thoroughly explored to understand the perceptions during the experiences of each participant. Through the depth of detail, internal validity was enhanced (Miles & Huberman, 1994) as each transcript was examined (Maxwell, 2005). All initial data were reviewed and coded to help determine the teacher follow-up questions. Moustakas (1994) suggested participant information be reviewed and probed further to clarify and validate the data. These teacher follow-up questions were then used as a way to further probe and clarify any statements from all participants. During the teacher follow-up interview, interpretations from all initially collected data were shared with reasons for selecting certain additional questions. The expanded timeframe between initial and the follow-up interview also increased credibility of the data as it allowed the teacher time to reflect. “Each participant may also feel more valued by being provided with the opportunity to be an active part of the research process” (p. 110). Credibility of the study was increased by teacher participant opportunity to clarify initial analysis through follow-up interviewing.

Validity of the interpretation was enriched through triangulation of all collected data. Triangulation occurred through the compilation of personal perceptions collected from each participant, the multiple perceptions of two types of participants, and the inclusion of a follow-up teacher interview based on the researcher analyzed initial responses from all participants. Within the compilation of personal perceptions collected from each participant, volunteered artifacts directly relating to the interview questions were offered to enhance individual's contributions to the study. Both teacher and student perceptions were included as the two types of participants. This inclusion of multiple data sources enabled each participant's responses to be confirmed in different contexts and at different times.

Dependability was enhanced through triangulation and verbatim transcription. Accurate records of procedural dates and times, with any additional details, were maintained. This increased transparency and possible duplication of study. The secure access and use of Microsoft Office Suite for managing and coding of data added to the integrity of the study.

Transferability

Yin (2009) argued that transferability is dependent on the conceptual framework of the research study rather than the number of cases. Yin noted replication could be achieved with only a few cases. Merriam (2009) suggested several strategies to enhance transferability of a qualitative study: (a) thick description, (b) maximum variation in the sample, and (c) characteristic of the sample.

A strategy to enhance the transferability of this study was the use of rich, thick description. This type of description was used to find rich themes that provided insight to others. Individual participant data were explored and described to add depth of understanding and increase transferability. As themes and commonalities were identified, data were explained within the context of the individual responses and artifacts as well as in contrast to other participant perceptions within the study. If a theme emerged describing a preconceived idea of influence to a participant in perceiving collaborative and creative thinking skill development that contrasted pointedly from other data collected, contextualization within the selected participant interview offered connection of emerging themes in a meaningful manner (Smith et al., 2009).

The details obtained from researcher analysis of initial interviewing, participant volunteered artifacts, followed up by further clarifying and probing with the teacher, increase transferability of the findings to suggest the design of wearable technologies for collaborative and creative thinking skill development in educational curricula. A rich description provided by a narrow population could promote transferability with a more significant sampling. The results of this study could advocate social change in other areas to promote understanding for the value of art in education. Due to the narrow participant selection, transferability of results to a similar institution may not be feasible. However, the findings may indicate the necessity for further studies. For this study, the concentration was on the depth of data analyzed from the perceptions of the participants (Moustakas, 1994).

Transferability of the results from this study may affect future educational decisions toward wearable technologies as an integrated curricular art and STEM practice. The information added to the field from this study will share perceptions from a certain group on collaborative and creative thinking skill development through design of wearable technologies. As the study participants were in an educational setting, this might provide relevance of the findings to other similar institutions. Insights from this study may also help to develop educational policy by informing upon the value of arts. An exploration into the perceptions of teacher and student participants supports further understanding of the skill development of collaboration and creative thinking. The exploration chosen contributes to the identified gap that persists for determining the value of art for the future of innovative workforce success.

Dependability

All participant interviews were recorded using QuickTime Audio Recording and Skype or telephone. Each file was transcribed verbatim by a professional transcription service. Each audio file was checked against its transcription to correct any mistakes to further improve dependability of the study. Each file was labeled with the date the interview took place and other organizationally identifying information. After each transcript was checked and corrected, it was coded using Microsoft Office Suite. Within this comprehensive tool, all of the codes were created, managed, and organized by participant. This coding process within Microsoft Office Suite further improved transparency of the data analysis. Data were continually secured, and password protected throughout all reviewing and coding.

Confirmability

Feelings and thoughts were noted in the margins of each printed interview protocol copy and throughout coding of the data to establish confirmability. Practicing in advance with other PhD colleagues and candidates helped build confidence toward the interviewing of actual participants. After these practice sessions, I received valuable feedback to implement for improvement in my participant interviews. Notes and collected data were continuously reviewed during coding. As themes and patterns developed from the initial interviews, interpretations were repeatedly checked to form the teacher follow-up questions for further probing and clarification.

Results by Research Question

This study was conducted to provide insights into collaborative and creative thinking skill development through the design of wearable technologies. Insights from this study may aid in decision making for school budgets to integrate the arts with STEM curricula. This study analyzed the results of three different sources of data as well as additional voluntarily offered artifacts by some participants to gain an understanding of perceptions on how collaborative and creative thinking skill is developed through the design of wearable technologies.

The results of the study are organized by research question. Data from teacher and student interviews as well as from voluntarily offered additional artifacts were explored to identify themes and relationships among the sources. As this design of wearable technologies opportunity was new to both students and teacher, the learning experience was knowledge building for both levels of participants. The constructivist environment provided participants a collective growth of content within a context. This growth led to similar themes between student and teacher data separated by perspective. The student experiences were individual and personal, whereas the teacher perceptions were whole group insights.

For Research Questions 1 and 2, the following themes were found: *divergent thinking, generating new knowledge, stimulating the imagination,* and *creative climate*. The themes organized under Research Questions 3 and 4 were: *diverse membership, culture of collaboration,* and *community building*. Words, artifacts, and experiences of participants were used to identify these themes and strengthen the credibility of the interpretation.

Research Question 1

Research Question 1 asked: what are students' perceptions regarding the development of creative thinking skills while designing wearable technologies?

Creative thinking skill development, as it emerged through the design of wearable technologies experiences of each participant, was perceived in terms of their capability. All of the participants noted development of creative thinking as the course progressed through individually perceived connections and knowledge building. The background initiation to the development of this skill came from different learning avenues. Consensus on the development of creative thinking being linked to personal interest was expressed. Creative thinking was similarly shared, having been defined by Jonassen (1996) as combining existing information with new to generate knowledge. Any lack of prior knowledge was not perceived by the participants to be an issue. In fact, Sally felt it played well to her inquisitive mindset. The Mindtool of wearable technologies inspired in her a desire to build knowledge in a new and personal way. As a sewing enthusiast, Sally saw ways to enhance her works by incorporating elements of embedded computing in conjunction with her traditional talent manipulating fabric crafts. She shared how the development of creative thinking through the design of wearable technologies changed her mindset:

> Creative thinking has changed me in that all I wanted to do was go back stage and see what kind of computer device she had on her tutu and how it worked and how it was lighting up. And if she turned it on or if it turned on when she zipped it up. Or does it turn on when she's spinning. And I thought of all these different options she could have with those LEDs that were in her tutu.

This course provided the constructivist-learning environment that inspired Sally and others, to combine fashion with technology. The Mindtool of wearable technologies functioned as an intellectual partner by engaging and facilitating knowledge building. Sally perceived the development of her creative thinking through the design of wearable technologies. Wearable technologies, as the Mindtool, allowed information to be taken from unrelated fields, and using technology, apply it toward knowledge being generated.

Jonassen believed that Mindtools enhanced learning to engage interactivity toward willingness to build on knowledge (1996). The analysis of the interviews revealed that the development of creative thinking was related to the individual's willingness to engage in the learning opportunity. Research Question 1 investigated students' perceptions on creative thinking skill development through the design of wearable technologies. The themes that emerged during data analysis were *divergent thinking, generating new knowledge, stimulating the imagination,* and *creative climate*. *Divergent thinking* was found as the students imagined creative ideas by exploring many possible solutions for their designs. Constantly interacting between their experiences and ideas *generated new knowledge* and meaning. Students were often confronted with questions from within the constructivist context of designing wearable technologies, which *stimulated their imaginations*. Nothing was too impossible to consider attempting in such an open, *creative climate.* Students' perceptions of these themes were shared based on each participant's individual personal experience, rather than consideration of the whole student group as one.

Divergent thinking. Spontaneous and free-flowing differing possibilities were a reoccurring thought shared throughout the interviewing process. Expanding opportunities made available as the course progressed contributed to divergent thinking. Divergent thinking was an expression of a willingness to engage in the design of wearable technologies. Engaged students became motivated learners acknowledging their need for growth by seeking knowledge to create connections. Students' role in the design exploration of wearable technologies was transformed through their divergent thinking during the course progression. Students were expected to take what they had learned through the course in addition to any prior experiences and knowledge that they had from their major and hobbies, and create an original project.

Sally, an instructional technology student with traditional crafting talents, shared her perceptions of divergent thinking through her interview and blog. She was inspired to create something different for her project. Looking at her life, she took something personal, her dog, and designed a programmed light up harness for walking together. Customizing the harness combined sewing and embroidery with the embedding of programmable electronic components. Her divergent thought process led to a personal and engaging, original idea. Sally explained:

> I wanted to do something -- this was supposed to be a project where we could just make something useful -- a lot of people made a like a stuffed animal that when you would squeeze its hands it would light up or something like that. And I wanted to do something a little bit different so I made a harness for my dog. And I put the LEDs on the front. And then I embroidered a little flower -- or butterfly, whatever. And then I bought the leash. And I thought when I first bought it, I thought, oh, that'll connect it. It'll be really cool with metal. But then you kind of have to test out the metal. This metal was coated so it didn't conduct.

Sally saw what a lot of people were making for projects and could have mimicked similarly with their thinking. Instead, she “wanted to do something a little bit different.” Sally’s thought process diverged from the thinking of her classmates toward a more meaningful learning experience applicable to her personal life. Sally’s creative thinking developed through her knowledge building with the Mindtool of wearable technologies.

The following pictures showcase the integration of Sally’s sewing talents with conductive thread and a programmable circuit board (the LilyPad) in the making of her light up dog harness. Once she figured out the conductivity connection necessary to complete the electronic path to the harness, embedded LEDs (Light Emitting Diode) would light up when the handle of the leash was squeezed.

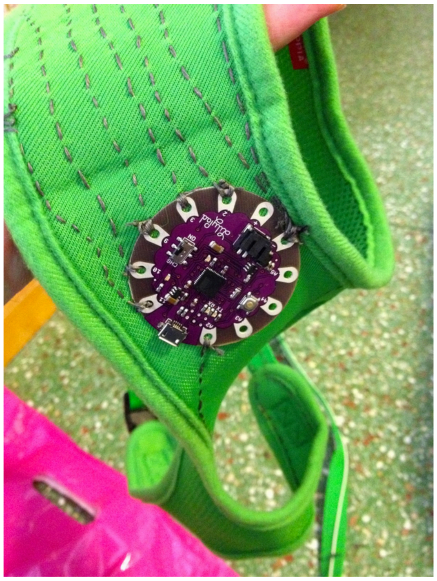

Figure 1. A LilyPad circuit board with conductive thread sewn onto a dog harness

Figure 2. The wearable technology dog harness design in progress

Figure 3. The dog harness leash electronics layout

Figure 4. The non-conductive metal coated dog harness leash clip

Figure 5. The squeeze sensor for activation of LEDs on the dog harness

Sally's "a little bit different" creation of the light up dog harness showed divergent thinking in relation to what she shared as the creative thinking direction of "a lot of people." The differing possibilities of this Mindtool can provide personalization to learning through constant interactivity with the constructivist-learning environment. This Mindtool allowed Sally to use her existing knowledge in the adapted constructivist-learning environment with a computer-based tool to design divergently. She customized her wearable technology project to be more meaningful to her life. The programmable computer-based tool (the LilyPad) and the constructivist-learning environment involving stored knowledge (the sewing) worked with the learner (Sally) as intellectual partners to connect and develop her creative thinking.

Sarah, an art major, described her experience of feeling her mind opening to any possibilities that presented themselves. Her thinking showed divergence through inspired discovery of the potential for the design of wearable technologies to augment her existing artistic endeavors. She saw the capability to explore with this Mindtool in creatively different ways from previous artistic explorations. Through examination and contemplation her desire to engage in constructing new knowledge was enhanced with divergent thinking. Sarah explained:

> You might be able to either come up with an idea of your own, something that's a spinoff, or maybe just one little curve of something can make you think of something that's completely awesome that you want to make.

Her insights into divergent paths that could be pursued showed a development of creative thinking from a realization of potential options through the design of wearable technologies. Divergent thinking was used to generate creative ideas by considering many possible solutions.

Scott pointed out that the realm of possibilities expands in a constructivist-learning environment with such a Mindtool. In consideration of the expertise brought by all the students in the class toward the free-flowing and spontaneous thinking that occurred, Scott remarked:

> Some of the most interesting projects came from these people who were in the middle and were completely new to everything and didn't feel like they were very good at electronics and didn't feel they were very good at crafting but had this kind of closet desire to become crafty or that where they didn't have the confidence, who were coming up with really cool ideas and because they didn't have knowledge on either end of the spectrum, they were willing to talk to people and try and get it--get it going.

Scott found inspiration from individuals “completely new to everything” the Mindtool of wearable technologies had to offer. From the crafting to the electronics, confidence rose as “cool ideas” were shared and people’s desire to try constructing new knowledge grew. Since some students had no existing knowledge from “either end of the spectrum” to engage in design that incorporated elements of embedded computing, the willingness to think divergently grew.

Each participant perceived divergent thinking as a vital part in the enjoyment and success with this Mindtool. Students showed divergent thinking as an approach to circumstances, which focused on investigating multiple possibilities toward a personalized idea. Students’ divergent thinking allowed thoughts to drift toward many different options, iterations, and ideas relating to the concept. Divergent thinking can be used as an approach to creative thinking in a range of innovative settings, from businesses to classrooms, by allowing individuals to imagine any option, head off in any direction, and purposely diverge from the traditional.

Generating new knowledge. Participants seemed to be aware of the impact creative thinking skill development had on the challenges of knowledge building through the design of wearable technologies. A common challenge of learning through a Mindtool is the engagement and facilitation of reasoning and complex problem solving (Jonassen, 1996). E-textiles is the designing of programmable garments, accessories, and costumes that incorporate elements of embedded computing, novel materials, sensors, and actuators, as well as traditional familial learning of fabric crafts (Kafai & Peppler, 2011). As a Mindtool, the computer-based tool and learning environment becomes an intellectual partner with the learner (Jonassen, 1996).

Each of the participants expressed the challenge of design when computers and materials are integrated. Struggles were shared about working with different elements together. Just as these students were expecting an elective course to learn a technology tool, they expressed a level of rigor to the detail required for even a partial success. Creative thinking took students beyond accepted knowledge to generate new knowledge (Jonassen, 1996).

Being interested in the maker community and the idea of fab labs, Scott reflected on his perception of successful knowledge building:

> We did the first project where you've got the sensors. Where you can make a little stuffed animal and put push sensors in and the lights light up and do different things. We did that one and it was kind of a paint-by-numbers version. But one of the things that you could do to customize it was make it a different shape or provide different ways of doing it. Using the wires and sewing stuff and stitching things together and using just all of that stuff that I was unfamiliar with. I did it--I had a physical object in my hand that I could say you know I made this. It sucks, but I made it. It was just really something. It was a personal victory.

Despite Scott's existing knowledge not being enough, the generating of new knowledge concerning the elements and design of the project deemed the experience a personal success. He saw the scaffolding occur that continually generated new knowledge. From a confidence building "paint-by-numbers" beginning to the allowable customization of further endeavors with the Mindtool of wearable technologies. In his final paper, he shared in more detail on the learning experience:

> The overall experience of the project was very positive. I learned how to solder—a skill that I've wanted for years, but been too scared to try. While my desired result required more skill than I started out with, it no longer gives me anxiety. The programming problems were very disappointing, but I'm glad that I was able to finish the crafting of the physical object. I think that I would not have counted it as a positive experience had I got the programming working but not completed the construction of the pyramid.

Scott's willingness to engage in generating new knowledge developed creative thinking in directions not ventured before. His desire to push his existing knowledge further grew. The problems proved challenging but surmountable through the construction of required new knowledge. Frustration in learning seemed tempered with celebrations along the way.

Sally reflected in her blog how the development of creative thinking led toward the scaffolding of new knowledge during her wearable technology design learning experience:

> My creative thinking along with this course has sort of expanded. I've got now that next step of scaffolding where I can say, well I know how to do this. You know, here's my crafting. Here's my technology. Well, now I can make something new. And I can make it colorful and I can make it fun because it's right up the alley of what we're learning and how we're creating new things with the wearable

> technology. I was able to understand the connections better this week; that is the connections I created with the conductive thread from the Tiny Lily to the LEDs. Stitching the initial lighting connections made more sense, I think because I could draw them out before hand, and we had a chance to test them with the alligator clips ahead of time. If I can see how something works and then get a chance to sketch it out I think I can make the jump to the next level of the actual connectivity between the battery and programed Lily to the lights.

Sally perceived the generation of new knowledge as the development of creative thinking. The challenges in learning with this Mindtool were deemed necessary for her feeling of success. By building a bridge connecting existing knowledge she envisioned new construction possibilities. With her "I know how to do this" feeling growing; Sally's creative thinking became free-flowing. The generation of new knowledge through the Mindtool of wearable technologies allowed Sally to create "colorful … fun …. new things" because it was "right up the alley of what we're learning."

Sarah, shared how she saw new knowledge generated through her several iterations on the design and redesign of a wearable technology:

> Well, I'm designing this little stabby doll. So I'm doing another iteration because that was, like, really difficult to do - It was way over-engineered for what it needed to be - For example, it doesn't need a computer. It just needs a battery. So I didn't know that at the time, and I've been redesigning a new one, and just to run the conductive thread or the traces, I've drawn. I, Like, I drew out a picture, added where I wanted the LED's, where I wanted the batteries, where I wanted the

> conductive patches for things to connect, and then try to figure out how the heck I'm going to connect them with the conductive thread without crossing any of the thread over. It took me five times. I've got all five pictures still because I'm hoping to use it, that example of, yes. Maybe that first time that you draw it, it's not going to actually work out. Maybe it's going to take you five times to draw it.

Sarah confronted the struggle of generating new knowledge as a development of creative thinking. Wearable technologies changed Sarah's perception of what creating a piece involves by taking ideas to places never thought of before. She became sensitive to the problem, the "over-engineered" doll, realized its deficiencies and desired to redesign a new one. Through acknowledgement of the disharmony with the original construction, she set out to identify difficulties and missing elements, searching for a solution to fill the knowledge gap. Sarah made guesses, modified, tested, and retested until she could finally communicate the results.

Jonassen (1996) reasoned that a constructivist-designed learning environment supported learning through the active creation of knowledge across domains. This Mindtool motivates learning through adjustable task difficulty, acceptance of alternatives, and scaffolded knowledge growth opportunity. The merger between fabric and electronic elements enables computing and electronics to be incorporated as wearable technologies. Students build knowledge from experiences during the learning, not solely from prior facts.

Stimulating the imagination. Imagination and creativity thrive within constraints (Root-Bernstein & Root-Bernstein, 2009). Constraints that were part of the course design, as learning environment parameters seemed to be accepted by students toward finding satisfaction. Decision-making occurred in cycles and evolved to more context specific decisions throughout the course progression. Jonassen believed that learners should be provided with intriguing, authentic, and motivating problems to solve (Jonassen & Reeves, 1996, p. 718).

Scott expressed how his creative thinking led his decision making to be specific to problem solving engagement. His imagination was stimulated by relevant and interesting learning opportunities through the exploration of e-textiles. Despite personal hesitation toward the unknown, the desire to engage with the Mindtool of wearable technologies stimulated his imagination to be “more ambitious” and “try a lot of different things.” Scott shared:

> It took me towards my insecurity at the time. I was scared to try a lot of different things. But as soon as I got past some of the fear… I bought a soldering iron I got some circuit board stuff and some solder and started trying to rig different things together. I went to the local thrift store and I bought a bunch of electronics and I started de-soldering parts and pieces off of it. And it was just like, it was this fad over a weekend where I just--where I had kind of wished I had that kind of stuff, but I didn't know where to start. It was like where I finally got to a point where I wasn't as scared anymore. I decided to do a more ambitious version of the fabric piano and integrate the strip lights I had purchased earlier in the semester.

As constraints were diminished, creative thinking expanded toward a growing feeling of success for interesting decision-making. Scott’s imagination had been stimulated by the

Mindtool of wearable technologies to such an extent that he “wished [he] had that kind of stuff” earlier. The Mindtool of wearable technologies provided him with a starting point to imagine “trying to rig different things together” through e-textiles. As the course progressed so did his development of creative thinking as new problems stimulated his interest and engagement.

Possibilities opened to stimulate Sally’s imagination as the course progressed. She found the stimulation of her imagination from the Mindtool of wearable technologies led to creative thinking skill development. Sally reflected on her knowledge expansion through connectivity and inquiry. Wondering what would happen if she added programmable electronic components to her sewing and embroidery stimulated her imagination in new directions. She expressed:

> It opened a whole slew of doors of what could possibly be. I think I looked at what I had been creating, which was, like I said, sewing and embroidery and things like that. And it sort of took it up a notch where I went what if I did this but -- oh, wouldn't it be cool if I added a string of lights to it? And then it could like light up if you step on it. Or it could light up if you, you know, if you're wearing and you zip it up. Or something like that. And I think it's really interesting.

Sally understood the potential of this Mindtool to steer the development of her creative thinking with technology-supported, problem solving pursuits through such an open-ended learning situation. She saw how taking traditional crafted materials and integrating them with programmable electronic components could add further dimension and interactivity to her creative thinking. Sally perceived that the Mindtool of wearable technologies “took it [creative thinking] up a notch.” The role of a Mindtool was to enable constructivism toward the enhancement of cognitive functioning and knowledge building (Jonassen, 1996). Sally considered her knowledge expanded through connections, inquiry, and reflection.

Sarah expressed the stimulation of her imagination by the creative thinking all around her throughout the course. Her mind desired to delve into all the ideas she saw to remix within her creations. This Mindtool provided questions, problems or projects that she was willing to unravel. Sarah explored and integrated nuances of other’s wearable technologies into her workings. She perceived:

> You can look at something and be, like, wow, I just love how they do this. How can I use it in my own stuff? So, to me, a lot of it's just researching what other people have done, getting inspiration from that, and also, you know, working, not working with but just being inspired by what people are coming up with and be, like, oh, I can totally do that.

Sarah was inspired by the potential of wearable technologies through all she saw being created with this Mindtool. She became engaged in her learning for the “love” of enhancing her personal interests with new artistic aesthetics discovered through the Mindtool of wearable technologies. Her personal interest in the problem drove her toward a goal and meaningful learning.

Constructivist-learning theory values a problem that is owned by the learner (Jonassen, 1999). The constructivist-learning environment and instructional design should address context, representation, and space to facilitate knowledge construction and meaning making. Cognitive tools that develop skills, including modeling, support, and knowledge connecting should be included (Hirumi, 2005).

Creativity climate. Harnessing the power of creativity to tackle challenges relies on a well-designed learning environment. The constructivist-learning environment design for the Mindtool of wearable technologies in this course offered applicable and easily accessible information. Social conversation and collaboration tools will support discourse in the learning community for knowledge building and sharing (Hirumi, 2005).

Scott explained the creativity climate as a “direct experiment in constructivist-learning.” He elaborated on the task understanding and planning support of the course:

> It was--I mean, everything about it was—she [the teacher] would introduce it, the concept and she kind of held our hands on the stuff for the introduction and then it reached the point where people were going off in different directions for their own projects where she wasn't the expert in anything in particular other than she knew other people who had tried different things.

Scott does not claim to be “crafty,” but he does “understand a lot of the computer science stuff.” He saw the creativity climate as providing an opportunity for “personal victory over the fear of not doing it right.” The constructivist-learning environment of wearable technologies helped build upon his and other student’s intrinsic curiosities. Scott found the experience transformative resulting in more meaningful learning. Creativity means that a person understands that there can be many ways to approach a problem. Scott expressed how his creative abilities increased when he realized there was more than one acceptable way of achieving one's goals. The creativity climate provided a failure-friendly environment that required creative thinking.

Sally described the creativity climate in support of her ongoing self-diagnosis to a dynamic goal:

> So we started out making bracelets. But that was really cool that I kind of just thought that I could take something, you know, that was simple for me to make, because it was just circles and I was throwing them together. And mine turned out to be more of a cuff, not really necessarily a bracelet. That I could take it and I could make it kind of interactive where when you snap the snaps together, that's your switch to turn it on. And that is really cool for me because I thought, man, if I can do this with a bracelet, why wouldn't I be able to do it with, you know, like a headband or a quilt or something like that? So I thought that was really intriguing when we started off and it ended up just kind of realizing that there are a ton of options you could have with just a few simple LED lights. And kind of something I never really thought about when I was crafting. For me, it was visual. It was tangible. I could create something that was colorful, that was fun. And it could be interactive. And it didn't have to be perfect, but it could be a part of how I work and how I think, if that makes sense. It's -- I think that I'm totally with my creative mind, I'm totally wired for a course like this just because it's something where you have your creativity, but you can expand it.

Her internal dialogues and adaptive support provided a self-monitoring of responsibilities toward her learning experience. The creativity climate provided through this Mindtool guided her desire to encounter and resolve complex, challenging cases. Through her remixing, reworking, and repurposing of knowledge Sally saw how the Mindtool of wearable technologies could expand her creative thinking. She went from crafting being more than “colorful” and “fun,” to also interactive. Sally thought the Mindtool of wearable technologies was intriguing to begin with, but “ended up realizing that there are a ton of options you could have with just a few simple LED lights.”

Sarah found that “being creative can give you more wearable options.” She shared her thoughts on mistakes being opportunities for learning:

> Just, like, by repetition, like, oh, the first one, it would work. It's not the best choice. Maybe if draw it again, maybe I can come up with a better idea or. So I just kept doing that until came up with the best idea. That I could see. So it's, like, once you get to that point, you can always take it to a group of people or one other person and be, like, do you see a way that I can improve this or any way that maybe I could draw more so in the conductive traces thread. Different need to be even a cleaner design.

Her involvement toward soliciting input from one or more people produced a more interpretable view of ideas. The construct of interest around this Mindtool supported Sarah in experiencing personal reflection necessary for meaningful learning. She kept trying to “come up with a better idea” until the point of satisfaction was reached and then she sought additional input for improvement. The design of wearable technologies offered a networked environment that encouraged thinking in the context.

According to Wagner, the most effective tools to design learning and support instruction are those where learning is student-centered for interpreting knowledge (2012, p. 142). "Technologies should not support learning by attempting to instruct the learners, but rather should be used as knowledge construction tools that students learn with, not from" (Jonassen et al., 1998, p. 1). Creative thinking resulted in authentic knowledge building.

The student participants in this study perceived creative thinking as taking a divergent direction to solving a problem, dealing with a concept, or brainstorming with everyone else. The perceived development of their creative thinking tested each individual's traditional knowledge to see circumstances in innovative ways. In Scott's case, he witnessed the development of creative thinking with his divergent thinking as well as in others designing differently from his approach within the same Mindtool of wearable technologies. Sally took her traditional crafting talents to the learning environment and saw how her creative thinking could generate new knowledge through scaffolding in interactive ways. Sarah's imagination was stimulated in her pursuit to discovering many avenues to resolve problems in new and exciting ways. The Mindtool of wearable technologies brought personal joy and perceived success to each learner.

Through the design of wearable technologies learners, were assisted within the creativity climate of this Mindtool in interpreting knowledge in a constructivist-learning environment. Creative thinking was developed using the Mindtool of wearable technologies through divergent thinking, the generating of new knowledge, stimulation of the imagination, and the creativity climate. To assist learners in interpreting knowledge in a constructivist-learning environment, the wearable technology Mindtool facilitated student development of creative thinking.

Research Question 2

Research Question 2 asked: what are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?

Creative thinking skill development, as it emerged through the design of wearable technologies experiences of each student participant, were perceived by the teacher in terms of their capability. The analysis of the interviews revealed that the development of creative thinking was related to the individual's willingness to engage in the learning opportunity. Research Question 2 investigated teachers' perceptions on creative thinking skill development through the design of wearable technologies. The themes that emerged during data analysis were *divergent thinking, generating new knowledge, stimulating the imagination,* and *creative climate*. The teacher witnessed *divergent thinking* in the students' imaginative ideas enhanced by peer input. Meaning making was achieved through the groups' desire to interact constantly with the Mindtool of wearable technologies leading to the *generating of new knowledge*. Inquiry driven constructivist experiences *stimulated their imaginations*. The teacher encouraged students by promoting a *creative climate* in which to take risks and experiment with ideas resulting in positive, innovative experiences. Students were able to make mistakes or even fail completely and still feel like they gained positive knowledge. Teachers' perceptions of these themes were shared based on consideration of the whole student group as one, rather than each participant's individual personal experience.

Divergent thinking. Through the design of wearable technologies, learners explore problems through creative thinking, manipulation, and reflection. Mikropoulos and Bellou (2013) think that the educational contribution becomes more effective when an approach to constructivism involves cognitive tools or Mindtools as proposed by Jonassen (2000). The teacher, Tiffany, shared an example of divergent thinking and the pride it raised as seen in one of her student's explorations through the design of wearable technologies:

> And so I had a student from the College of Business make this amazing something I think for his nephew, uh, one of those little small carpets that has like roads and little houses and stuff designed into it and what he did is he added circuits to it so that, and he added some copper tape to a Hot Wheels and when you drove the Hot Wheels over the roads when it got next to the fire station it would light up. Okay, so he's from the College of Business but to me that felt phenomenally creative that you took this kid toy thing and changed it in a way to make it interactive.

The design of wearable technologies as a Mindtool involved the learner in constructing both a personally designed physical object and building the connected knowledge it took to accomplish the task. This student took something existing "and changed it in a way to make it interactive." She explained divergent thinking in the follow-up interview further with "a student who has different prior experiences will come up with a different kind of thing." Tiffany felt that her students were showing pride through successful divergent thinking with their design ideas. The Hot Wheels project is an example of pride being perceived through successful divergent thinking. "…successful in that students on their reviews say things like how transformative it was, how they were doing things they never thought of before, one of my students thanked me for helping her be brave making circuits." Her students were learning by doing in both the virtual and real world, and they were facing cognitive conflicts and knowledge building through design opportunities. She sees creative thinking as being able to move "knowledge from one domain into another." Tiffany elaborated:

> I think a lot of the creativity comes from here are the things I know, here are the supplies that I could work with, either that I know or are available, what can I do with them. And then when the problems come up, how do I solve those problems.

The divergent thinking becomes apparent when learners explore different options of "what can I do with them." The development of their creative thinking drives them to "solve those problems." Tiffany described:

> If their LilyPad is far away from those patches or from the lights then you often, what happens then is the resistance builds up in the thread and that affects how well things work. Often they have to redo their stitching, test things with the multimeter, figure out what they need to do, do they need to reinforce their stitching with more thread, can we use some conductive fabric tape, can we use copper tape, or a little bit more conductive material, where do you need those, and then just the programming where they want different things. The different lighting patterns and stuff. All the things that seem to come up are so different and it's all the same project, but what students do with it is so different. How many lights

> they have, what their project looks like, how their lights are programmed with different patterns.

She summed up her perception of learner divergent thinking through the design of wearable technologies as “it’s just really cool what people come up with.”

Constructivism is an educational theory that suggests learning is the building of knowledge structures by the learner through interaction with the environment (Jonassen et al., 1998, p. 1). Learning is the building of knowledge structures, not just the obtaining of knowledge. The constructivist design for learning requires “interaction with the environment.” Jonassen believed that because emerging technologies available for learners’ environments go beyond just a computer, possibilities for student-centered designing are exponential (Jonassen, 1999, p. 215).

Generating new knowledge. The design of wearable technologies, as a Mindtool, engaged learners to bring together existing knowledge with new information in innovative ways. Traditionally rigor was associated with mastery of content alone. Knowledge can be built upon as information changes constantly. Learners need content knowledge within context to apply and transform their knowledge for skill development toward creative thinking (Bellanca & Brandt, 2010, p. 271). New knowledge was generated as circumstances changed. The course syllabus described the potential for generating new knowledge as:

> The course is about designing. In it you will learn to design innovative crafts that bring together a variety of materials, computing, and crafting techniques in innovative ways. It’s about creativity and personalized design with materials and

> techniques new and old. Along the way you will learn some things about electricity, crafts, and computing. And maybe even a bit about design, interactivity, and learning.

This course provided support for creative thinking skill development through the generation of new knowledge. It offered the design of wearable technologies, as the Mindtool context for individuals to create knowledge. Through deliberately and actively engaging student to bring together existing ideas into new configurations, creative thinking was developed. Taking risks and experimenting are behaviors that were associated with creativity and innovation. Tiffany explained how the design of wearable technologies as the Mindtool generated creative thinking that was produced by deliberately and actively engaging her students to bring together knowledge domains:

> We go into other projects where they can take advantage of that knowledge. I think the wider, the more materials they get exposed to that allows them to combine things from different domains, from your kitchen, from your bedroom, your yard tools, whatever, party supplies, you can those. And that seems to be, I mean you are making tangible projects, materials are obviously a big deal. That expands upon what they can use.

She saw creative thinking as the generation of new knowledge within or across domains, including spaces, objects, and hobbies, expanding the learning horizon from both within the classroom and beyond. Inspiration could be anywhere. Tiffany described Sally's light-up dog harness wearable technology as an example of creativity involving multiple domains:

I think this is definitely a version of creativity, moving knowledge from one domain into another, so I have a student who is a quilter. So she's really, really good with the sewing crafts and piecing things together and she has a dog and what she thought would be fun would be to make this project where you squeeze two patches and have something light up. She thought it would be really cool to do on a dog collar. Actually, she wanted to do it on a collar and I suggested a halter because she would have a little bit more space. So the two patches were on the loop end of the leash where you squeeze it. We worked this out together, trying to figure it out. So her idea led to okay so how could we do this and a lot of adaptation of the idea. So there is one patch at the top and one on the bottom and when you touch them you are touching both and you can squeeze harder or lighter. That was very far away from the lights, which are all the way away on the halter. She put the lights on the halter and tested them and they all worked. And then she had to create this leash and so she, I think, sewed all the way through the leash, but you also had to be careful that the two patches that you touched, they have to go down, the two lines have to go all the way down the leash and not touch because they are two different charges. Then you get to the bottom and the thing is the leash had this hook that, you know, a little clip, that clipped on. It was metal but it wasn't conductive because it was painted over. So at first we thought we could use that as a metal thing, but then we realized we couldn't, but we did want the detachability. So now she has this, and how do I attach this sensor to my thing and one of the things she came up with was that she has a couple of hooks

> and she has like a needle and a hook and eye for both the positive and the negative charge down there on the base of it. Then there are some parts that aren't attached to anything. Like you can't just have loose threads hanging because then they're not insulated. So they'll short circuit out. So she made these cute, just took this darling little fabric, sewed it and turned it inside out and made a little tube and used that and it was really cute and it was extremely well crafted and it worked perfectly. So to me that was just creative. It wasn't like she was conscientiously saying ooooh what can I do to combine my quilting expertise with this new e-textile stuff. It was just that she had skills at her disposal in regard to sewing, materials for sewing, and those sorts of things and she was able to utilize those in solving a problem.

Sally's design enhancements to her existing knowledge generated new knowledge through interactivity. She was able to take skills she had previously gained to assist in solving and adapting to new problems. The challenges encountered through the design of wearable technologies scaffolded Sally's generating of new knowledge. In the follow-up teacher interview, Tiffany added further to thoughts about her students making connections from different knowledge domains:

> They brought expertise with them and that gave probable influence to their creativity. It just depends on the kind of courses they had, or the particular instructors. I learn creativity for myself from education courses. I've never had an art course so I can't even speak to that. I've learned a lot extracurricularly (sic). Creativity is so disciplinarily defined. Creativity is within a domain and someone

> who is creative in one area may not be creative in another area. It is valued in contrast to what has been there. How people evaluate something as creative just depends on what they think is creative. Some things certainly help, being able to bridge different domains and for that you need to frame things as relevant to each other. Or you are just the kind of person who sees the link. It could be domains that you cross in your own life, so say there is something I have expertise in one area and then I find it relevant here.

Evaluation of the Mindtool spurred students to rely on personal expertise to help bridge different domains and frame creations as relatable and creative. Individuals need to feel free to act creatively and innovatively. Tiffany viewed the act of defining one's problem and setting goals as an important part of being creative. Tiffany saw in Sally, and other students, the motivation to think outside the box to make new and interesting connections, links, from multiple knowledge domains.

Stimulating the imagination. Seemingly trivial imaginative inclinations can cause individual and organizational innovation. A readiness to embrace change opens individuals to new possibilities and a willingness to face unavoidable quirks of life (Bellanca & Brandt, 2010, p. 271). Tiffany reflected upon how the course constraints changed over time and what it meant to learner response:

> Given that adaptation to what you have available. And as we progressed throughout the course I give fewer and fewer constraints. Which can often be a really big challenge for students, sometimes they come up with projects that are really too big or they don't realize how long it is going to take or they don't

> realize that someone hasn't really done this before or not in this specific way. They have to work out those challenges. That gets them to be a little bit more playful with what they use. They think a lot about a human computer interaction.

Learners were empowered to be more productive and creative through the design of wearable technologies as the Mindtool. As Tiffany eliminated constraints and judgment, students' creative thinking expanded. Through new ways of tackling old issues, and constructive practice of ideas that may or may not be practical, students discovered their impact on each other. The development of creative thinking, allowed students to find interesting and innovative ways of resolving original problems. Forward-thinking economies and innovative businesses progressively acknowledge employees who can adjust and promote the ideal of an innovative workforce. Stimulating the imagination enables learners to customize their work and respond to expectations through creative thinking. (Partnership for 21st Century Skills, 2013).

Tiffany shared an example of how, through the design of wearable technology, students' imaginations were stimulated:

> A lot of creative thinking comes in so let's say they want to make a stuffed doll. Then they have to figure out even just spatially and logistically how to put the circuits on one side or the other. Do they want their computer LilyPad hidden or visible? They have to think about how they are, where they are going to squeeze, like, the patches. So I tell them, think about where you want those patches. If you are wearing something where do you want it on your body?

Tiffany saw in her students the capability and developed ability in learning to imagine the possibilities and then customize to fit circumstances. They adapted their knowledge as creative thinking developed. Figuring out the different directions possible toward a personally perceived successful outcome stimulated the students' imaginations. The design of wearable technologies as a Mindtool favored an emphasis on development of the individual through the discovery and exploration of a creative idea.

Creativity climate. The learning environment in Tiffany's course encouraged risk taking and active meaning making. Students were encouraged to ask questions, offer their ideas, discuss their understanding of the principle, give feedback to each other, and create and share their thoughts and opinions. They were invited to reflect regularly on their learning, and the teacher was a model of reflective practice.

Tiffany shared how her students openly and regularly reflected upon their learning. The feedback sessions were perceived as positive influences on the design of Sally's dog harness wearable technology in particular. She shared:

> They [the students] would give feedback in the moment. Certainly, I would give a lot of feedback because I have a lot of experience. So like the girl with the dog halter, we brainstormed that together, but we also did some of that out loud, so that other people could…I haven't done a formal analysis of who learned what, but we know that knowledge diffusion happens. Ideas spread just from seeing them. Humans are very good, I mean, children, that's how they learn. They watch and they imitate. And they learn with things that often become internalized afterwards. That happens a lot. We do that a lot for the final projects, which are

> longer and they get help from one another. That has been really, really important. A lot of students struggle with just having ideas of what to do. Once they see other peoples projects they go, “oh that was cool, I could’ve done that, like that is actually doable, that is within my skill set, I could’ve done something like that. And so you see more throughout. Not everyone is like that, but a lot of people get ideas.

Her modeling of reflective practice by brainstorming with the students helped build a trust to the risk taking of “putting oneself out there” which helped build the creativity climate for the design of wearable technologies. The feedback was a shared effort toward improving the overall outcome for a learner perceived successful solution. The “struggle with just having ideas of what to do” was perceived by students as surmountable through the shared creativity climate.

Personal invention and innovation involve problem solving from one’s heart as Tiffany expressed with this thought in reference to the Mindtool of wearable technologies, “That’s one thing I love about this. It’s guaranteed to go wrong somewhere and you have to figure it out.” In a traditional course, learning relies on observation, brainstorming, and trial-and-error to develop creative thinking. Problem solving with the Mindtool of wearable technologies provides steps to close the gap between what is and what could be. She explained how the design of wearable technologies as the Mindtool sets a learning climate allowing for creative thinking to develop from the many potential designs options and solutions of wearable technologies:

> One of the really exciting things that I find about this is that the aesthetics and personalization really helped people learn the technologies, the circuitry, the programming, that closeness of how those all relate together is what makes it a really awesome tech activity. The personal ownership and that aesthetic component are a big deal. If I just gave everyone, and made this project saying exactly how it would be done, they would learn something by it, but it's not just the same as in a sense, creating your own problems. And learning from that.

Ownership of the problem and the ability to aesthetically adapt this Mindtool led to a personalization of desired learning. The closeness of how all the elements to the design of wearable technologies relate together is what builds the excitement through this Mindtool.

Designing a creative climate produced many interesting ideas and solutions from which learners selected the most promising. Providing the design of wearable technologies as a Mindtool invites divergent thinking. Brainstorming, such as was shared between Sally and Tiffany about the design of the wearable technology dog harness, helps explain a range of approaches to suit different customizations. The combination of technology and traditional knowledge works well together. Mistakes were seen as growth opportunities, rather than failures. Problem solving through active learning enhances personal perception of success. Students were engaged in the learning process, constructing meaning both individually and collectively. Once a learner is given the opportunity to explore their learning preference, they can work on expanding the ways to reach perceived personal success.

Through the design of wearable technologies as the Mindtool, creative thinking is developed. Mindtools stimulate the imagination and spur development of creative thinking. Students existing knowledge from every aspect of their lives is drawn upon to give personal meaning to the learning. Different domains of knowledge are connected through stimulation of the imagination to generate new knowledge within the creativity climate.

Research Question 3

Research Question 3 asked: what are students' perceptions regarding the development of collaborative skills while designing wearable technologies?

The problems that have an impact on the future of innovation for the world are complex, but increasingly these problems are addressable through scientific pursuit (Falk-Krzesinski et al., 2010). The complexity of these problems necessitates cross-disciplinary engagement and collaboration. STEM addresses science, technology, engineering, and math. The missing component that could raise the engagement of learning is art (Guimerans, 2012).

Wearable technologies as a Mindtool brought the challenge of design to the environment, building knowledge through opportunities for personalization and customization. Businesses are exploring the concept of artistic contexts to serve as learning tools for the enhancement of skill development for building ability in areas such as collaboration (Americans for the Arts, 2012). An economic trend is towards real-time, spontaneous collaboration (Rosen, 2009, p. 9). Students with diverse backgrounds, different prior knowledge, and various experiences were participants in the design of wearable technologies. Participation can be simultaneous, instead of passing instructions through levels and functions for others to implement (p. 11). Wearable technologies, as a Mindtool, allowed free-flowing, interactive participation from a diverse community, toward the building of a culture of collaboration. Rosen believed collaboration was significant in sparking innovation (p. 11).

Collaborative skill development, as it emerged through the design of wearable technologies experiences of each participant, was perceived in terms of their capability. The analysis of the interviews revealed that the development of collaboration was related to the individual's willingness to engage in the learning opportunity. Research Question 3 investigated students' perceptions on collaborative skill development through the design of wearable technologies. The themes that emerged during data analysis were *diverse membership, culture of collaboration,* and *community building*. A *diverse membership* meant students found opportunity within the group to leverage different opinions and outlooks for the design of their wearable technologies. The *culture of collaboration* allowed for changes in designs as well as options for one's work. *Community building* offered authentic learning through common interest relationships. Students' perceptions of these themes were shared based on each participant's individual personal experience, rather than consideration of the whole student group as one.

Diverse membership. Students saw diversity as an avenue that allowed viewing in a different way. A diverse membership highlighted that no two people were the same and learners had different needs. Individuals needed an understanding of issues that affected them and others. They needed to work collaboratively and be able to learn from others with diverse cultures and backgrounds. Through the design of wearable technologies, collaboration was developed by individuals' desires to discover options seen by others. As a Mindtool, wearable technologies added enticement to learning with the integration of art. In relation to this Mindtool being enticing to a diverse population of students, Scott offered this description in regards to the students enrolled in the course:

> We were so diverse. I mean there was a huge group of people from a lot of different backgrounds. There was an amazing variety of people that showed up. You had people from lots of different majors, you had undergraduates and graduates, you even had a teacher who was willing to say, you know, I don't know, let's see--let's do this and see if it works. We had people who are very crafty and not that comfortable with electronics and then--and there were like people who are really comfortable with programming and electronics who haven't crafted before. There was a lot of expertise. But no one was really solid on both ends and so that, the whole student body played well because we had such a good camaraderie and people were willing to help. And it was these times that allowed us to be vulnerable and to also be able to recognize that yeah, I think you've got the skills that I don't have. So you're valuable to our community and can help me with this and I'll help you with that. There's a lot of give and take that way I think. Because it was so diverse and because there was such a disparity on different things that we were trying to do both crafting and electronics, people would come up with the idea that they wanted and they would have to talk to other people who were the experts in whatever area it was and then figure out how to do it. We were

> able to kind of give a different perspective. There was a little bit of cross-pollination going on.

This is evidence of individuals' desires to meet, get to know each other, and come to learn from others with varying experiences. The design of wearable technologies enabled a positive experience through diversity. The different elements of learning within this constructivist environment meant everyone was both an expert and a novice. Shared vulnerabilities led to collaborative knowledge building among learners as well as increased confidences through the design of wearable technologies. The diverse perspectives from different learners fostered the growth of ideas. The Mindtool of wearable technologies nurtured development of collaboration through a diverse membership by encouraging a desire to seek other's input toward construction of an idea.

Sally echoed Scott's thoughts by sharing her appreciation for the diverse membership that made up the collective knowledge building of this course:

> We had a lot of students in this course from a lot of different areas; family consumer and human development, engineering, math, business, and there was a journalism and communications student, I think, as well. It's really cool to have that many backgrounds come together and kind of form community learning that's so important. And that's why it's so fun.

The bringing together of so much diverse expertise, expanded through the opportunity to share inspired learning, made the design of wearable technologies as a Mindtool to be deemed "fun." Collaborative skill development from such a variety of individuals became a means to an end in figuring out how to solve problems. The global community even contributed to Sally's wearable technologies experience through information shared over the Internet. She explained:

> I must say that the programming was great fun once I figured out exactly what was needed. The blinking patterns were actually pulled from a project of a gracious someone online. I pulled their code in and fit it to what I needed. Thank heavens for kind crafters everywhere!

Her resourcefulness to find a like-minded community on the Internet extended the range of diversity outside of the immediate classroom experience providing an even wider variety of perspectives. This is evidence to the development of collaborative skills through the design of wearable technologies. With many different points of view and cultural experiences, Sally's needs were better served by more people thinking of interesting solutions. Finding commonality within a diverse membership builds a personal bridge toward expanding upon a shared interest.

Sarah saw this Mindtool as a game changer to equal involvement of diverse individuals in gaining knowledge together. She shared:

> And it's not as threatening, and, like, most, yes, boys will sit there when they're, like, 10 or 11, they'll stay at home, and they'll sit there and program for the fun of it, but girls are, like, why should we. There's no inherent gain to them. So by saying, hey, what if you can make a tiara that has LED on it, and glitters whenever you spin around or something. That flashes whenever you spin around. Like, that, having an inherent gain, having something that you can work toward, that's what gives meaning. That's what gets people into it –

Sarah appreciated the aesthetic artistic opportunities available through this Mindtool as well as the technical programming capabilities it allowed. As an art major, she saw the beauty in the bringing together of multiple domains from a diverse membership for a positive experience. Bringing together various views, created favorable conditions for learners from different cultures, backgrounds, and experiences to collaboratively create something together.

The design of wearable technologies as a Mindtool enabled a diverse membership of students to engage in discussions in which they shared and solved problems. The design of wearable technologies as the Mindtool provided the context for problem solving constructively, which is necessary for relationship building within diverse groups of learners. Learning collaboratively in context, building upon each other's diverse existing knowledge became the learners' perceived avenue toward success

Culture of collaboration. Value was generated as obstacles dissolved. Rosen (2009) defined collaboration as "working together to create value while sharing virtual or physical space" (p. 9). Collaboration requires a diverse group of interested individuals and a plan to develop an element of innovative value (p. 10). Rosen believed that for decision making and problem solving to build knowledge, diverse individuals need to collaborate spontaneously. Individuals create value when collaborative efforts and tools build upon existing collective knowledge. (p. 12). As a communications student, Scott saw the transformational potential of this Mindtool in contrast to traditional learning. He explained:

> The idea of crowd sourcing and the social corporations and all these types of things are community connected. I don't know that a lot of people view it that way but I very much see the social part being a direct connection to all these innovations.

Scott understood the value generated through collaboration from various cultures for the future of his and others learning. He further discussed how it developed through the learning environment of this course:

> She's [the teacher] only one person and if everybody had a question or was trying to get it, and she was stuck on the other side of the room going from group to group, either you had to go and then stand and wait for her or you had to figure out who else in the class might be able to help you and when--especially when you realize that, you know, there's--depending on the question, there's a high likelihood that you're going to stand there for five minutes trying to get an answer and she won't have it. So there's the hurdle of depending on the teacher or having access to the teacher's knowledge or maybe pretty good as far as an access to equipment and things like that enable scaffolding our prior knowledge into other things.

The desire to gain knowledge enabling scaffolding of prior knowledge into the design of wearable technologies developed collaboration through impatience and need. Coming together in real-time rather than waiting for somebody else's input built a culture of collaboration for problem solving. Students sought expertise from others' availability and expertise for their design of wearable technologies. In Scott's final paper, he shared some examples of collaborative skill development within the collective knowledge built through the Mindtool of wearable technologies:

> During the semester I talked with Julie and we had an idea to work together and create an interactive grid of LEDs that would produce emergent patterns in three dimensions. This was overambitious for the timeframe and skillset we both had, but together we thought it might be a good option.

Motivation to build knowledge through the Mindtool of wearable technologies raised the personal expectation of problem solving. The culture of collaboration provided safety to push exploration challenges. Scott had another positive experience furthering his development of collaboration on another wearable technology project. He shared:

> Lynn was interested in working with the strip of LEDs I had purchased and proposed that we work as a team in order to create a theatrical piece for an outside project she was working on. I thought that this was a good idea. We worked together for about a week.

Each wearable technology experience Scott shared showed opportunity for different knowledge to be gained together through exploration with the Mindtool of wearable technologies. Challenges provided through the design of wearable technologies allowed learners to share their viewpoints, compare ideas, and work towards building something in the context of a collaborative effort. This culture of collaboration generated new ideas learners had not considered, which allowed for individually perceived better results to be applied to the project.

"Rich, real-time collaboration lets people with a variety of skills and talents in multiple fields and functions come together spontaneously and create value" (Rosen, 2009, p. 22). Motivation that is generated by sharing collective knowledge builds an ability to tap into developing skills (p. 70). Sally shared her experience of relationship building through the Mindtool of wearable technologies as value intuitive toward learning. "That sort of bond you make with your peers when you're going through kind of something where you might not know how to do something." She welcomed the technological, economic, and cultural influences that differentiated the ways people collaborated. A varied group of individuals offers opportunity for more idea generation toward problem solving, developing collaborative skill as an advantage (Rosen, 2009). Students viewed creative challenges differently from their peers. Drawing on the collective knowledge building encouraged through the Mindtool of wearable technologies, the development of collaboration allowed learners to benefit from their differences. Sally reflected upon her collaborative skill development through this Mindtool:

> I think collaboration is awesome in a place where I could really open up and just be creative. Collaboration is so awesome because I have my set of skills. And you have your set of skills. Or, you know, Samantha has her set of skills and Danielle has hers. And we can bring those together and make something really cool and new.

Sally perceived value in being able to contribute and receive support in response. This culture of collaboration encouraged her to "really open up." Everyone had a "set of skills" they could offer as their expertise to share. The culture of collaboration brought together different skill sets to "make something really cool and new." This development supported Sally's learning in new dimensions through the set of skills offered from each different individual.

Wearable technology has shown the potential to empower learners. This relates to new kinds of value-added that builds motivation toward engagement for personal needs (Rosen, 2009, p. 9). Sarah realized the value-added in the development of collaboration through social learning and shared this thought. "You have to learn how to work with people, and collaboration is really, even if you had nothing to bring, it's all social and social maneuvering, and time to understand group dynamics." Sarah's perception of her collaborative skill development showed an appreciation of this Mindtool in enabling opportunities to learn together. Groups of individuals came together to accomplish similar tasks or goals toward the personal design customization of wearable technologies.

Sharing experiences through the Mindtool of wearable technologies sped up the design process. Speeding up the design process would be of benefit to organizations as concerns can be resolved quicker with workers skilled in collaborative efforts. Today, information can be gathered, exchanged, and interacted with whenever, wherever, and however desired. A culture of collaboration allowed primary source information to be accessed on demand with instant analysis of the implications in real-time with the support of others with similar interest.

Community building. By constructively exploring differences and developing a collaborative plan for action, decision-making for problems became a shared activity.

Through community building, participants felt safe offering opinions, thoughts were respected, participants were free to ask questions, they had the opportunity to engage in conversations, and support toward solutions was readily available within the members. Expertise was broadly distributed as membership spanned silos of knowledge combining experiences and backgrounds. Communication became more personal, more conversational, and more exploratory.

Scott described his perception of community building during the course in relation to the diverse expertise within the participants. Desiring to expand one's knowledge by seeking information developed camaraderie among learners leading to community building. He explained:

> If everybody had a question or was trying to get it, and she [the teacher] was stuck on the other side of the room going from group to group, either you had to go and then stand and wait for her or you had to figure out who else in the class might be able to help you and when--especially when you realize that, you know, there's--depending on the question, there's a high likelihood that you're going to stand there for five minutes trying to get an answer and she won't have it. So there's the hurdle of depending on the teacher or having access to the teacher's knowledge or maybe pretty good as far as an access to equipment and things like that enable scaffolding our prior knowledge into other things. All of those--this thing that you generally try and grow knowledge would have to a certain degree be dependent upon ourselves and with her permission and encouragement we were able to build a community and that was where we were able to do that.

Collaborative exchanges through the Mindtool of wearable technologies seemed to be loosely structured and highly adaptive. By offering opportunities for connections to be explored, student sharing of prior knowledge enabled the scaffolding of design “into other things.” Collective knowledge building developed a community of learners. This community of learners offered rich opportunities for knowledge building. With the right people available for constructive learning through this Mindtool, students were able to create, collaborate, and change the design of wearable technologies together.

Sally felt safe, respected, free, engaged in opportunities, and supported. She shared her perceptions on the building of community through the design of wearable technologies as a Mindtool:

> So my knowledge can help them grow. But what they know can help me as well. Like I talked about the zone of proximal development and helping each other. But I think creating that community makes it even better because you're enjoying being around each other. You're enjoying what you're learning. And then sometimes you're learning but you don't really realize you're learning. You're learning something new, but it's fun. And that's where kind of a gratification kind of comes into play, where you're not really -- you don't really know that you're learning, but in the end you think okay, maybe I've -- maybe I know how to do that because that's what we just did.

Sally’s appreciation for the benefit of community building was excitedly expressed during her interview. Each participant faced challenges with the Mindtool. Existing knowledge was not enough. Gaining new knowledge required ingenuity to network and pursue support toward perceived solutions. Working together to implement ideas increased rigor, and also increased enjoyment.

Sarah shared how community building enhanced her knowledge in this course. She explained what it meant to the design of wearable technologies to be part of a community:

> If some person would say, hey, let's work on this. Maybe I could do this part of the coding online over here. Maybe you could do that, or maybe we could work on smaller projects, but then share our notes so that we can advance faster than we would alone, then I would call that collaborative - What I think it [community building] means is when people willingly come together to possibly work on parts of a project together. Maybe one person can help the other person by teaching them chunks such as how to code in Arduino or how to make better code. So it's, like, once you get to that point, you can always ask a group of people and be, like, do you see a way that I can improve this or any way that maybe I could draw more so in the conductive traces thread. Different need to be even a cleaner design.

Sarah felt her design was smarter and stronger through community building. She saw how learning with this Mindtool could be made considerably easier with the support of community building. When participants collectively shared decision-making, and design together, everyone benefited. There seemed to be a heightened engagement and enjoyment in the work, and a feeling that successful results could be reached.

The design of wearable technologies as a Mindtool offered learners the benefit of community building as an expandable context within the learning environment. Participants enjoyed informed support and experienced many opportunities to contribute. The students in this course were independent in their way but found community building established a give and take among learners to produce solutions that none of them on their own could design.

Research Question 4

Research Question 4 asked: what are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?

The teacher perceived collaborative skill development in terms of each student participant's capability as it emerged through the design of wearable technology experiences. The analysis of the interviews revealed that the development of collaboration was related to the individual's willingness to engage in the learning opportunity. Research Question 4 investigated teachers' perceptions on collaborative skill development through the design of wearable technologies. The themes that emerged during data analysis were *diverse membership, culture of collaboration,* and *community building*. A *diverse membership* meant the student groups found opportunity within the available network to leverage different opinions and outlooks for the design of wearable technologies. The *culture of collaboration* permitted changes in designs as well as options for group work efforts. *Community building* offered authentic learning opportunities through common interest explorations. Teachers' perceptions of these themes were shared based on the whole student group as one, rather than each participant's individual personal experience.

Diverse membership. Students with distinct interests reached beyond academia to teach others through the design of wearable technologies. This Mindtool alleviated perceived struggles and challenges associated with learning alone. Knowledge building became different and learner-centered, less boring, and humbler. The course syllabus had an introduction question asking participants to consider "Why computing-related professions are among the least diverse in society?" In her reply to this course introductory question, Tiffany shared her reflection on advertising and recruiting efforts for the course.

> The course was intended to bring people from a range of different fields. Kids, students can incorporate any numbers of kinds of crafts, but by really foregrounding e-textiles and traditional crafts I think [wearable technologies] is more funded. Hopefully it helps to diversify the people who feel like they are programmers, or that programming is and computing are skills that they are capable of and perhaps interested in. It's not gonna change the number of programming majors. These are mostly students in their late college or graduate school careers, but I know some students have taken up a bit more programming either in hobbies or in courses. Maybe it will affect the way they teach and the way they raise their children a little bit, so anything we can do to broaden the perspective of how computing is useful for and scalable to their futures too.

Tiffany felt the Mindtool of wearable technologies enabled learners to develop a network approach toward innovation. Possibilities for innovation were discovered through the collective learning network established by a diverse membership enrolled in the course. She believed the Mindtool of wearable technologies could "broaden the perspective of how computing is useful for and scalable to their futures." Her students benefited from the prior knowledge and experiences of a diverse membership through the design of wearable technologies. Communication, trust, and openness enabled the diverse membership to feel comfortable expressing their unique opinions toward collaborative skill development.

The range of discipline majors brought by the varied participants helped develop a collective knowledge to be tapped through the design of wearable technologies as the Mindtool. Tiffany continued with more discussion on her advertising and recruiting efforts for the course in terms of diversifying the membership:

> Getting people from different college disciplines, like the quilter was majoring in instructional technologies and learning sciences, but that is something she brought from outside the course. Some people were drawn in by programming, some people were drawn in by sewing, some people by this meets a requirement and for my minor and it looks more fun than another class or it looks more cool than another class. I try to create that kind of space, through how I advertised and recruiting. You wouldn't get that if you just say, hey it's a computing course. If I highlight the sewing stuff then attract the computing people with more hardware

> interests who come that don't mind the sewing or they are willing to do it. I don't need to do as much work recruiting them in some ways.

The learning environment invited collaborative skill development through diverse membership. As the Mindtool, wearable technologies added design into the context of the learning opportunity. The addition of design to the learning environment drew in different people because "it looks more fun than another class or it looks more cool than another class." The Mindtool of wearable technologies attracted a diverse membership by allowing individuals' to further their prior knowledge "from outside the course" as well as build upon their prior knowledge from within the course. The diverse membership enhanced the desire to develop collaboration through the enticing knowledge available amongst other students and an extended network.

Tiffany sought to "create that kind of space" where learners could develop collaborative skills to scaffold their learning through a network of participants. Tiffany added clarification to her reasons for seeking a diverse membership by consideration of what such a range of individuals could bring to the learning environment:

> It may be an individual who has skills in different areas that they see the relevance for or that becomes relevant. It could be multiple individuals that have skills in different areas that they can tap into by seeing each other, or learn.

By tapping into each other's skills, learning collaboratively became relevant for knowledge building. Each participant's background and experiences brought a collective knowledge to the course that only needed interactivity among learners to be tapped. The

Mindtool of wearable technologies provided the opportunity to develop collaborative skill across a diverse membership of knowledge.

STEM fields may gain increased value from integrating with the arts, as a varied group of individuals can generate more ideas together sharing knowledge toward greater possible innovation (Lovell, 2011). An advantage is built through collaborative skill development from a diverse group of individuals sharing content openly within a context toward a common goal (Patterson et al., 2011). The existing view of the 21st century workforce is of employees expected to innovate by collaborating with other individuals of diverse professions, interests, educational backgrounds, and cultures (Siler, 2011, p. 417).

Culture of collaboration. Social discourse bears the fruit of creative thought (Vygotsky, 1978). Learners embraced the design of wearable technologies as a Mindtool instrument of change, and they welcomed the collaborative spirit and the camaraderie that accompanied the learning. Collaboration was necessary to lead to transformational learning. The Mindtool of wearable technologies transformed traditional learning leading learners to create next-generation innovations. Tiffany reflected on how her students learned through the design of wearable technologies and how this Mindtool transformed their knowledge building together:

> So like the girl with the dog halter, we brainstormed that together, but we also did some of that out loud, so that other people could…I haven't done a formal analysis of who learned what, but we know that knowledge diffusion happens. Ideas spread just from seeing them. Humans are very good, I mean, children,

> that's how they learn. They watch and they imitate. And they learn with things that often become internalized afterwards. That happens a lot. We do that a lot for the final projects, which are longer and they get help from one another. That has been really, really important. A lot of students struggle with just having ideas of what to do. Once they see other peoples projects they go, "oh that was cool, I could've done that, like that is actually doable, that is within my skill set, I could've done something like that. And so you see more throughout. Not everyone is like that, but a lot of people get ideas.

A culture of collaboration served as a catalyst for knowledge building and further exploration toward individual collaborative skill development. Tiffany's constructivist-learning environment with the Mindtool of wearable technologies meant students "learn with things that often become internalized afterwards." This Mindtool encouraged sharing for discovery and allowed collaboration to develop. Students realized a culture of collaboration revealed others' design of wearable technologies as "doable." Each participant's collaborative skill developed through "help from one another." Within this culture of collaboration "knowledge diffusion happens" as "ideas spread."

Tiffany saw student learning as active. Participants became personally responsible for their learning through the engagement of a Mindtool that builds understanding and meaning making. The Mindtool of wearable technologies eased the "struggles" of learning by scaffolding tasks through collaborative contextualization of the activity. She elaborated on the freedom learning gained within a culture of collaboration:

> I think it's to me most obvious in their final projects because that's where they had the most freedom just in bringing their own expertise wherever that lay via their own personal experiences even in the same context you see a lot of variety. You see a lot of cultural games that were made into electronic dolls or creations. The way students used different materials. Maybe they had more familiarity with where, you know, we had fashion people who integrated e-textiles into wigs and dresses but they had a lot of expertise in making those things. One of my students loved to try to integrate sculptured elements into her projects whether it's blown glass, or little polymer clay claws, on her monster Clyde. I saw woodworking brought in, here I was taught something not something I taught the students. They had to learn that somewhere else. I saw them with the games get really creative with making different game controllers out of water bowls, out of quilts, out of a cut up Twister game, a Dance Dance Revolution pad that was in the form of a quilt. I saw origami cranes paper mobiles, necklaces made out of tiles and different materials.

The Mindtool of wearable technologies encouraged a culture of collaboration to be developed among the learners. Tiffany was asking students to become full-fledged participants in their learning, a learning that they created, manipulated, and applied through the Mindtool of wearable technologies. The following advice was given to the students in the beginning from the course syllabus:

> Get help whenever, wherever, and from whomever you want – friends, family, classmates, YouTube, books, Wikipedia. Make sure you give credit where credit

> is due. Be sure to have ownership over your designs, even if you get tons of help from many people.

The culture of collaboration let students find sparks of innovation by collaboratively learning through the network of participants. Real-time, spontaneous sharing of knowledge scaffolded the learning into tasks deemed desirable to reach each participant's innovative solution. Rather than collecting information, as has been the traditional method for learning, the constructivist-learning environment let participants explore the Mindtool of wearable technologies together. Exploring the Mindtool of wearable technologies together permitted collaborative decision making on what to do with the information instead.

Community building. Collaborative communities were built within the constructivist-learning environment. Learners found each other, shared ideas, explored, and discovered together. Participants began to imagine and act from a new sense of possibility through the Mindtool of wearable technologies. Collaboration was communally developed with a common context offering multidimensional approaches toward individual learning. Tiffany would encourage community building by drawing attention to available expertise amongst the participants. She explained:

> If I know someone has expertise on something else I go, "ask so and so." Certainly, as soon as students start seeing each other's projects they start realizing so and so's probably got more experience in this and so and so has more experience in this. There is the working with your partner and then there is also, especially the hand crafted technology, no one gets the same project. It is intended

> to be a diversified expertise kind of experience. So someone else may want to use a stroke sensor, or a knitted thing at the end, but they may not have done that project so hopefully they get to learn about some of those other materials from other students. They understand the best, the ones that they themselves did. During final projects students often go outside of the class to get help. So if they want something that is going to be really difficult to program they go and find expertise on it. One guy didn't know a thing about sewing, I mean even going up and down through the cloth, no, no idea. He got help from his Grandma. Grandma helped him make his projects look better. I love that this kind of thing, and this is why I will continue to do e-textiles more than 3D printing or laser-cutting or those sorts of things, by drawing on hand crafted skills it doesn't have to be sewing, it can be woodworking, or something else, it makes certain people qualify as experts who often don't in academic settings.

Tiffany learned from her students through the Mindtool of wearable technologies as well. From woodworking to other participant talent, this Mindtool will keep her forever enamored by its potential for expanding the context of learning. Community building took the constructivist-learning environment beyond the traditional classroom. The course syllabus even suggested:

> Learn as a Community: We're in this together, and the more we share, the better all of our designs and understanding will be. Draw on your prior expertise. Share honest constructive criticism with your classmates. Listen to criticism. Support each other.

Participants were inspired to learn from each other through sharing. The collective expertise available built the community. A collaborative approach developed through constructive criticism and support. The Mindtool of wearable technologies transformed learning and teaching through how participants dealt with knowledge in an active, self-directed, and constructive way. It allowed endless innovation and interaction with an expandable learning environment.

The skill development of collaboration through the design of wearable technologies was transformative. The culture of collaboration allowed engagement with the Mindtool and each other in such a way that the diverse membership raised one another to higher levels of motivation. Through diverse membership, a culture of collaboration, and community building, individuals did not tend to see their interests in conflict with those of others, but worked to make the whole greater than the sum of the parts. Collaboration empowered participants and created a sense of ownership and belonging within a community. When decisions were reached, they were the group's efforts. Community building meant sharing prior knowledge, focusing on results, strengthening relationships, being open, inviting opinions, bringing out the best in others, and celebrating achievements together.

Summary

The Mindtool of wearable technologies provided opportunities for students to access information and learn more quickly. It engaged learners in collaborative and creative thinking through the construction of knowledge that they would not have been able to discover otherwise. The participants were motivated to engage with the learning environment to build upon their knowledge. Learning was active, creative, and student-centered. Learners engaged in reflective thinking that led to knowledge construction. Learning was student-centered, making the participants responsible and reflective problem solvers. Participants added personal meaning to their learning by connecting knowledge, considering collectively shared information, and building toward innovative ideas.

In Chapter 5, the purpose of the study and implications of the findings are organized within the conceptual framework. Recommendations for further research and the implications for social change are provided with a review of current research related to the development of collaborative and creative thinking skills through Mindtools.

Chapter 5: Discussion, Conclusions, and Recommendations

Many researchers have investigated the impact of art on student learning in science, technology, engineering, and mathematics and found positive results. Studies have also shown that creative thinking skills are developed through the arts. Researchers have suggested that Mindtools encourage creative thinking and could develop collaborative skills (Hwang et al., 2011). “Mindtools are computer-based tools and learning environments adapted or developed to function as intellectual partners with the learner in order to engage and facilitate critical thinking and higher order learning” (Jonassen, 1996, p. 9).

This qualitative case study was undertaken to explore teacher and student perceptions on collaborative and creative thinking skill development through the design of wearable technologies as a Mindtool. Wearable technologies are technology-enhanced garments or pieces of technology having to do with the combining of fashion and technology (Olsson, 2012). The conceptual framework involved an interpretation of constructivism with Mindtools (Jonassen, 2005) and a culture of collaboration (Rosen, 2009) as the foundations for the exploration of skill development.

A qualitative case study design was used as a means of gathering teacher and student perceptions about collaborative and creative thinking skill development through the design of wearable technologies. This study was designed to explore student skill development experiences in a particular classroom rather than to evaluate the constructivist-learning environment. Perceptions on how engagement in digital artistic design of wearable technologies affects the collaborative and creative thinking skill development in learners were explored. Interviews were conducted with each of four participants consisting of three students and one instructor, who participated in a wearable technology integrated curriculum in a Rocky Mountain state; an additional follow-up interview was conducted with the instructor. The research included Skype or telephone audio-recorded interviews conducted outside of academic time requirements as the data collection technique. Participant offered artifacts of art-technology collaborations and creative thinking were also examined. The data were triangulated for clarity, interpretation, and support. Categorical aggregation was used to code data for themes and patterns.

The participants perceived an improved development of collaborative and creative thinking skills through the design of wearable technologies. Students indicated they became motivated, risk taking, constructivist knowledge builders of the Mindtool as they worked together to develop wearable technologies. Singer (2011) highlighted the importance of creativity in education, saying, "effective learning is basically creative; and the creativity we revere may itself be thought of as an extension and application of the learning process (p. 61)." The teacher perceived that when she facilitated student choices, inquiry, imagination, and collaboration in a failure-friendly constructivist-learning environment student creativity was enhanced.

Interpretation of the Findings

In order to interpret the results from the shared experiences of the participants, I analyzed data using a conceptual framework based on Jonassen's (1996) modeling using Mindtools for conceptual change and Rosen's (2009) culture of collaboration. Jonassen's

(1996) idea of Mindtools guided the interpretation of the findings for research questions 1 and 2 on how students and teachers perceived development of creative thinking when designing wearable technologies. Corporate and professional fields are not depending only on knowledge-based abilities, skills, and degrees; in addition, they are seeking aptitudes such as creative thinking and collaboration. The need for collaboration as a learning and innovation skill led to the interpretation of findings for research questions 3 and 4. Rosen's assumptions on the culture of collaboration and Jonassen's work on Mindtools highlighted technology as a cognitive tool that provided insight into the perceptions from each participant.

As part of the conceptual framework, Jonassen's (1996) modeling using Mindtools was useful in interpreting results for the first two research questions because participants considered knowledge expanded through connections, inquiry, and reflection in spite of institutional challenges and opportunities. Engaged students became motivated learners acknowledging their need for growth by seeking knowledge to create connections. The Mindtool of wearable technologies served to motivate student learning through adjustable task difficulty, acceptance of alternatives, and scaffolded knowledge growth opportunities. During the construction of knowledge, a Mindtool serves as a cognitive tool (1996). The design of wearable technologies as a Mindtool involved the participants in synchronously building physical objects while connecting knowledge for problem solving decisions to accomplish tasks. Multifaceted opportunities to perceive and interpret authenticity support the learning process by actively creating knowledge through integrated experiences (1996). The design of wearable technologies as a

Mindtool used the building of design knowledge to connect learning toward problem solving. Learners found significance through the exploration of design because it was an integral component of life. As a Mindtool, wearable technologies added enticement to learning with the integration of art.

To shape an understanding of collaboration, Rosen's theory (2009) on the culture of collaboration was used to categorize the needs facing workforce success. An innovation gap exists related to collaborative and creative thinking skill development in terms of students being prepared to enter careers following high school (Partnership for 21st Century Skills Framework, 2013). Rosen (2009) stated that collaboration was a significant factor in sparking innovation (p. 11). Diversity-acknowledged learning through collaborative efforts builds respect in contexts that increase global awareness (Patterson, Carrillo, & Salinas, 2011). Wearable technologies, as a Mindtool, allowed free-flowing, interactive participation from a diverse community, toward the building of a culture of collaboration. Through the design of wearable technologies, collaboration was developed by individuals' desires to discover options seen by others.

Research Question 1

Research Question 1 asked what students' perceptions were regarding the development of creative thinking skills while designing wearable technologies. The students in this study mentioned their initiation to the development of creative thinking came from different learning avenues. Participants' personal interests were consistently linked to the development of creative thinking through the design of wearable technologies. Any lack of prior knowledge was not found to be an issue. These participant experiences conformed to Jonassen's (1996) definition of creative thinking as "going beyond accepted knowledge to generate new knowledge" (Jonassen, 1996, p. 237). The Mindtool of wearable technologies inspired a desire to build and connect knowledge in a new and personal way.

The Mindtool of wearable technologies provided a constructivist-learning environment that inspired participants to combine fashion with technology. Participants saw ways to enhance the design of wearable technologies by incorporating elements of embedded computing with traditional aspects of fabric crafts. Jonassen believed ownership of the problem was the key to learning (1998, p. 215). He specialized in taking knowledge from unrelated fields, using technology, and applying it to information being learned (1996). In the same way, wearable technologies allowed information to be taken from unrelated fields and using technology, apply it toward knowledge being generated. The programmable computer-based tool and the constructivist-learning environment involving previously stored knowledge served as cognitive tools to build learner engagement and motivation toward development of creative thinking. This aligns with Jonassen's definition of a Mindtool as "computer-based tools and learning environments adapted or developed to function as intellectual partners with the learner in order to engage and facilitate critical thinking and higher order learning" (1996, p. 9).

Spontaneous and free-flowing differing possibilities with the Mindtool of wearable technologies were a reoccurring thought shared throughout the interviewing process. Opportunities were expanded as student knowledge grew, contributing to divergent thinking. Divergent thinking was interpreted as an expression of willingness to engage in the design of wearable technologies. Jonassen (1996) believed that Mindtools enhanced learning to engage interactivity toward willingness to build on knowledge. Analysis of the interviews revealed that the development of creative thinking was related to the individual's willingness to engage in the learning opportunity. Engaged students became motivated learners embracing their need for growth by seeking knowledge to create connections. Students' role in the design exploration of wearable technologies was transformed through their divergent thinking as the course progressed, just as Jonassen transformed constructivism theory to include technology in ways previously considered inconceivable (1996, p 25). Students' divergent thinking allowed thoughts to drift toward many different options, iterations, and ideas relating to a concept. Students showed divergent thinking as an approach to circumstances, focusing on investigating multiple possibilities toward a personalized idea. The differing possibilities of this Mindtool provided a personalization to learning through constant interactivity with the constructivist-learning environment. Conceptual frameworks supportive of constructivism suggest student-centered, technology-supported, problem-based learning environments with open-ended solutions (Jonassen, 1996). Students took what they learned through the design of wearable technologies, in addition to their prior knowledge and experiences from their major and hobbies, and created an original product. Participants perceived divergent thinking as a vital part in their enjoyment and success with this Mindtool. Divergent thinking can be used as an approach toward innovative creativity in a wide variety of settings, ranging from businesses to classrooms by allowing imaginations to consider any possibility, explore new ways, and purposely diverge from traditional thoughts.

Jonassen (1998) believed that the opportunities for pedagogic design are far more interesting for the future because emerging technologies have extended opportunities for learning. Each of the participants expressed a challenge to design when computers and materials were integrated. Struggles were shared about working with different elements together. Just as these students were expecting an elective course to learn a technology tool, they expressed a level of rigor to the detail required for even a partial success. The problems proved challenging but surmountable through the construction of required new knowledge. Frustration in learning seemed tempered with celebrations along the way. Jonassen's (1996) modeling using Mindtools for conceptual change was reinforced by the participants' consideration of knowledge expanded through connections, inquiry, and reflection in spite of institutional challenges and opportunities.

Jonassen (1996) believed a constructivist-designed learning environment supported learning through the active creation of knowledge across domains. A Mindtool provides learning within a context-rich, experience-based activity that builds knowledge through construction. Wearable technologies motivated student learning through adjustable task difficulty, acceptance of alternatives, and scaffolded knowledge growth opportunities. According to Wagner, when a learner's role is that of designer, tools are utilized effectively for interpretation to support knowledge building (2012, p. 142). "Technologies should not support learning by attempting to instruct the learners, but rather should be used as knowledge construction tools that students learn with, not from"

(Jonassen et al., 1998, p. 1). Student learning was a progression of actively created knowledge through integrated experiences with their existing schemata. The merger between fabric and electronic elements enabled computing and electronics to be incorporated as wearable technologies. The Mindtool of wearable technologies supported students' multiple perspectives and interpretations through their constructed design knowledge.

Imagination and creativity thrive within constraints (Root-Bernstein, & Root-Bernstein, 2009). Students found learning satisfaction through constraints. Decision-making occurred in cycles and became more context specific throughout the course progression. As constraints were diminished, creative thinking expanded toward a growing feeling of success for interesting and attainable outcomes. Jonassen believed accomplishing this necessitated intertwining instructional design with various instructional technologies (Jonassen, 1996). This Mindtool provided inquiry questions, scalable problems, and imaginative projects that participants were willing to unravel through knowledge construction. This provision was consistent with Jonassen's belief that "students must be provided with interesting, relevant, and engaging problems to solve" (Jonassen & Reeves, 1996, p. 718).

Harnessing the power of creativity to tackle challenges relied on the learning environment. A creativity climate provided a failure-friendly environment that encouraged creative thinking. A study by Pelfrey (2011) found that when teachers facilitate student choice, inquiry, imagination, and collaboration in a failure-friendly constructivist-learning environment, student creativity is enhanced. The creativity climate provided through this Mindtool guided students' desire to encounter and resolve complex, challenging cases. Through remixing, reworking, and repurposing of knowledge students perceived how the Mindtool of wearable technologies could facilitate the development of creative thinking.

The student participants in this study perceived creative thinking as taking a divergent direction to solving a problem, dealing with a concept, or brainstorming with others. The perceived development of their creative thinking tested each individual's traditional knowledge to see circumstances in innovative ways. Students witnessed the development of creativity through divergent thinking as well as in others designing differently from their approach with the same Mindtool of wearable technologies. Participants took traditional crafting talents to the learning environment and saw how the development of creative thinking generated new knowledge through scaffolding of tasks in interactive ways. Imagination was stimulated in the pursuit to discover many avenues to resolve problems. The Mindtool of wearable technologies brought personal joy and perceived success to each learner.

Through the design of wearable technologies, learners were assisted by the creativity climate of this Mindtool to interpret knowledge within a constructivist-learning environment. Creative thinking was developed using the Mindtool of wearable technologies through divergent thinking, the generating of new knowledge, stimulation of the imagination, and the creativity climate. To assist learners in interpreting knowledge in a constructivist-learning environment, the wearable technology Mindtool facilitated student development of creative thinking. Student perceived development of creative thinking resulted in new learning about real-world behavior and its meaning (Yin, 2011).

Research Question 2

Research Question 2 asked what teachers' perceptions were regarding student development of creative thinking skills through the designing of wearable technologies. The teacher explained how the design of wearable technologies enabled learners to explore problems through creative thinking, manipulation, and reflection. The design of wearable technologies as a Mindtool involved the learner in constructing both a personally designed physical object and building the connected knowledge it took to accomplish the task. Students learned by doing in both the virtual and real world, and they faced cognitive conflicts and knowledge building through design opportunities. This reinforced Mikropoulos and Bellou's (2013) belief that the educational contribution becomes more effective when an approach to constructivism involves cognitive tools or Mindtools as proposed by Jonassen (2000). Constructivism is an educational theory that suggests learning is the building of knowledge structures by the learner through interaction with the environment (Jonassen et al., 1998, p. 1). Learning was the building of knowledge structures, not just the obtaining of knowledge. The constructivist design for learning requires "interaction with the environment." The design of wearable technologies, as a Mindtool, engaged learners to bring together existing knowledge and materials with new information in innovative ways.

Traditionally rigor was associated with mastery of content alone. Information changes knowledge constantly. Learners need content knowledge within context to apply and transform their knowledge for skill development toward creative thinking (Bellanca & Brandt, 2010, p. 271). New knowledge was generated as circumstances changed. The Mindtool of wearable technologies provided support for creative thinking skill development through the generation of new knowledge. The design of wearable technologies was offered as the Mindtool context for individuals to create knowledge. Through deliberate and active engagement students brought together existing ideas into new configurations, therefore creative thinking was developed.

Taking risks and experimenting were behaviors associated with creativity and innovation. Creative thinking enabled the generation of new knowledge within or across domains, including spaces, objects, and hobbies. This generation of new knowledge expanded the learning horizon from both within the classroom and beyond. Inspiration was found anywhere and everywhere. Students' design enhancements generated new knowledge through interactivity. They were able to take skills previously gained to assist in solving and adapting to new problems. The challenges encountered through the design of wearable technologies scaffolded the generating of new knowledge. Evaluation of the Mindtool spurred students to rely on personal expertise to help bridge different domains and frame creations as relatable and creative. Individuals needed to feel free to act creatively and innovatively. The act of defining one's problem and setting goals was found to be an important part of being creative. The teacher saw in the students, the motivation to think outside the box to make new, interesting connections, and links, from multiple knowledge domains.

Research Question 3

Research Question 3 asked what students' perceptions were regarding the development of collaborative skills while designing wearable technologies.
Wearable technologies, as a Mindtool, allowed free-flowing, interactive participation from a diverse community, toward the building of a culture of collaboration. This culture of collaboration allowed participation to be simultaneous, instead of passing instructions through levels and functions for others to implement (Rosen, 2009, p. 11). An economic trend is towards real-time, spontaneous collaboration (p. 9). I found that the students saw diversity as an avenue that allowed viewing in a different way. The diverse membership of the course emphasized that no two people were the same and learners had different needs. Individuals needed an understanding of issues that affected their design of wearable technologies, as well as others. They needed to work collaboratively and be able to learn from others with diverse cultures and backgrounds. Through the design of wearable technologies, collaboration was developed by individuals' desires to realize options possible as seen by others. The diverse perspectives from different learners fostered an evolution of ideas. The Mindtool of wearable technologies nurtured development of collaboration across the diverse membership by encouraging individual aspiration toward deciphering design concepts. This supports Rosen's belief that collaboration is significant in sparking innovation (2009, p. 11).

As a Mindtool, wearable technologies enticed learners by adding the integration of art. The different directions available toward learning with the Mindtool of wearable technologies meant every participant was both an expert and a novice. Students shared vulnerabilities as well as confidences with each other through the design of wearable technologies that led to collaborative knowledge building among learners. This collaborative skill development from such a diverse membership of individuals became a means to an end in figuring out how to solve problems.

Student resourcefulness to find similarly supportive learners on the Internet designing wearable technologies extended the range of diversity outside of the immediate classroom experience. This network provided an even wider diversity of perspectives. With many different points of view and cultural experiences, students' needs were better served by an expandable diverse membership brainstorming interesting solutions. Technological, economic, and cultural trends have changed the ways people collaborate according to Rosen (2009, p. 10). Motivation that is generated by sharing collective knowledge builds an ability to tap into developing skills (p. 70). Drawing on the positive energy of the collective knowledge building that was encouraged through the Mindtool of wearable technologies, the development of collaboration allowed learners to benefit from their differences. Finding some commonality within a diverse membership built personal bridges toward expanding learning of a shared interest, such as the Mindtool of wearable technologies. Bridging together diverse opinions, created openings for individuals from different cultures, backgrounds, and experiences to work collaboratively. "Rich, real-time collaboration lets people with a variety of skills and talents in multiple fields and functions come together spontaneously and create value" (Rosen, 2009, p. 22). The design of wearable technologies as a Mindtool enabled this diverse membership of students to engage in constructing knowledge that required brainstorming of innovative ideas and collaboratively solving problems.

This Mindtool provided the context for resolving conflicts in constructive ways, which is essential for positive relationships among diverse individuals. A learning ecology to explore the arts allows an avenue to integrate technology (Steed, 2010). This taps a collective knowledge through collaboration (Hwang et al., 2011). Working collaboratively to resolve conflicts, both individually and collectively, among the diverse membership became the learners' perceived avenue toward success.

Value was generated as obstacles dissolved. Rosen (2009) defined collaboration as "working together to create value while sharing virtual or physical space" (p. 9). It takes a few individuals with a common goal, engaging through collaboration, to create added value to something (p. 10). He explained that collaboration is central to creating wealth. People working collaboratively achieve greater success than individuals working alone. (p. 12). The students' desire to gain knowledge enabled scaffolding of prior knowledge into the design of wearable technologies. This desire established a need to develop collaboration through impatience. Coming together spontaneously rather than waiting for input built a culture of collaboration for problem solving. Students sought knowledge from others' availability and expertise rather than wait for traditional avenues to provide information.

The building of knowledge through the Mindtool of wearable technologies raised students' motivation to find solutions to problems. The culture of collaboration provided safety to push exploration challenges. Challenges offered while designing wearable technologies legitimized learners sharing their opinions, relating ideas, and working together towards the building of knowledge within the context of the Mindtool. This culture of collaboration generated new ideas learners had not considered, which allowed for individually perceived better results to be applied to the project.

The design of wearable technologies as a Mindtool showed potential to empower learners. Solutions may be seen completely differently from one individual to the next. Building on collective knowledge, differences are beneficially highlighted through collaboration adding value to a group solution. Bringing people together simultaneously to share spontaneous input solves problems through more efficient decisions (Rosen, 2009). This broader perspective relates to new kinds of value-added that motivates engagement toward fulfillment of personal goals (Rosen, 2009, p. 9). The students came together to accomplish tasks toward the personalization and design customization of their wearable technologies. Sharing experiences through the Mindtool of wearable technologies sped up the design process. Speeding up the design process would be of benefit to organizations as concerns can be resolved quicker with workers skilled in collaborative efforts. Today, information can be gathered, exchanged, and interacted with whenever, wherever, and however desired. The culture of collaboration allowed primary source information to be accessed by students on demand with instant analysis of the implications in real-time through the support of other learners.

By constructively exploring options and developing a collaborative plan for action, decision-making for problems became a shared activity. Through community building, participants felt safe contributing opinions as their thoughts were respected.

Participants were free to ask questions and to take part in conversations, in order to support as well as get support for solutions within the diverse membership. Expertise was broadly distributed as membership spanned silos of knowledge combining experiences and backgrounds. A recurring concern in the literature was that *silo* thinking in disciplines makes collaboration challenging (Linton, 2009). In fact, Linton (2009) stated a "silo effect" in learning and the isolation it causes goes against human nature. Linton indicated that learner collaboration with others and ideas from different disciplines can increase knowledge and creativity leading to more productive and effective results. Through the design of wearable technologies as a Mindtool, communication became more personal, more conversational, and more exploratory. Desiring to expand one's knowledge by seeking information developed camaraderie among learners leading to community building.

Collaborative exchanges through the Mindtool of wearable technologies were loosely structured and highly adaptive. By presenting possibilities for connections to be expanded upon, student sharing of prior knowledge enabled scaffolding of tasks for the designing of their wearable technologies. Five elements were identified to support such instruction from determining a common goal, continual assessment, active and authentic information avenues, communication, to adjustments in responsibility (Puntambekar & Kolodner, 2005). The students' collective knowledge building developed a community of learners. This community of learners presented rich opportunities for constructivist-learning. With such a diverse and expandable community available, students created, collaborated, and changed the design of their wearable technologies together.

Each participant faced unique challenges with the Mindtool of wearable technologies. Their prior knowledge proved not to be enough. However, the gaining of new knowledge required individual ingenuity to network and pursue support toward perceived solutions to problems. Working together to implement ideas increased attention, as well as enjoyment. When participants collectively shared decision-making, and designing together, the built community benefited. Rosen believed that to find solutions through efficient decision making, individuals must spontaneously collaborate together (2009, p. 2). Today, information can be gathered, exchanged, and interacted with whenever, wherever, and however desired. The culture of collaboration allowed primary source information on demand with analysis of the implications in real-time with others of similar interest. This demand proved to heighten student engagement and enjoyment in the work, leading to individual's feelings that successful results were doable. The design of wearable technologies as a Mindtool offered learners the benefit of community building as an expandable context within the learning environment. Participants enjoyed informed support and experienced many opportunities to contribute. The students in this course were independent in their way but found community building established a give and take among learners to produce solutions that none of them on their own could design.

Research Question 4

Research Question 4 asked what teachers' perceptions were regarding student development of collaborative skills through the designing of wearable technologies.

The teacher in this study felt students with distinct interests reached beyond limits of academia to teach and learn from others. The Mindtool of wearable technologies alleviated perceived struggles and challenges previously associated with learning alone. Knowledge building became different, learner-centered, less boring, and humbler. Possibilities for innovation were discovered through the collective learning network established by a diverse membership enrolled in the course. The teacher explained how students benefited from the prior knowledge and experiences of a diverse membership. Communication, trust, and openness enabled the diverse membership to feel comfortable expressing individually unique opinions. The range of discipline majors brought by the varied participants helped develop a collective knowledge to be tapped throughout the designing of wearable technologies. The learning environment invited collaborative skill development through this diverse membership.

As the Mindtool, wearable technologies added design into the context of a learning opportunity. The teacher sought to design a learning environment where learners developed collaborative skills to scaffold their learning with a network of participants. Brown described this as an “open, complex, adaptive system comprising elements that are dynamic and interdependent” (2000, p. 19), where Barron defined a learning ecology as the “set of contexts found in physical or virtual spaces that provide opportunities for learning” (2006, p. 195). Learning is interpreted through a collaborative collective knowledge building environment (Lin, 2011). By tapping into each other’s skills, learning collaboratively became relevant to knowledge building. Each participant’s background and experiences brought a collective knowledge to the course that only needed interactivity among learners to be tapped. The Mindtool of wearable technologies provided the opportunity to develop a collaboratively built collective knowledge resource across a diverse membership of participants.

The teacher saw learners embraced the Mindtool of wearable technologies as a model for conceptual change. Students welcomed the collaborative spirit and the camaraderie that accompanied the learning. Collaboration was necessary in order to lead to transformational learning. The Mindtool of wearable technologies transformed traditional learning to create next-generation innovations. A culture of collaboration served as a conduit for knowledge building as well as promoting development of collaborative skill. A culture of collaboration dissolves the obstacles of time and space, produces outcomes, and generates value (Rosen, 2009, p. 9). Students required an understanding of the possibilities and the impossibilities of the Mindtool involved. The Mindtool of wearable technologies encouraged sharing between learners for exploration allowing for a culture of collaboration. Participants became personally responsible for their learning through the engagement of a Mindtool that built understanding and meaning making. The Mindtool of wearable technologies eased difficulties for learners by scaffolding tasks through collaborative contextualization of the activity. Cognitive tools that support skill development toward problem solving, modeling, and knowledge building should be included (Hirumi, 2005).

The Mindtool of wearable technologies encouraged a culture of collaboration to be developed among the learners. The culture of collaboration let students find sparks of innovation by collaboratively learning through a diverse network of participants. Real-time, spontaneous sharing of knowledge scaffolded learning struggles into tasks deemed desirable by students in order to reach each participant's innovative solution. Rather than solely collecting information, as has been the traditional method for learning, this constructivist-learning environment let participants explore the Mindtool of wearable technologies together. Collaborative decision-making permitted students to determine the purpose of acquired information instead of solely memorizing it.

Collaborative communities were built within this constructivist-learning environment. Learners found each other, shared ideas, explored, and discovered together. Participants imagined and acted upon a new sense of possibilities. Collaboration was communally developed within the common context of the wearable technologies. The design of wearable technologies as a Mindtool offered multidimensional approaches toward individual learning. Community building took the constructivist-learning environment beyond the traditional classroom in search of furthering knowledge. Participants were driven to learn from each other through sharing. The collective expertise available built the community. Students' collaborative skill development occurred through constructive criticism and support.

The teacher experienced the Mindtool of wearable technologies transforming student learning and her teaching by participants dealing with knowledge in an active, self-directed, and constructive way. Wearable technologies as a Mindtool allowed endless innovation and interaction with an expandable learning environment. The skill development of collaboration through the design of wearable technologies was transformative. The culture of collaboration allowed engagement with the Mindtool and each other in such a way that the diverse membership raised one another to higher levels of motivation. Through diverse membership, a culture of collaboration, and community building, individuals did not tend to see their interests in conflict with those of others, but worked to make the whole greater than the sum of the parts. Collaboration empowered participants and created a sense of ownership and belonging within a community. When decisions were reached, they were the group's efforts. Community building meant sharing prior knowledge, focusing on results, strengthening relationships, being open, inviting opinions, bringing out the best in others, and celebrating achievements, together. The constructivist-learning environment provided opportunities for students to access information and to learn more quickly. It engaged learners in collaborative and creative thinking through construction of knowledge that they would not have been able to discover otherwise. The participants were motivated to engage with the learning environment to interpret for knowledge building. Learning was active, creative, and student-centered. Learners engaged in reflective thinking that led to knowledge construction. Participants were responsible for their own learning. Learners added personal meaning to their creative thinking by adding depth, other's ideas, and application of new knowledge.

Limitations of the Study

Case studies, by definition, are not generalizable. Yin (2009) cautioned against generalizing the results of a case study, stating, "cases are not 'sampling units' and should not be chosen for this reason" (p. 38). The results of this study, therefore, are of greatest use to those in the educational and business community who may choose to transfer the findings to their environment. The information added to the field from this study shares perceptions from a certain group on collaborative and creative thinking skill development through the design of wearable technologies.

Limitations arose when the collected data, determined themes and patterns, and interpretations were analyzed. The possibility exists that "everyday contextual understandings are reintroduced" (Mishler, 1991, p. 5). Other limitations may be found due to inconsistencies in individual opinions and the environment of qualitative research that is "exploratory and inductive in nature" (Trochim, 2006, p. 20). This study's primary limitation was the specific criteria chosen to select participants.

A sample of two teachers and eight students who participated in a wearable technology integrated curriculum in a Rocky Mountain state was the selected population for this study. Certain criteria directed purposeful sampling to teachers and students who were involved in a wearable technology integrated curriculum. The participant sample size of three students and one teacher recruited from a Rocky Mountain region state educational institution constituted a limitation of the scope. Data for analysis were based on experiences and not individuals or groups. Therefore, seeking further participants from alternative environments was unnecessary. Smith et al. (2009) recommended a sampling of three participants to collect relevant data for analysis by beginning researchers. This suggestion offered a basis from which to determine the appropriate number for this study. A minimum of 3 and a maximum of 10 participants was the chosen sampling to ensure depth and detail of data collection. Reasoning for the selection logic was justified by the availability of participants, quality assurance for data analysis, and considerations of participation willingness. Due to the narrow population of participants available for the study, results may not be transferable beyond the specific population from which the sample was drawn.

Each of the three global editions of the New Media Consortium Horizon Report (2013) – higher education, K-12 education, and museum education – emphasized six emerging technologies expected to find mainstream use over the next 5 years. On this list of emerging technologies, set at 4 or 5 years away, is wearable technology (p. 5). An increasing array of wearable technology has become available, hinting at the potential for teaching and learning, though there remains to be seen many concrete education examples (p. 6).

Yin (1994) recognized the importance of incorporating "correct operational measures for the concepts being studied" (p. 27). He suggested that procedures be chosen from successful examples tested in previously relatable projects. A familiarity of the organization should be developed prior to any data collection implementation. This familiarity could include preliminary communications about documents.

The Rocky Mountain Region state educational institution department head agreed to serve as a community partner for the study to identify potential participants from their organization for interview consideration. A purposively chosen consenting teacher participant provided potential student candidates to consider for data collection. Student participants were purposively chosen through the selection criteria, and an email invitation was sent. According to Van Manen, in order "to uncover the meaning of a phenomenon, individuals who have experienced the event must be included in a study and carefully interviewed to allow meaning to surface" (1990, p. 30). One teacher and three consenting students were interviewed.

The results of this study could advocate social change in other areas to promote understanding of the value of art in education. Due to the narrow participant selection, transferability of results to a similar institution may not be feasible. However, the findings may indicate the necessity for further studies. For this study, the concentration was on the depth of data analyzed from the perceptions of the participants (Moustakas, 1994).

An additional limitation was that only teacher and student perceptions were included in the data collection for this study. Additional possibilities for data could aid in building a more comprehensive knowledge of the participants. Further interviewing with parents or peers could provide more perceptive insights regarding the development of collaborative and creative thinking skills. However, such additions could also diminish clearer findings from the experience of selected participants. A rich description provided by a narrower population could promote transferability with a more significant sampling. Demographic information beyond what is shared through Skype or telephone audio-recorded interviews was not collected but may yield implications. These interviews were completed remotely and, aside from gender, no knowledge of socioeconomic status or ethnicity was gained.

Recommendations for Action

Educational institutions that see innovation tightly associated with Science, Technology, Engineering, and Math, the STEM subjects, need to consider the integration of a Mindtool such as the design of wearable technologies to further encourage the development of collaborative and creative thinking skills to flourish. Art needs to be added to the STEM initiative to create STEAM (Guimerans, 2012). The designing of wearable technologies as a Mindtool has shown promise as a new way to introduce STEM to students with diverse backgrounds and experiences. Having an idea of what to expect from an artistic Mindtool may help both the staff and students have a rewarding experience with the design of wearable technologies. The perceptions of the participants shared through this study can help in considering the added value of the arts to STEM. STEM fields would gain increased value from integrating with the arts. A varied contributing group of individuals will produce more diverse ideas (Lovell, 2011).

The national push to engage students in the exploration of science, technology, engineering, and math would be enhanced with the continued and reinstated inclusion of artistic integrations that strengthen the STEM curriculum. Schools could use the information provided from this research to strengthen and enhance their STEM programs by understanding the perceptions of each participant's experience with the Mindtool of wearable technologies. This information would advance practice and policy in education by enforcing the value of the arts in STEM. Schools can use the findings from this work to create programs and curricula that will help prepare students for their future success. The design of wearable technologies adds artistic value through constructivist-learning by building skill development of collaborative and creative thinking.

Recommendations for Further Research

The No Child Left Behind Act (NCLB) had a detrimental effect on the benefits of the arts as a core subject for learners (Americans for the Arts, 2012). If the arts are facilitating the development of collaborative and creative thinking skill development that employers are assuming schools are providing, then the value of arts in curriculum needs to be reassessed and the arts reinstated and increased in public schools. The national push to engage students in the exploration of science, technology, engineering, and math (STEM) initiatives may be enhanced with the continued and reinstated inclusion of artistic integrations that strengthen the STEM curriculum. The following recommendations are based on the participants' perceptions of collaborative and creative thinking skill development through the design of wearable technologies as a Mindtool.

1. Wearable technology, as a Mindtool, represents one new direction in bridging the knowledge domains of craft, technology, and learning. An increasing array of wearable technology has become available, making claims about the potential for knowledge building although few research studies were found to measure the validity of these claims (NMC Horizon Report, 2013, p. 6). Other technological Mindtools need to be explored and researched to determine if they have a similar or different impact on learning as wearable technologies. Qualitative case study research is needed to investigate various arts by blending human-computer interactivity with wood, ceramics, or glasswork to determine their impact on the development of creative thinking and collaborative skills in learners. My study could be used as a model for research with different artistic Mindtools and at different age levels.

2. Individuals spend time decorating themselves. If time spent on fashion could be tapped in an educational way perhaps this energy could be focused to increase technological literacy and inspire the next generation of designers and engineers. Research needs to be conducted to determine if the experience of participating in a workshop or course involving a Mindtool such as the design of wearable technologies could impact attitudes towards technology. A study researching versions of a kit for wearable technologies and capabilities for mass reusable artistic Mindtools could provide insights into best practices for implementation. Continued research is needed to explore ways to integrate artistic Mindtools available to teachers and students in a productive manner. Easing adoption of artistic Mindtools through a kit with mass reusable potential could prove valuable to adding art to STEM.
3. As people use wearable technologies, advantages and limitations are revealed. Possible investigation as to the potential of wearable technologies in areas beyond education, such as assistive technologies, provides areas for further research. The human-computer interactivity of wearable technologies could enhance the quality of life and learning for many with special needs.
4. Future research into how creative thinking and collaborative skills are utilized within individuals' jobs is needed. Findings from further research would lead to insights into how to integrate an art education agenda to enhance the needs of students to develop skills for innovation. The more that is understood about problems and challenges students will have to face for their future successes, the more that can be done to prepare them thoroughly. For example, knowing how employers look for tendencies

toward creative problem solving during an interview could give students an edge toward being exceptional in an interview and being successful in their futures.

5. Research about the connections art-technology and learning could contribute to the field of educational technology should be conducted. Research measuring student skill development in schools that integrate artistic Mindtools across disciplines would further support the value of art added to STEM. Research is needed focusing on teacher professional development that is most effective in increasing artistic Mindtool implementation in specific disciplines, as a constructivist tool associated with best classroom practices.
6. Beyond learning about circuitry, the real promise of wearable technology artifacts is their capacity to follow students into their peer and family settings, potentially transforming their identities in these social circles and sparking relevant conversations. Further interviewing with parents and peers could provide more perceptive insights regarding the development of collaborative and creative thinking skill.

Implications for Social Change

The perceptions and shared experiences of the students and teacher may provide other educational institutions with insight into what to expect when adding an artistic Mindtool to the curricular offerings. Participants reported that the diverse membership, a culture of collaboration, community building, a creativity climate, stimulation of their imaginations, generation of new knowledge, and divergent thinking were benefits to learning within the artistically constructive learning environment. An implication for positive social change for student learning would be the inclusion of artistic Mindtools, such as the design of wearable technologies, into curricular offerings. Students in both physical and virtual settings could learn together, either online or face-to-face, to exchange ideas and provide each other opportunities to build knowledge. By ensuring that children have opportunities to engage in learning with artistic Mindtools such as the design of wearable technologies for furthering the development of collaborative and creative thinking skills, the value added will provide for their future success.

Positive social change beyond the student level can affect the development of collaborative and creative thinking skills for employees. Results indicated companies want employees to identify problems and new patterns, integrate knowledge across fields, be original, and possess basic curiosity (Lichtenberg et al., 2008). Companies today are seeking the shared creation of value that the students in this study found through the design of wearable technologies. Enhanced value was created when collaboratively designing products concurrently. The economic trend is to search for the best talent at the best price, regardless of geography. As organizations explore globalization, the desire to innovate and build value drives the need to collaborate (Fawcett, Jones, & Fawcett, 2012). With the expectation of hurdling obstacles, companies adopt processes, systems, strategies, and tools to enable collaboration. A reason collaborative skills are not developed in organizations relates to their cultures (Rosen, 2009, p. 3). Effective collaboration can produce many benefits for individuals or organizations. The collaborating group needs a common goal. The group should consist of individuals with appropriate skills. Individuals need readily accessible and applicable resources, and an environment conducive to collaboration (Rogers-Brown, 2010). Businesses are exploring the concept of artistic contexts to serve as learning tools for the enhancement of skill development for building ability in areas such as collaboration (Americans for the Arts, 2012). The design of wearable technologies as a Mindtool could provide such an artistic resource to companies as a learning tool to enhance employee development of collaborative and creative thinking skills.

Global economic needs in demand for future innovation and success will be better addressed with the results from this study. Education can empower positive social change by addressing the needs of future employers. Supporting student attainment of collaborative and creative thinking skill development is important because the global economy is seeking these skills. The design of wearable technologies as a Mindtool facilitated the development of these skills that employers are assuming schools are providing.

Conclusion

As a teacher for 25 years and as a student for life, I can relate to and understand the many challenges and struggles these participants spoke about in working with this Mindtool. Hearing their passions build through the design of wearable technologies was revitalizing because each sincerely desired to make a positive contribution to the collective knowledge. These participants had insightful perceptions on the development of collaborative and creative thinking skill through the design of wearable technologies as a Mindtool. Each found value from the inclusion of art.

The interview process gave me insight about my perceptions on learning and reminded me that everything I do should be learner-centered. These participants expressed their determination to find ways to make things work despite obstacles. The collaborative spirit of engagement encouraged a determination to affect real learning.

I also realized that the participants enjoyed having the time to speak of their perceptions and experiences. Since they enjoyed their learning experiences with this Mindtool, the opportunity to help expand the opportunity to others through my research was empowering. Several of them thanked me for giving them the chance to talk about their experiences.

Collaborative and creative thinking is not only important to improve student learning, but also as a way to learn to work together innovatively as future professionals. The participants validated each other's efforts within the constructivist-learning environment, which created a camaraderie that enhanced their experiences as learners. The research experience was both humbling and energizing as I look toward the future and how I can affect positive social change.

As a society that depends on and is proud of innovation, it is vital to inspire in learners the belief that they can be creators by collaborating together. An increasing array of wearable technology has become available, hinting at the potential for teaching and learning, though there remains to be seen many concrete education examples (NMC Horizon Report, 2013, p. 6). Few individuals understand what goes into the making of devices and gadgets or have even attempted to create their own. The design of wearable technologies as a Mindtool demonstrated to be effective at tapping this desire in learners.

The future potential of wearable technologies expands into fields such as medicine and space exploration. By offering students the Mindtool of wearable technologies, doors to emerging options for student futures may open.

Wearable technologies have developed into a specialized field of design, occupied mostly by engineers and designers. Through the design of wearable technologies as a Mindtool, inquiry about who constructs technology, what it looks like, and what it does, comes into play for anyone to explore. This Mindtool combines tools in the hands with that of the mind. The design of wearable technologies combines these two by making invisible technology visible. There is always the benefit of how the design of wearable technologies acquaints learners to programming electronics. Additionally the construction of materials involved is pulling upon knowledge from traditional crafts. When students create wearable technologies they gain knowledge of craft techniques that have been pushed out of schools in recent years while programming their constructions. Through the design of wearable technologies, students can construct and see connections interactively. Wearable technologies, as a Mindtool tempts learners to engage with the physical world while improving their technological literacy.

Do-It-Yourself communities are becoming vital informal learning centers, yet they are detached from schools. Through the design of wearable technologies as a Mindtool, this detachment can be connected and expanded to produce learning potential toward student future success. The existing view of the 21st century workforce is of employees expected to innovate by collaborating with other individuals of diverse professions, interests, educational backgrounds, and cultures (Siler, 2011, p. 417).

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Appendix A: Interview Questions

Research Question 1: What are students' perceptions regarding the development of creative thinking skills while designing wearable technologies?

Student Interview Questions

- What do you think creative thinking means?
- How did your creative thinking change as you moved through the design of your wearable technology?
- How did creative thinking influence the design of your wearable technology?
- How do you think creative thinking is learned?
- Is there anything I have not asked you that you feel is important to add to our conversation about the designing of your wearable technology?

Research Question 2: What are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?

Initial Teacher Interview Questions

- How would you define creative thinking?
- What evidence of creative thinking did you see in the students while they were designing wearable technologies?
- How did the students' creative thinking change as they moved through the designing of wearable technologies?
- How did the development of creative thinking affect the students' designing of wearable technologies?
- How do you think creative thinking is developed?
- Is there anything I have not asked you that you feel is important to add to our conversation about the students' designing of wearable technologies?

Research Question 3: What are students' perceptions regarding the development of collaborative skills while designing wearable technologies?

Student Interview Questions

- What do you think collaboration means?
- How did your collaboration change as you moved through the design of your wearable technology?
- How did collaboration influence the design of your wearable technology?
- How did your collaboration with others help or hinder the designing of wearable technologies?
- How do you think collaboration is learned?
- Is there anything I have not asked you that you feel is important to add to our conversation about the designing of your wearable technology?

- Is there anything I have not asked you that you feel is important to share?

Research Question 4: What are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?

Initial Teacher Interview Questions

- How would you define collaboration?
- What evidence of collaboration did you see in the students while they were designing wearable technologies?
- How did the students' collaborative abilities change as they moved through the designing of wearable technologies?
- How did the development of collaboration affect the students' designing of wearable technologies?
- How do you think collaboration is developed?
- Is there anything I have not asked you that you feel is important to add to our conversation about the students' designing of wearable technologies?

Teacher Follow-up Interview Questions

Research Question 1: What are students' perceptions regarding the development of creative thinking skills while designing wearable technologies?

Teacher Follow-up Interview Questions
When I examined all of the student interviews I discovered that

- Students shared thoughts about creativity as having developed at home or through academic experiences. Where did you see your students' creativity coming more from, academic knowledge or extracurricular knowledge? Why?

Research Question 2: What are teachers' perceptions regarding student development of creative thinking skills through the designing of wearable technologies?

Teacher Follow-up Interview Questions

- Did you see participants from particular colleges/domains as showing/having more creative thinking tendencies over the duration of the course?
- The syllabus suggested, thinking creatively, taking risks, and doing something new. Can you share examples of how students making "hybrid creations that cross domains" showcased these suggestions?

Research Question 3: What are students' perceptions regarding the development of collaborative skills while designing wearable technologies?

Teacher Follow-up Questions
When I examined all of the student interviews I discovered that

- Students shared about your encouragement of learning avenues for finding help. Can you share some examples of how far you saw that extended?

Research Question 4: What are teachers' perceptions regarding student development of collaborative skills through the designing of wearable technologies?

Teacher Follow-up Questions

- Did you see participants from particular colleges/domains as showing/having more collaboration tendencies over the duration of the course?
- Did you feel there was more collaboration regarding the technology knowledge building or craft knowledge building domain of the learning?
- What differences could you see in the development of collaboration in students between the two course offerings because of the additional recruitment outside of your own department?
- Looking at the syllabus, a question was asked in the introduction. "Why are computing-related professions among the least diverse in society?" How do you think your course addressed this issue?

Appendix B: Letter of Cooperation

XXXXXXXXXX
XXXXXXXXXX
XXXXXXXXXX

April 11, 2014

Dear Ms. Korte,

Based on my review of your research proposal, I give permission for you to conduct the study entitled *Student and Teacher Perceptions on the Development of Collaborative and Creative Thinking Skills Through the Design of Wearable Technologies* within the XXXXXXXXXX. As part of this study, I authorize you to contact XXXXXXXXXX to recruit student members of e-textile curricula enrolled students, collect interviews, and share broad results of your findings with permission from the participants. Individuals' participation by teachers and students will be voluntary and at their own discretion.

We understand that our organization's responsibilities include allowing access to teacher and student participants to conduct audio-recorded interviews. We reserve the right to withdraw from the study at any time if our circumstances change.

I confirm that I am authorized to approve research in this setting.

I understand that the data collected will remain entirely confidential and may not be provided to anyone outside of the research team without permission from the Walden University IRB.

Sincerely,

Walden University policy on electronic signatures: An electronic signature is just as valid as a written signature as long as both parties have agreed to conduct the transaction electronically. Electronic signatures are regulated by the Uniform Electronic Transactions Act. Electronic signatures are only valid when the signer is either (a) the sender of the email, or (b) copied on the email containing the signed document. Legally an "electronic signature" can be the person's typed name, their email address, or any other identifying marker. Walden University staff verifies any electronic signatures that do not originate from a password-protected source (i.e., an email address officially on file with Walden).

Appendix C: Teacher Invitation to Participate in Research Email Script

Dear [Teacher],

Because of your inclusion of wearable technologies in your curriculum, I would like to invite you to participate in my research study on how wearable technologies help students develop collaboration and creative thinking skills. I am a doctoral student at Walden University and am inviting teachers and students who have participated in an integrated e-textile curricular experience to be in my study. The purpose of this study is to understand your perceptions on student collaborative and creative thinking skill development through the designing of wearable technologies.

The form attached is part of a process called "informed consent" to allow you to understand this study before deciding whether to take part. If you are willing to talk with me about your experiences and perceptions about how students develop collaboration and creative skills during the process of developing wearable technologies, please read the form attached and then reply to this email with the word CONSENT.

Thank you for considering,

~Laurie Korte

laurie.korte@waldenu.edu
XXX-XXX-XXXX

Appendix D: Teacher Consent Form

You are invited to take part in a research study exploring your perceptions on the development of student collaborative and creative thinking skills through the design of wearable technologies. I am inviting teachers and students who have participated in an integrated e-textile curricular experience to be in my study. This form is part of a process to allow you to understand this study before deciding whether to take part.

This study is being conducted by Laurie Korte, who is a doctoral student at Walden University.

Background Information:
The purpose of this study is to understand your perceptions on student collaborative and creative thinking skill development through the designing of wearable technologies.

Procedures:
If you agree to be in this project, you will be asked to:

Participate in two audio-recorded interviews of approximately 30 to 45 minutes each where you will share your personal experiences and perceptions insights on how your students developed or did not develop collaborative and creative thinking skills through the design of wearable technology.

Here are some sample questions:

- How would you define creative thinking?
- What evidence of creative thinking did you see in the students while they were designing wearable technologies?
- How did the students' creative thinking change as they moved through the designing of wearable technologies?
- How did the development of collaboration affect the students' designing of wearable technologies?
- How do you think collaboration is developed?

Voluntary Nature of the Study:
This study is voluntary. Everyone will respect your decision of whether or not you want to be in the study. No one at [redacted]or Walden University will treat you differently if you decide not to be in the study. If you decide to consent now, you can still change your mind later. Anyone who feels stressed during the study may stop at any time.

Potential Risks and Benefits of Being in the Study:
Being in this type of study involves some risk of the minor discomforts that can be encountered in daily life, such as the delegating time needed to participate in the interview. Being in this study would not pose risk to your safety or wellbeing.

The individual potential benefits for participating in this study are minimal; although your experiences may help others develop programs and support to improve creative thinking and collaborative skill development opportunities for other students.

Compensation:
You will not receive any payment for participation.

Privacy:
Any information you provide will be kept confidential. The researcher will not use your information for any purposes outside of this research project. Also, the researcher will not include your name or anything else that could identify you in any reports of the study. Data will be kept for a period of at least 5 years, as required by the university.

I am required to inform you that there are two exceptions to the promise of confidentiality. Any information revealed concerning suicide, homicide, or child abuse or neglect is required by law to be reported to the proper authorities.

Asking Questions:
You may ask any questions you have now. Or if you have questions later, you may contact the researcher via phone, [redacted] or email, laurie.korte@waldenu.edu.
If you want to talk privately about your rights as a participant, you can call Dr. Leilani Endicott. She is the Walden University staff member who can discuss this with you. Her phone number is 612-312-1210. Walden University's approval number for this study is 03-21-14-0162090 and it expires on March 10, 2015.

The researcher will give you a copy of this form to keep for your records.

Statement of Consent:
I have read the above information and I feel I understand the study well enough to make a decision about my involvement in this optional research project. By replying to this email indicating my "consent," I am giving Laurie Korte permission to contact me about the study. I understand that I am agreeing to the terms described above.

Printed Name of Teacher ______________________
Teacher's Written or Electronic* Signature ______________________
Date of Consent ______________________

*Electronic signatures are regulated by the Uniform Electronic Transactions Act. Legally, an "electronic signature" can be the person's typed name, their email address, or any other identifying marker. An electronic signature is just as valid as a written signature as long as both parties have agreed to conduct the transaction electronically.

This has been approved by the Institutional Review Board of WALDEN UNIVERSITY as an acceptable documentation of the informed consent process and is valid for one year after the stamped date.

2014.04.22 11:14:17 -05'00'

Appendix E: Adult Student Invitation to Participate in Research Email Script

Dear [Student],

Recently, you were in XXXX's class where you designed e-textiles. I am interested in hearing your thoughts on how collaborative and creative thinking skills developed during this project. I would like to interview you to understand your perceptions of how these skills developed through the design of your course project. I am a doctoral student at Walden University and am inviting teachers and students who have participated in an integrated e-textile curricular experience to be in my study.

Before I interview you, it is necessary that you consent to my interview with you. If you are willing for me to talk with you, please read the form attached and then reply to this email with the word CONSENT. This is part of a process called "informed consent" to allow you to understand this study before deciding whether to take part.

Thank you for considering,
~Laurie Korte

laurie.korte@waldenu.edu
XXX-XXX-XXXX

Appendix F: Adult Student Consent Form

You are invited to take part in a research study exploring your perceptions on the development of student collaborative and creative thinking skills through the design of wearable technologies. I am inviting teachers and students who have participated in an integrated e-textile curricular experiences to be in my study. This form is part of a process to allow you to understand this study before deciding whether to take part.

This study is being conducted by Laurie Korte, who is a doctoral student at Walden University.

Background Information:
The purpose of this project is to understand your thoughts regarding how you may have developed creative thinking and collaboration skills while you were designing wearable technologies in Ms. XXX's class.

Procedures:
If you agree to be in this project, you will be asked to:

> Participate in one audio-recorded interview of approximately 30 to 45 minutes where you will share your personal experiences on collaborative and creative thinking skill development through the design of wearable technology Ms. XXX's class.

Here are some sample questions:

- What do you think creative thinking means?
- How did your creative thinking change as you moved through the design of your wearable technology?
- How did creative thinking influence the design of your wearable technology?
- How did your collaboration with others help or hinder the design of your wearable technology?
- How do you think collaboration is learned?

Voluntary Nature of the Study:
This study is voluntary. Everyone will respect your decision of whether or not you want to be in the study. No one at the [redacted] or Walden University will treat you differently if you decide not to be in the study. If you decide to consent now, you can still change your mind later. Anyone who feels stressed during the study may stop at any time.

Potential Risks and Benefits of Being in the Study:
Being in this type of study involves some risk of the minor discomforts that can be encountered in daily life, such as the delegating time needed to participate in the interview. Being in this study would not pose risk to your safety or wellbeing.

The individual potential benefits for participating in this study are minimal; although your experiences may help others develop programs and support to improve creative thinking and collaborative skill development opportunities for other students.

Compensation:

You will not receive any payment for participation.

Privacy:
Any information you provide will be kept confidential. The researcher will not use your information for any purposes outside of this research project. Also, the researcher will not include your name or anything else that could identify you in any reports of the study. Data will be kept for a period of at least 5 years, as required by the university.

Asking Questions:
You may ask any questions you have now. Or if you have questions later, you may contact the researcher via phone, [redacted] email, laurie.korte@waldenu.edu.
If you want to talk privately about your rights as a participant, you can call Dr. Leilani Endicott. She is the Walden University staff member who can discuss this with you. Her phone number is 612-312-1210. Walden University's approval number for this study is 03-21-14-0162090 and it expires on March 10, 2015.

The researcher will give you a copy of this form to keep for your records.

Statement of Consent:
I have read the above information and I feel I understand the study well enough to make a decision about my involvement in this optional research project. By replying to this email indicating my "consent," I am giving Laurie Korte permission to contact me about the study. I understand that I am agreeing to the terms described above.

Printed Name of Student ______________________
Student's Written or Electronic* Signature ______________________
Date of Consent ______________________

*Electronic signatures are regulated by the Uniform Electronic Transactions Act. Legally, an "electronic signature" can be the person's typed name, their email address, or any other identifying marker. An electronic signature is just as valid as a written signature as long as both parties have agreed to conduct the transaction electronically.

Appendix G: Interview Protocol

Interviews are semi-structured with already prepared questions to focus on the research objectives and serve as a guide. In the course of the interview, questions will be adapted where necessary and depending on the position of the participant being interviewed. The open-ended questions allow reformulation of the questions based on participants' responses to make it possible to solicit detailed experiences of participants. Thus the nature of questions will be participant driven and not the other way around. This interview protocol has space to take notes during questions as well as review recording transcripts following. Interviews will be recorded using QuickTime Player.

Student Interview Guide

Thank you for agreeing to participate in my study. In joining my project you will take part in this one audio-recorded interview of approximately 30 to 45 minutes where you will share your personal experiences on collaborative and creative thinking skill development through the design of wearable technology XXXX's class. The assent form you signed provided some sample interview questions I will be asking. As a reminder, you don't have to be in this project if you don't want to, if you want to stop, you can. Everything you tell me during this project will be kept private. That means that no one else will know your name or what answers you gave.

Time of Interview:

Date:

Method: Skype/Telephone

Interviewer: Laurie Korte, I am a student at Walden University, working on my doctoral degree.

Interviewee:

Position of Interviewee: Student

Brief description of study: The purpose of this project is to understand your thoughts regarding how you may have developed creative thinking and collaboration skills while you were designing wearable technologies in XXXX's class. I am hoping this project might help others develop wearable technology programs and help to improve creative thinking and collaborative skill development opportunities for other students.

Student Interview Questions

- What do you think creative thinking means?
- How did your creative thinking change as you moved through the design of your wearable technology?
- How did creative thinking influence the design of your wearable technology?
- How do you think creative thinking is learned?
- What do you think collaboration means?
- How did your collaboration change as you moved through the design of your wearable technology?
- How did collaboration influence the design of your wearable technology?
- How did your collaboration with others help or hinder the designing of wearable technologies?
- How do you think collaboration is learned?
- Is there anything I have not asked you that you feel is important to add to our conversation about the designing of your wearable technology?

Again, thank you for agreeing to participate in my study.

Teacher Interview Guide

Thank you for agreeing to participate in my study. In joining my project you will take part in two audio-recorded interviews. The first will be approximately 30 to 45 minutes where you will share your personal experiences and perceptions on how your students developed or did not develop collaborative and creative thinking skills through the design of wearable technology. A shorter follow-up interview will be based on analyzed initial responses from all participants to offer further clarity to the collected data. The consent form you signed provided some sample interview questions I will be asking. As a reminder, this study is voluntary. You can change your mind at any point. Anyone who feels stressed during the study may stop at any time. Everything you tell me during this project will be kept private. That means that no one else will know your name or what answers you gave.

Time of Interview:

Date:

Method: Skype/Telephone

Interviewer: Laurie Korte, doctoral student at Walden University.

Interviewee:

Position of Interviewee: Teacher

Brief description of study: The purpose of this study is to understand your perceptions on student collaborative and creative thinking skill development through the designing of wearable technologies. I am hoping this project might help others develop wearable technology programs and help to improve creative thinking and collaborative skill development opportunities for other students.

Teacher Interview Questions

- How would you define creative thinking?
- What evidence of creative thinking did you see in the students while they were designing wearable technologies?

- How did the students' creative thinking change as they moved through the designing of wearable technologies?
- How did the development of creative thinking affect the students' designing of wearable technologies?
- How do you think creative thinking is developed?
- How would you define collaboration?
- What evidence of collaboration did you see in the students while they were designing wearable technologies?
- How did the students' collaborative abilities change as they moved through the designing of wearable technologies?
- How did the development of collaboration affect the students' designing of wearable technologies?
- How do you think collaboration is developed?
- Is there anything I have not asked you that you feel is important to add to our conversation about the students' designing of wearable technologies?

Again, thank you for agreeing to participate in my study.

Teacher Follow-up Interview Questions

- Looking at the syllabus, a question was asked in the introduction. "Why are computing-related professions among the least diverse in society?" How do you think your course addressed this issue?

- What differences could you see in the development of collaboration in students between the two course offerings because of the additional recruitment outside of your own department?
- Students shared thoughts with me about creativity as having developed at home or through academic experiences. Where did you see your students' creativity coming more from, academic knowledge or extracurricular knowledge? Why?
- Do you feel there was more collaboration regarding the technology knowledge building or craft knowledge building domain of the learning?
- Did you see participants from particular colleges/domains as showing/having more creativity or collaboration tendencies over the duration of the course?
- Student shared about your encouragement of learning avenues for finding help. Can you share some examples of how far you saw that extended?
- The syllabus suggested, thinking creatively, taking risks, and doing something new. Can you share examples of how students making "hybrid creations that cross domains" showcased these suggestions?

Again, thank you for agreeing to participate in my study.

Appendix H: Confidentiality Agreement

AUTOMATIC SYNC
TECHNOLOGIES

Handling of User-Submitted Content

Preserving the confidentiality of your intellectual property is very important to Automatic Sync Technologies (AST). We believe that the content that you submit to us for captioning must be both kept confidential and secure. We consistently strive to put our best efforts towards achieving both of these objectives.

"Content" means any media or transcripts that you send to us either through the CaptionSync website or through our mail-in DVD authoring service, and any of the caption results that we generate for you.

AST engages subcontractors to provide portions of the services that we offer to you. It is necessary for AST to disclose your Content to these subcontractors in order to deliver our service to you. All such subcontractors have entered into Non Disclosure Agreements ("NDA") with AST, prohibiting them from using, disclosing, or distributing your Content in any way. Other than our disclosure to such subcontractors as necessary to deliver our service, AST commits to you that we will not disclose or distribute your Content to any other parties.

For Content submitted through our CaptionSync webservice, all Content is transmitted to our servers through encrypted data links. Once on our server, we employ a number of defenses to prevent unauthorized users from gaining access to any information on your account, including any Content that you have submitted. Caption results are returned to you via email at your option; if this poses a security concern to you, you may disable this feature on your account.

Copies of your Content are retained on our server for at least six months to enable you to access and regenerate your caption results. During that time, your Content will be accessible only to AST personnel or users of your account(s).

For Content submitted to our mail-in DVD authoring service, both the captioned DVD and your original media are returned to you via courier. Any electronic residuals that result from this work are treated as your confidential information.

AST is sensitive to user's confidentiality concerns and recognizes the need to communicate how we deal with the Content you submit. Please be assured that AST handles your Content only to the extent necessary to deliver our service to you and nothing more.

Curriculum Vitae

Laurie E. Korte
laurie.korte@waldenu.edu

SUMMARY OF QUALIFICATIONS

- Development of web-based multimedia learning environments
- Collaboration with staff to plan development and production of curriculum/teaching tools
- Facilitation of development processes from conceptualization to assessment, articulating and attending to concise learning goal outcomes and measures
- Management of budget and timelines
- Creation of working relationships with staff that encourage collaboration and result in the development of activities within and outside of district to meet specified learning goals
- Participation in Curriculum Committee teams to design technology integrated content
- Delivery of training and implementation updates with staff
- Evaluation of content to guide recommendations on materials and program development

EDUCATION

PhD in Education – Specialization: Educational Technology 2014
Walden University, Minneapolis, MN
Dissertation: Collaborative and Creative Thinking Skill Development Through the Design of Wearable Technologies

Master, Library and Information Sciences 2002
University of Wisconsin, Milwaukee, WI

Bachelor of Science, Secondary Education 1989
Butler University, Indianapolis, IN

CERTIFICATIONS

Moodle 2 Administration 2012-Present
Remote-Learner

Type 10, Information Specialist 2007-Present
Illinois State Board of Education

Type 09, Standard Teaching 1989-Present
Illinois State Board of Education

EXPERIENCE

E-learning Facilitator Trainer and Course Creator 2014-Present
North East Florida Educational Consortium, Putnam County, Florida

- Work in collaboration with NEFEC to identify the elements and objectives for an introductory course
- Create a facilitator introductory course on Moodle
- Facilitate a live synchronous webinar session for NEFEC
- Build other courses in Moodle upon request using course content currently in Blackboard

Educational Technology Specialist 2007-Present

- Work with various educators around the world throughout project lifecycles to meet desired specific needs from strategy to implementation to maintenance
- Provide formal and informal presentations with personalized detail to requested requirements
- Assist in course design and migration of existing content
- Work with teams and individuals combining subject matter expertise with technology field knowledge to create effective learning online
- Support individuals and teams globally in managing Moodle implementations

District Technology Integration Specialist 2007-2013
Northbrook District 28, Northbrook, IL

- Planned, delivered, and evaluated instruction based upon knowledge of subject matter in the technology field
- Applied effective methods and strategies for teaching concepts and skills to students, educators, and administrators in various educational settings
- Identified and applied educational and technology-related research, the psychology of learning, and instructional design principles in guiding use of technologies
- Developed curricular plans and teaching aids based on standards for use of learning technologies, integrating across subject and content areas

- Implemented information access and delivery of resources to support curriculum
- Planned and optimized budget and grants to achieve high academic and information literacy goals
- Encouraged, planned, and fulfilled collaborative growth functions

New Teacher Mentor 2012-2013
Northbrook District 28, Northbrook, IL
- Provided demonstration lessons
- Led professional development activities
- Participated in formalized peer review process as a formative evaluator
- Facilitated curriculum planning

Superintendent's Advisory Forum Member 2012-2013
Northbrook School District 28, Northbrook, IL
- Promoted and encouraged staff involvement in district efforts
- Assisted in identification and assessment of district needs
- Fostered and promoted communication between staff and administration

Science Curriculum Developer 2010-2012
Northbrook School District 28, Northbrook, IL
- Collaborated on integrated approach to teaching of Science standards
- Organized standards around conceptual strands
- Created and accumulated units of instruction
- Participated in development of ideas with teams of teachers

Social Studies Curriculum Developer 2008-2010
Northbrook District 28, Northbrook, IL
- Collaborated on integrated approach to teaching of Social Studies standards
- Organized standards around conceptual strands
- Created and accumulated units of instruction
- Participated in development of ideas with teams of teachers

Adjunct Online Instructor 2009-2010
Southern New Hampshire University, Manchester, NH
- Taught online Instructional Design/Distance Learning Platform Implementation
- Conceptualized with course members to build scalable Learning Management System sites
- Brainstormed creative implementations and innovative instructional strategies for participant design of E-Learning offerings
- Guided visual instructional graphic design, user interface, interactions and finished products with learners
- Shared usability and experience design, information design, communications and new technologies

E-Learning Instructional Designer/E-School Administrator 2008-2010
Global Classroom, Portsmouth, NH

- Designed and integrated classroom content Using Moodle to help participants implement online learning environments
- Provided training resources and professional support
- Facilitated and guided course member development of implementation
- Focused participant design of E-Learning toward teaching of pedagogy and content to promote higher quality education.
- Collaborated with subject matter experts and team members

Educational ToolKit Designer 2001-2002
Chicago Botanic Garden, Glencoe, IL

- Collected and created resources for area school districts
- Organized learning tools and materials
- Designed grade level appropriate activities for guided facilitation
- Enhanced field experience learning opportunities

Library Media Information Specialist 2000-2007
Grayslake Community Consolidated School District 46, Grayslake, IL

- Integrated high tech resources with traditional information sources to expand and enhance the educational process
- Partnered with teachers to achieve information literacy goals
- Collaborated on correlating library resources and projects with curriculum and lesson plans
- Created and implemented lesson plans and activities that spark curiosity and inspire lifetime learning
- Conducted new teacher trainings annually
- Programmed and facilitated guest speakers
- Created learning tools such as games and templates

Science Teacher 1991-2000
Arlington Heights School District 25, Arlington Heights, IL
Grayslake Community Consolidated School District 46, Grayslake, IL

- Developed and implemented lesson plans that fulfilled the requirements of district's curriculum
- Prepared lessons that reflected accommodations for differences in student learning styles
- Presented subject matter according to guidelines established by Illinois State Board of Education, board policies, and administrative regulations
- Planned and used appropriate instructional and learning strategies, activities, materials, and equipment that reflected understanding of the learning styles and needs of students assigned

- Conducted assessment of student learning styles and used results to plan instructional activities
- Worked cooperatively with special education teachers to modify curricula as needed for special education students according to guidelines established in Individual Education Plans (IEP)

Broadcast Club Coordinator 2002-2007
Grayslake Community Consolidated School District 46, Grayslake, IL

- Coordinated upper elementary student on-site broadcasts including news releases, scheduling entertainment and publicity interviews
- Supervised student station representatives and ensured proper representation of materials integrated into the live broadcasts
- Assisted team with programming and equipment as needed

Website Editor 1997-2000
Grayslake Community Consolidated School District 46, Grayslake, IL

- Produced interesting relevant new content
- Sourced artwork, and commissioned photographers
- Liaised with clients and internal departments
- Maintained site and ensured information accuracy

Science Olympiad Coach 1992-2000
Arlington Heights School District 25, Arlington Heights, IL
Grayslake Community Consolidated School District 46, Grayslake, IL

- Coached team and individuals to national-level awards.
- Assisted in recruiting team members and mentors
- Maintained information exchange between parents, students, mentors and coaches
- Scheduled meets, meetings, and practice sessions
- Provided training and materials as needed

Wetlands Curriculum Design and Instruction 1991-1996
Arlington Heights School District 25, Arlington Heights, IL

- Created and taught Wetlands curriculum that earned an award and had students standing in line to sign up
- Initiated and directed a major research project under the guidance of the Illinois State Museum
- Taught 8th graders to apply scientific methodology to long-term case study of the Purple Loosestrife, a non-native plant
- Facilitated 8th Graders' teaching design of elective Wetlands unit to 3rd Graders
- Presented Wetland Curriculum at 1994 Illinois State Science Teacher Convention
- Engaged students in research of economic and environmental impact of proposed gambling casino. Staged debate and school voting process that mirrored actual community vote, and received newspaper coverage

PUBLICATIONS

Moodle Magic: Make It Happen
FTC Publishing. 2007
These are amazing times for the Internet and online learning. We are seeing a rapidly increasing commitment to Internet-based learning from teachers, students, and institutions of all kinds, using it to increase flexibility and communication within existing courses and to enable courses that could never exist before. Moodle has been implemented for users at all age levels. Online classroom are here NOW! Colleges and Universities offer Distance Learning NOW! There are even Virtual High Schools NOW! Let me show you what others and myself have come up with as well as some tips and tricks to make it easier, friendlier, and safe. Don't let the learning stop with the dismissal bell. This is a chance to showcase learning at home too. As a Librarian/Media Specialist/Information Specialist/Teacher/Administrator or whatever title you have...you can do this.

Open Source Opens Classrooms
FTC Publishing. 2008
What is OpenOffice? What is GIMP? What is Inkscape? How much do these programs cost? How do I use them? This book will discuss free open source applications that provide many of the same features as comparable commercial applications without the high price tag. Open Source Opens Classrooms looks at how to access powerful and free technology choices. It highlights Free Open Source Software (FOSS) that is comparable to commercial applications for students and teachers at all levels. With Open Source Opens Classrooms you will no longer have to worry about creating purchase orders to obtain that perfect application you need for your classroom.

Differentiation in Professional Development
CUBE (Computer Update Bulletin for Educators) V. 2009, Issue 4. 2009
As an Educational Technology Specialist, the professional learning network I have grown is appreciative and respectful of the willingness and contributions I have been making to further the world of education technology. The request from the Illinois Computing Educators to co-author a focus piece on Professional Development and the success my district colleague and I have found in our differentiated offerings was a treat. Collaborating is always more intriguing and inspiring as two heads are better than one.

Moodle Magic: Make It Happen
CUBE (Computer Update Bulletin for Educators) V. 2010, Issue 2. 2010
As the author and multiple national conference presenter of Moodle Magic: Make It Happen I was asked to offer my thoughts in writing on tips and tricks to creating an online classroom environment. Being a district Moodle administrator twice and a facilitator for Moodle on an international hosting platform I have many ideas to share. Willing to help get more to expand their learning from anywhere at any time, I was more

than happy for the opportunity.

PROJECTS

Students Involved in Technology (SIT) 2010–2012

The Students Involved with Technology Conference is an annual conference occurring at several sites throughout Illinois. It originated in Bloomington-Normal and has since expanded. It is a conference for 3rd-12th grade students. The SIT Conference is completely presented by 3rd-12th grade students. While adult volunteers from local schools and the community help the day run smoothly, all presentations are prepared and presented by students.

TORCH! 2011–2013

TORCH! The Northfield Township Teaching and Learning Conference, emerged from a conversation between colleagues. The desire was to provide opportunities to collaborate with colleagues seeking expansion of best practices. Consideration for the idea of an event, devoted to sharing, conversations and growth was begun. Set in mid-August, it seemed like the perfect way to end the summer and to start the year with fresh ideas and inspiration.

PROFESSIONAL PRESENTATIONS

2013 - Presented Development of Collaboration, Creative Thinking, and Social Change Learning Skills Through Digital Creation of E-textiles Poster Session at Illinois Computing Educators Conference
Highlighted Ph.D. Dissertation topic research.

2013 - Co-Presented iPad/iPod/Apple TV Health/Fitness Technology Integration Session at N-ICE Mini Conference
Highlighted implementation, exploration and learning of 6th-8th graders with digital technologies in a Life Skills curriculum.

2012 – Presented Development of Collaboration, Creative Thinking, and Social Change Learning Skills Through Digital Creation of E-Textiles Prospectus at PhD Residency 3 Student Panel
Highlighted Ph.D. Dissertation topic research.

2010 - Presented Moodle Workshop at Illinois Computing Educators Conference
Facilitating professional development of e-Learning environment creating.

2010 - Co-Presented PicoCrickets Poster Session at N-ICE Mini Conference
Highlighted engineering, math exploration and learning of 3rd-5th graders with PicoCrickets and PicoBlocks programming.

2009 -- Presented Moodle 2-day Workshop for Cook County ICT in Illinois
Facilitated professional development of e-Learning environment creating.

2009 - Presented Moodle 2-day Workshop at Illinois Computing Educators Conference
Facilitated professional development of e-Learning environment creating.

2009 - Presented Moodle Seminar at Pete and C Conference in Pennsylvania
Facilitated professional development of e-Learning environment creating.

2008 - Virtually presented Moodle for Women of Web 2.0 (WOW2.0) on EdTechTalk
Via Skype and screen sharing capabilities showcased Moodle opportunities for classroom exploration and integration.

2008 - Presented Moodle Seminar at K-12 Open Minds Conference in Indiana
Facilitated professional development of e-Learning environment creating.

2008 - Virtually Co-Presented Open Source Opens Classrooms at Illinois Computing Educators Conference
Via Skype and screen sharing capabilities showcased Open Source opportunities for classroom exploration and integration.

2008 - Presented Moodle Seminar at N-ICE Mini Conference in Illinois
Facilitated professional development of e-Learning environment creating.

2008 - Presented Moodle Workshop at Star-Online Mini Conference in Illinois
Facilitated professional development of e-Learning environment creating.

2008 - Presented Moodle Magic: Make It Happen: Exploration of E-Learning Implementation at National Educators Computing Conference (NECC)
Open Source Lab workshop facilitation of e-Learning integration.

2007 - Presented Moodle Workshop at Illinois Computing Educators Conference
Facilitated professional development of e-Learning environment creating.

2006 - Presented Moodle Poster Session at Illinois Computing Educators Conference
Highlighted 2nd grade - 4th use of e-Learning.

1994 - Presented award-winning authored Wetlands Curriculum at Illinois State Science Teacher Convention
The Wetlands Curriculum was created and taught as an elective offering at a Junior High School. This implemented the idea that students apply the scientific methodology to long-term case studies. In turn, students then developed and taught elective Wetlands offerings

to younger elementary grades.

AWARDS AND RECOGNITIONS

Larry Stilgebauer Technology Award	2010
Environmental Awareness in Education Award	1994

GRANTS AND SCHOLARSHIPS

ICE (Illinois Computing Educators) Scholarship	2009, 2011
N-ICE (Northern Illinois Computing Educators) Mini Grant	2009, 2012