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Making it Matters: Makerspaces' Impact on Creativity in an Elementary School Media Center

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Approval Page

This dissertation was submitted by Janet Blair Austin under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education.

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Abstract

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This mixed-methods action research study investigated the impact of makerspaces on student creativity. Seventy fifth-grade students were exposed to makerspaces for 12 weeks. Quantitative data were collected using two assessment instruments. Prior to the experience, the students were given a preassessment of their creative potential using the Torrance Test of Creative Thinking (TTCT). After 12 weeks, students were given a postassessment using a different form. A paired sample *t* test was used to analyze the pre and posttest results. In addition, teachers were asked to evaluate student creativity by completing the creativity portion of the Scales for Rating the Behavior Characteristics of Superior Students (SRBCSS). Qualitative data were collected from an open-ended questionnaire completed by the teachers. The questionnaire was used to determine the teacher perceptions of student experiences with makerspaces related to creativity.

The results of the pre- and post-TTCT were analyzed. The *t* test showed a significant gain in the mean score for the target group with the exclusion of one outlier score. The results of the Pearson's R analysis compared student TTCT posttests with teacher rankings of individual students on the SRBCSS. The analysis showed a positive correlation. An open-ended questionnaire was completed by the teachers and coded for themes. The data were coded using Tesch's Eight Steps for coding information. The coding resulted in three themes related to creativity in makerspaces: communication, engagement, and motivation. The data allowed the researcher to determine if makerspaces in an elementary school media center had a positive influence on student creative growth.

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Chapter 1: Introduction

School libraries around the world are changing (Fleming, 2015; Kuhlthau, 2010). "Global interconnectedness enabled by information technology calls for new skills, knowledge, and ways of learning to prepare students for living and working in the 21st century" (Kuhlthau, 2010, p. 1). According to Robinson and Aronica (2015), many conventional aspects of schooling have been rethought and repurposed. One of the most conventional parts of many schools has been the traditional library. Through the years, some schools have renamed these spaces as media centers to include technology and other resources beyond printed books. Increased access to digital media through technology has been a driving change in the function and use of the school library. Increasing numbers of electronic books and other digital media have lessened the need for brick and mortar spaces as storehouses for books (Stanley, 2011). There are now new purposes for common areas in schools such as libraries, media centers, cafeterias, atriums, and foyers. These areas are now being used to meet the creative needs of students in the 21st century (Fleming, 2015; Stanley, 2011). As part of the change in the purpose and use of media centers, makerspaces have been appearing in schools across the United States (Canino-Fluit, 2014; Fleming, 2015; Hlubinka et al. 2013; Maker Media, 2016).

Background

Makerspaces and the Maker Movement. The researcher explored the impact of spaces within educational settings known as makerspaces. The people using the spaces have been referred to as makers. Makerspaces in schools are spaces where students have opportunities to explore, build, make, use tools, and develop creative projects (Fleming, 2015). Projects range from simple to complex. Some makerspaces involve highly

technological machinery and equipment, while other spaces provide everyday items such as crayons, cardboard, and masking tape. Makerspaces first began gaining notoriety around 2006 (Canino-Fluit, 2014; Martinez & Stager, 2013). They began as part of a larger phenomenon in our society known as the Maker Movement. It was about this time when school media coordinators and librarians began noticing the trend and started implementing makerspaces in school settings (Canino-Fluit, 2014). The purpose of this study focused on a makerspace within an elementary school media center. To begin, it is important to understand the broader context of makerspaces to have a better understanding of the implications of this work.

Makerspace interest grew out of what has been called the Maker Movement (Maker Media, 2016). Several key events led to thousands of makerspaces emerging in public and private spaces throughout the United States (Fleming, 2015). In 2006, Maker Media began as a global networking site created to connect all kinds of makers with each other to provide support. According to their website, "Maker Media serves a growing community of makers who bring a DIY mindset to technology. Whether as hobbyists or professionals, makers are creative, resourceful, and curious, developing projects that demonstrate how they can interact with the world around them" (Maker Media, 2016, para. 1). Around this same time, Maker Media began publishing *Make Magazine* which has become an important communication tool for the movement. In 2006, the first Maker Faire was said to spark the worldwide Maker Movement which continues to influence innovation and education (Maker Media, 2016).

In 2009, the movement was recognized when President Obama launched the Educate to Innovate Initiative. Through focus on science, technology, engineering, and mathematics (STEM) subjects, the president urged students to become makers. "Every

child, a maker" became the slogan of the president in terms of this initiative (The White House, 2016, para. 1). The focus of this program was to encourage young people and adults to design and build on their own (The White House, 2016).

The momentum of the Maker Movement found its way into both public and private entities. Many businesses, libraries, museums, community centers, churches, and schools all over the United States have gotten involved with makerspaces (Peppler & Bender, 2013). The movement emphasized several key ideas. First, it helped individuals to hone skills that are important for survival in the future: creativity, innovation, problem solving, and collaboration (Peppler & Bender, 2013). It has also provided opportunities for learning and self-expression within a community environment (Bevan, Gutwill, Petrich, & Wilkinson, 2014). Additionally, the Maker Movement facilitated the development of important technical, artistic, and mechanical skills needed for the future workforce of our nation (Tierney, 2015).

Maker Faires are events associated with the Maker Movement. These are gatherings of makers in festivals or conventions held to showcase the creations of the participants. *Make Magazine* sponsors and hosts these regularly across the country (Hlubinka et al., 2013). In 2012, a Maker Faire was held in San Mateo, California with about 120,000 participants. Mini-Maker Faires are held in smaller communities, while larger cities host bigger events. These smaller Maker Faires have also grown (Hlubinka et al., 2013). The projects at a Maker Faire vary widely in scale and scope. President Obama supported such endeavors. During the launch of his Educate to Innovate campaign to improve STEM education, the president spoke of his support. Kalil (2012) cited the President's words:

I want us all to think about new and creative ways to engage young people in

> science and engineering, whether it's science festivals, robotics competitions, fairs that encourage young people to create and build and invent—to be makers of things, not just consumers of things. (para. 4)

The role of creativity. Makerspaces are places where creativity can be explored by giving makers opportunities to express their ideas in a hands-on fashion as he or she makes things (Bowler, 2014). To provide opportunities for the nurturance and development of students' creative potential, spaces for open-ended exploration may play a key role. School libraries and media centers have become places where opportunities for creative expression happen. The opportunity to develop creative potential is important because creativity as a personal attribute has become a desirable and lucrative characteristic (Florida, 2007). Creativity has become an economic commodity in the 21st century (Benton, Mullins, Shelley, & Dempsey, 2013; Florida, 2007). Business, industry, and society in general need creative thinkers to face challenges and opportunities of the future (Florida, 2007). The rise of the creative class in the 21st century refers to those people in society who make their living through endeavors that involve creative energy (Florida, 2007). The age of knowledge and information for which schools have tried to prepare students has rapidly turned into an age of new conceptualization and creativity (Pink, 2006). If we follow the trends of recent years, it is possible many of the jobs our children will have in the future do not even exist yet. Technological knowledge has exploded exponentially during the past several decades, and creative thinkers are needed to know what to do with it (Pink, 2006). With the increased demand for creativity in our society, it is important for educators to understand exactly what creativity is and how it impacts our students. Makerspaces relate to this because these are potential places in schools for creativity to be nurtured.

Statement of the Problem

The United States educational system is faced with the problem of preparing students for a future of great uncertainty. Cornish (2004) referred to this uncertainty as "The Great Transformation" (p. 9). Cornish wrote,

> We begin to sense the existence of the Great Transformation as we notice the rapid changes in our lives: new technologies, new buildings, and new lifestyles. It is not simply that human life is changing, but that it is changing extremely fast. (p. 10)

Technology, the economy, and social institutions have experienced this rapid change phenomenon; and it has influenced all aspects of life, especially how people live and work (Cornish, 2014). The economic stability of the United States depends on entrepreneurial innovation (Benton et al., 2013; Cox, 2009; Ross, 2016). Studies reported by Benton et al. (2013) found that the United States ranked behind other countries in several areas including global innovation-based competitiveness.

Robinson and Aronica (2015) noted the problem in education related to this is the fact that public education reflects an industrial model that is far outdated.

> The issue in a nutshell is this: most of the developed countries did not have mass systems of public education much before the middle of the nineteenth century. These systems were developed in large part to meet the labor needs of the Industrial Revolution and they are organized on the principles of mass production. The standards movement is allegedly focused on making these systems more efficient and accountable. The problem is that these systems are inherently unsuited to the wholly different circumstances of the twenty-first century. (Robinson & Aronica, 2015, p. xxiii)

Since 1965, the population of the world has doubled to more than seven billion, and the numbers are rising. As this has happened, the amounts of technologies and means of communication have also risen. According to Robinson and Aronica (2015), this is only the beginning. "The old systems of education were not designed with this world in mind. Improving them by rising to conventional standards will not meet the challenges we now face" (Robinson & Aronica, 2015, p. xxiii).

A study by Lichtenstein, Lyons, and Kutzhanova (2004) noted seeking innovation is of critical importance for the sustainability of our society. This study looked at the trends of economic growth and development in communities nationwide. Enabling innovation starts by supporting its development among our youngest students (Benton et al., 2013). Makerspaces may be places where innovations can begin, because they are places where makers can be creative and try new ideas.

Teachers have always known that to be successful, they must meet the needs of students regardless of their background. This includes student needs to express creativity. Not only is it important to understand where students come from but also to have a clear vision of how they can succeed in the future (Robinson & Aronica, 2015). In the era in which we live, this has not always been clear. Teaching practices are needed that encourage creativity and innovative thinking to prepare students for the future. Teachers and students must look toward trying new things to facilitate rich conceptualization and creativity (Pink, 2006).

One of the ways creativity can be nurtured is by giving it an opportunity to grow. This includes giving it space and opportunity in an environment where teachers and students can do the work of creating (Robinson & Aronica, 2015). The Maker Movement has grown out of this need to give makers a platform for creating (Maker Media, 2016).

This also applies to learners in the educational environment (Fleming, 2015). Makerspaces in schools have been born as places where students can go to create, build, make, and develop their own creative ideas into actual products (Fleming, 2015). Making at school is about helping students to identify the problems they want to solve and the things they want to create related to their own inquiry. Makerspaces are more than just crafting corners. "By providing students with space and resources and inviting them to experiment, we can empower them to think of themselves as something other than consumers" (Canino-Fluit, 2014, p. 22).

Another very important aspect of makerspaces is the collaborative effect making with others has on the learning process. Students learn from each other in sharing ideas and tools (Britton, 2012). In addition to creativity, collaboration is a critical skill for 21st century learners (Partnership for 21st Century Learning, 2016). Makerspaces give students the opportunity to work with others. Together, alongside others, students work on creative endeavors in an environment where collaboration is encouraged (Britton, 2012). When students have problems they cannot solve themselves, others in the makerspace may share ideas and give suggestions. Students can work in community to solve problems that are of interest to them. This process can be very motivational and drive inquiry-based learning (Educause, 2013).

Makerspaces can be places where inquiry-based learning can occur and can be fueled by creativity. Kuhlthau (2010) discussed the importance of inquiry in school media centers. This connects to the problem this researcher investigated. "Educators around the world are seeking ways to prepare students for living and working in the changing information environment of the 21st century" (Kuhlthau 2010, p. 2). Kuhlthau also noted the importance of the media center and the media coordinator in the

preparation of students for living and working in this new complex environment. The role of the media coordinator is to facilitate "new ways of learning" (Kuhlthau, 2010, p. 2). Media coordinators can guide students through the inquiry process into much deeper and more meaningful kinds of learning to engage, motivate, and challenge students (Kuhlthau, 2010). Makerspaces are an avenue for increasing the opportunities for both creativity and inquiry. This is because students solving creative problems can be guided by the media coordinator or other teachers toward research and reference material that support student exploration and acquiring new knowledge (Weisgrau, 2015). Curiosity along with creativity may lead to new discoveries and innovations. The key issue involved in this research is whether makerspaces help students to be more creative.

Purpose of the Study

The purpose of the study was to gauge the impact makerspaces had on the development of creativity in elementary school students. Creativity has been identified as one of the key learning skills needed for students to be successful in the 21st century (Partnership for 21st Century Learning, 2016). According to Robinson and Aronica (2015), schools need to help students cultivate their creativity to sustain a future that is economically sound and environmentally sustainable. Makerspaces may inspire students to pursue their own creative aspirations. "Innovation is fundamentally an inspired activity, and the right environment has the potential to inspire new thoughts and endeavors" (Kurti, Kurti, & Fleming, 2014, p. 8). This study was aimed at determining if a makerspace in an elementary school media center could provide the opportunities and resources for students to work in such a way that their ability to think creatively is enhanced.

Significance of the Study

Makerspaces is a growing phenomenon in the United States. Schools have embraced the model because of the potential there is for encouraging creativity in students (Bevan, Petrich, & Wilkinson, 2014). According to Bevan, Petrich et al. (2014),

> Maker activities may come across as playful, even slightly wacky, explosions of inventiveness. But in education contexts like schools, museums, libraries, and after-school programs, research shows that if the invitation to creativity is accompanied by intentional structure and guidance, maker activities can be channeled to support deep student learning. (p. 28)

Makerspaces are different from traditional arts and crafts or vocational programs because the projects are driven by student interest and motivation within a community of makers (Bevan, Petrich et al., 2014). Makers is the term given to the individuals who are focused on making things (Hlubinka et al., 2013). The focus is on producing things rather than consuming things (Hlubinka et al., 2013). Quite often, making involves recycling or upcycling of materials once considered trash; therefore, it can have a positive environmental effect as well (Hlubinka et al., 2013).

Makers are encouraged to follow their own inquiry toward developing ideas that solve problems (Bevan, Petrich et al., 2014). Making is also done in a community. Students work on their ideas in a setting where other makers are present (Hlubinka et al., 2013). At times, the students may call on their peers for help, ideas, or suggestions. In turn, they may offer their ideas to classmates. The Partnership for 21st Century Learning (2016) recognized communication, collaboration, and critical thinking in addition to creativity as important skills all students should cultivate. Makerspaces are settings that facilitate these skills (Hlubinka et al., 2013). For the purpose of this study, the research

focused on creativity as a 21st century skill by investigating whether makerspaces increase creativity potential.

Research Questions

To determine if makerspaces had an impact on student creativity, the researcher conducted a mixed-methods action research study. The researcher is a media coordinator in an elementary school where makerspaces were implemented prior to the study. The following questions enabled the researcher to collect both quantitative and qualitative data.

1. To what extent does student exposure to makerspaces in an elementary school media center have an impact on student scores on the Torrance Test of Creative Thinking (TTCT)?
2. To what extent is there an association between student scores on the TTCT and teacher ratings of creativity on the Scales for Rating the Behavior Characteristics of Superior Students (SRBCSS)?
3. What are teacher perceptions of student creativity after student exposure to makerspaces in an elementary school media center?

Theoretical Framework

Makerspaces can be examined through a constructionist framework. Constructionism is a theory related to constructivism (Ackermann, n.d.). Constructivism is associated with the work of Jean Piaget and deals with the development of knowledge within an individual (Hruby, 2001). Piaget's theory focused on how learning happens as knowledge is constructed over time through stages (Ackermann, n.d.). According to constructivist theory, the learning process happens within the individual. Constructionist theory differs in that it is something that happens through social construction (Hruby,

2001). The focus is on physically making something to construct learning through a building process (Ackermann, n.d.). Seymour Papert is often associated with the ideas of constructionism. Papert is known for his work with designing technological systems for children during the 1970s and 1980s (Blikstein, 2013). He expanded the ideas of Piaget to use technology as a platform for invention (Blikstein, 2013). Logo is the system of programming that he developed which has enabled children to program and control tangible objects such as Lego building blocks (Blikstein, 2013).

Assumptions

The assumptions in this study were related to the elements of the school environment and learning situations which were considered likely to occur (Simon, 2011). The participants in the study were exposed to makerspaces in the school media center twice per week for the duration of 12 weeks. It was assumed that students enrolled in the fifth grade would be present at school and take part in the activities available in the makerspaces each week. It was also assumed the teachers of these students would be truthful in their qualitative feedback measuring their perceptions of student creativity. The activities the students participated in were part of the regularly planned curriculum.

Limitations

Limitations were conditions which were out of the control of the researcher with the potential to influence the outcome of the study (Simon, 2011). One limitation of the study is the element of time (Simon, 2011). The duration of the study was 12 weeks. The time was set to coincide with the fifth graders' access to the media center where they had access to the makerspaces. In addition to the weekly scheduled visit to the media center, students had one additional time scheduled weekly to address the issue of adequate exposure to the treatment of the makerspaces.

Another limitation of the study is the amount of materials available for the makerspaces. Makerspaces require resources. To address this limitation, a grant was written and awarded to fund materials for the makerspaces. This included Lego robotics kits, and littleBits magnetic circuitry devices as well as arts and paper materials for building and construction projects.

Delimitations

Delimitations are those factors that limit the scope and define the boundaries of the research study over which the researcher has some control (Simon, 2011). The delimiting factors of this action research study include the population which consists of 70 fifth-grade students from five classrooms within an elementary school. These students were selected because of their level of understanding and because research has shown that this age group often displays a slump in creative behavior (Runco, 2007). This population is also a convenience sample because they were students of the researcher already scheduled to use the media center for makerspaces. The makerspace at this school was made of materials for design and building activities including technology resources. These areas were within the school media center and under the direction of the media coordinator (also the researcher).

Deficiencies in the Literature

Makerspaces are a relatively new endeavor for most schools and therefore formal research studies related to the topic in elementary education was sparse. There are many articles and reviews of how makerspaces can be implemented which describe how they have been created and how they operate; however, data regarding the effectiveness of makerspaces was difficult to find. There is also a wealth of descriptive literature designed for media coordinators and others involved in implementing makerspaces, but

evaluative data regarding impact were not readily found.

The researcher did discover a qualitative study which investigated the competencies of those involved in implementing makerspaces. The findings of this study included the top 10 competencies for professionals (such as librarians and media coordinators) who oversee facilitating the spaces. These included people, management, and technology skills as well as implications for library professionals (Koh & Abbas, 2015). Although this study was related to media coordinators, it did not address the impact on student creativity directly.

Another qualitative study by Sheridan et al. (2014) compared three makerspaces. These makerspaces all served adults, and none were in school settings. One of the settings was a commercial business makerspace. The other two were based in a community center and a museum. This study sought to compare the environments of the spaces in terms of tools, usage, and opportunities (Sheridan et al, 2014).

Although the role of creativity in makerspaces has been discussed in the research, data regarding whether makerspaces enhanced creativity was not discovered by the researcher. Along these lines, another piece missing in the literature is research dealing with the fidelity of implementation of makerspaces. There is no single model or methodology for starting a makerspace and evaluating the effectiveness. Definitions of makerspaces are varied and range in complexity depending on the context and situation. This is because makerspaces in themselves are meant to be open-ended. Their purpose is to promote creativity. Tight definitions, standards, and guidelines are contrary to the concept of makerspaces (Cooper, 2013).

Finding literature related to creativity was far less challenging. There was a wealth of information related to creativity focused on definitions and the theories

surrounding it. It was also quite easy to find information on creativity programs and strategies for promoting creative thinking. There were assessments available to gauge creativity in individuals discussed in the literature. Most of the creativity assessment research is geared toward the perceptions of creativity. One of the most well-known studies is one by Paul Torrance who studied the progress of students for over a 40-year period based on the results of his test of creative potential. The longitudinal study proved the test to be highly valid (Cramond, Matthews-Morgan, Bandalos, & Zuo, 2005).

Runco (2007) discussed the great number of studies that have attempted to show the results of creativity training or programs to increase creativity. According to Runco, "There have been so many studies of the enhancement of creativity that meta-analyses have also been conducted" (p. 369). One of these studies by Rose and Lin (1984) investigated programs that used the Torrance test to measure effectiveness. They found most improvement efforts could be grouped into one of six categories: Parnes-Osborn Creative Problem-Solving Programs (or adaptions); Covington's Productive Thinking Program; The Purdue Creative Thinking Program; multiple-components programs; school programs; and kinesthetic, dramatic or transcendental meditation efforts. The study showed that the most effective program to be the Parnes-Osborn program (Rose & Lin, 1984). The Parnes-Osborn model is a creative problem-solving model developed in 1960 by Osborn who is known for originating the process of brainstorming. The model was later refined by Parnes and several others to what it is today (Rose & Lin, 1984). Of all the programs studied, "The most dramatic effects were apparent in the Parnes-Osborn program (eta=.63)" (Runco, 2007, p. 369). Rose and Lin (1984) concluded the other programs reviewed had more moderate effects. Overall, it was concluded from the meta-analysis that creativity can be both innate within an individual and nurtured through

enhancement techniques (Rose & Lin, 1984).

Audience

The audience for this study includes educators interested in creativity and how it applies to teaching and learning. The action research is especially relevant to librarians and media coordinators who may wish to implement makerspaces in the media centers where they work. Teachers wishing to teach students how to be more creative may also pick up on ideas that could be applicable in classroom settings as well. Administrators and supervisors may also be interested in the results of the study to determine whether makerspaces are worthy of support. These leaders as well as others in positions of power would be interested in the results of the study to determine whether money should be allocated for resources, materials, and supplies for the implementation of makerspaces. Organizations and individuals who provide grant money may be interested in the impact of makerspaces on student creative learning when considering funding for such endeavors.

Research Design

The research design used for this study was an embedded mixed-methods action research model. Specifically, the design was a convergent, embedded mixed-methods model. The students involved in the study consisted of 70 fifth-grade students who attended a Title 1 public elementary school in North Carolina. The students were exposed to the treatment of makerspaces in the school media center twice weekly for 12 weeks. The population consisted of students at the school where the researcher worked as the media coordinator.

The quantitative information included analysis of a pre and postadministration of the TTCT to heterogeneous groups of fifth graders. These data were analyzed using a

paired sample *t* test to look at relationships between the independent and dependent variables. Students were given a pretest prior to their experience with makerspaces and then a posttest after the experience. The second part of the study also considered quantitative data contributed by teachers through a creativity rating scale on each of their students. The instrument used was the SRBCSS. This is a Likert-like rating scale that looks specifically at creativity as one of the distinguishing characteristics of the students. A Pearson's R test was used to analyze whether there is an association between the TTCT scores and the SRBCSS ratings.

The third data point was qualitative. The same teachers were given an open-ended questionnaire to probe their perceptions of student creativity in a narrative format. These qualitative data were intended to inform how makerspaces influenced the students and if there were other factors teachers felt influenced their students' creativity. The questionnaire was piloted with third-grade teachers in the same school to establish reliability and validity prior to beginning the study. The data were analyzed to look for trends and patterns in response to support or refute the quantifiable results.

Definitions of Terms

Convergent thinking. Convergent thinking is characterized by conventional paths of thought (Runco, 2007). "Convergent thinking questions always have one (or very few) correct or conventional answers" (Runco, 2007, p. 4).

Creative capital. Creative capital refers to the resources and abilities an individual possesses which enable him or her to gain benefit (Brecknock, 2003; Florida, 2007; Robinson & Stern, 1998).

Creative class. The term for a social class composed of individuals who use and/or depend on creativity to prosper economically (Brecknock, 2003; Florida, 2007;

Robinson & Stern, 1998).

Creativity. Researchers have focused on creativity primarily in two ways: creativity as a function of human intelligence or creativity as its own construct (Kaufman, 2009). Most creativity definitions include mention of creativity as something that is new and something that is useful or relevant (Kaufman, 2009). Researchers including Runco, Jaeger, and Stein would assert that creativity is the creation of something that is novel and of value (Weisberg, 2015). Robinson and Aronica (2015) defined creativity in a similar way and added the importance of imagination and innovation. "Imagination is the root of creativity. It is the ability to bring to mind things that aren't present in our senses. Creativity is putting your imagination to work. It is applied imagination. Innovation is putting new ideas into practice" (Robinson & Aronica, 2015, p. 118). Creativity is also thought to deal with divergent thinking (Antonenko & Thompson, 2011), but divergent thinking alone does not necessarily define creativity (Kaufman, 2009). Guildford and Torrance focused on describing creativity as having the following four components involved: fluency, flexibility, originality and elaboration (Kaufman, 2009).

Divergent thinking. "Divergent thinking is the intellectual ability to think of many original, diverse, and elaborate ideas; while convergent thinking includes skills to logically evaluate, critique and choose the best idea from a selection of ideas" (Antonenko & Thompson, 2011, p. 205).

DIYer. An individual who is motivated to "do-it-yourself" in terms of making, building, and/or creating things (Bajarin, 2014).

Elaboration. "…ability to develop, embroider, embellish, carry out, or otherwise elaborate ideas…" (Torrance, 2008, p. 48).

Fab Lab. Short for fabrication laboratory. This is a space where products are

created using technology tools, machinery, and raw materials. The Fab Lab at the Massachusetts Institute of Technology (MIT) is known to be "comprised of off-the-shelf, industrial-grade fabrication and electronics tools, wrapped in open source software and programs" (Fab Foundation, 2016, para. 2).

Flexibility. Refers to the number of different categories of ideas (Runco, 2007; Torrance, 1974).

Fluency. The number of ideas posed (Runco, 2007; Torrance, 1974).

Innovation. Robinson and Aronica (2015) defined innovation as putting new ideas into practice.

Inquiry. The inquiry-based learning approach originated in the sciences based around the development and testing of hypotheses. Inquiry is the development of meaningful questions by students that guide their learning processes (Coffman, 2013).

Lego Education. Lego Education is a division of the Lego company specializing in providing learning experiences through the popular toy building blocks. The content of Lego Education is focused on STEM as well as literacy and humanities topics. The resources are designed to provide hands-on, manipulative experiences that inspire children to create, reason, and invent. Digitalization is also part of the program as there are software applications that enable the Legos to move, make noise, and do things (Lego Education, 2013).

littleBits. "littleBits is a platform of easy-to-use electronic building blocks that empower you to invent anything, from your own remote controlled car, to a smart home device. The bits snap together with magnets, no soldering, no wiring, no programming needed" (Sansing, 2015, p. 10).

Maker Faire. A gathering of makers. It was created by *Make Magazine* to

promote and support arts, crafts, engineering, and science projects (Maker Media, 2016). Maker Faires operate on both large and small scale. These events showcase projects by makers. The projects emphasize creativity and innovation and are reflective of the energy behind the Maker Movement (Hlubinka, et al., 2013).

Maker. Individuals who have a certain mindset geared toward making things. "Makers believe that if you can imagine it, you can make it" (Hlubinka et al., 2013, p. 2). Makers see themselves as more of creators than consumers (Hlubinka et al., 2013).

> Makers seek out opportunities to learn to do new things, especially through hands-on, do-it-yourself (DIY) interactions . . . Makers comprise a community of creative and technical people that help one another do better. They are open, inclusive, encouraging and generous in spirit. Makers are generally not in it for the money. This isn't about filing patents or making a profit. At the same time, (makers are) not anti-commercial— Makers sometimes start businesses . . . makers celebrate other makers — what they make, how they make it and the enthusiasm and passion that drives them. (Hlubinka et al., 2013, p. 2)

Maker Movement. Refers to a direction in American society where people are inspired to create and invent. The movement is towards encouraging people to be more of producers than consumers. Creativity is encouraged and processes for making new things are valued (Hlubinka et al., 2013).

Makerspaces. Spaces within buildings where students can come to work on creating with the indirect guidance of a professional (Canino-Fluit, 2014). "A makerspace is a physical location where people gather to share resources and knowledge, work on projects, network, and build" (Educause, 2013, para. 5). "Makerspaces come in all shapes and sizes, but they all serve as a gathering point for tools, projects, mentors and

expertise. A collection of tools does not define a Makerspace. Rather, we define it by what it enables: making" (Hlubinka et al., 2013, p. 1).

Media coordinator. A library education professional working in a school library media center whose duties include supervising and/or managing the collection, teaching students, and maintaining technology assets (Ballard, 2016).

Originality. The number of unique ideas that have not been posed before (Runco, 2007; Torrance, 1974).

SRBCSS. Also known as The Renzulli Scales, this is a battery of statements designed to rank a teacher's perception of certain behavioral characteristics including creativity (Renzulli et al., 2010).

School library media center. The school library media center is a common area within a school setting where students come to do research, leisure reading, and participate in classes designed to enhance literacy and inquiry-based practices. Another term for media center is library.

STEM education. An acronym for the movement in education emphasizing science, technology, engineering, and mathematics to increase the global competitiveness of students in the United States (Bailey, 2005; Guyotte, Sochacka, Costantino, Waither, & Kellam, 2014).

STEAM education. In addition to STEM subjects as a focus, art educational practices are also included in the acronym (Claymier, 2014; Erikson, 2013; Guyotte et al., 2014; Padovan, 2015).

Tinkering. "Tinkering is a branch of making that emphasizes creative, improvisational problem solving. It centers on the open-ended design and construction of objects or installation, generally using both high-and low-tech tools" (Bevan, Gutwill et

al., 2014, p. 99).

TTCT. Well-known and widely used test of creativity. It was developed by Ellis Paul Torrance and focuses on four key characteristics to rank creativity within an individual: fluency, flexibility, originality, and elaboration (Runco, 2007).

Summary

Chapter 1 was an overview of the study. It began with background information on makerspaces and the Maker Movement, because these are relatively new topics in the field of education. The problem involved in this study dealt with how creativity could be promoted in students, because this is a skill that research has identified as important for future success in the 21st century (Partnership for 21st Century Learning, 2016; Robinson & Aronica, 2015). The purpose of the study was to investigate whether makerspaces could enhance student creativity. The research questions were stated related to this followed by the assumptions, limitations, and delimitations associated with the study. Deficiencies in the literature as well as definitions of key terms were also presented in this chapter.

Many of the key ideas presented in the research will be discussed in the following literature review (Chapter 2). The subject of creativity in educational settings is extremely broad; therefore, the researcher focused on the importance of understanding creativity as it applies to 21st century learning situations (Partnership for 21st Century Learning, 2016). The teaching of creativity is also discussed as it applies to the implementation of makerspaces (Fleming, 2015; Sternberg, 1995). Measuring creativity was also of interest to the researcher for assessing the impact of makerspaces in an elementary school media center through action research. The role of the media coordinator also came into play in how creative activities were facilitated in the media

center's makerspaces. Finally, the literature review examines the theoretical frameworks related to makerspaces. The researcher discusses how constructionist theory aligns with the basic goals of learning by making (Papert & Harel, 1991).

Following Chapter 2, Chapter 3 explains the mixed method action research approach. The methodology describes the participants including the demographics of the population sample. Procedures are outlined indicating the sequence of the activities, the way the study was conducted, the research design, the rationale for the methods, and justification of the appropriateness of the methods. The instruments used are cited and described. The limitations of the study are presented including possible threats to validity and reliability. In addition, the delimitations are also included. The researcher analyzes and reports the results in Chapter 4. Chapter 5 focuses on conclusions, discussion, and recommendations from the researcher.

Chapter 2: Literature Review

Introduction

The literature review focused on research towards understanding the use of makerspaces in a school media center as a means of enhancing creative potential in students. The problem investigated how to develop creative potential in elementary school students to prepare them for their futures. The purpose of the study was to gauge the impact makerspaces had on the development of creativity in elementary school students. This action research study was a mixed-methods procedure. The study analyzed student performances on a test of divergent thinking (TTCT) and teacher perceptions of student creativity levels as evidenced on the Scales for Rating the Behavior of Superior Students (SRBSS). A qualitative questionnaire was given to the teachers of the students in the study to describe exposure to makerspaces in an elementary school library. The first section of the literature review focuses on creativity through the lens of education; the second section focuses on makerspaces; and the third section focuses on constructionist theory as it is applied to creativity and makerspaces.

Creativity in Education

Creativity and 21st century education. Florida (2007) discussed the emergence of a new class within American society. The creative class is known as a movement of people from all over the world working in careers which require creativity (Brecknock, 2003; Florida, 2007; Runco, 2007). Florida (2007) estimated that the population of the creative class in the United States was equal to about 30% of the workforce. During the last several decades, new fields and careers have emerged because of creative endeavors. "The resulting evidence of the links between creative capital, quality of life, and competitiveness have made the creative industries a serious economic factor that needs to

be considered particularly in regard to city viability" (Brecknock, 2003, para. 1). With this in mind, it is important for educators to consider how to promote practices which may encourage the development of creativity within students (Robinson & Aronica, 2015).

The predominant model of education in the United States is considered outdated by many in the educational field (Pink, 2006; Robinson & Aronica, 2015). According to Robinson and Aronica (2015), the model of schooling still used in many places today was designed over 100 years ago to meet the demands of the Industrial Revolution. The factory model used during this time focused on systems of efficiency for mass production. Neat and orderly rows in classrooms reflected the model factories set up for automation and efficiency. These educational models are long outdated, do not address the needs of our world now, and must be changed (Robinson & Aronica, 2015).

The answers to the uncertainty and challenges society faces lie in the cultivation of creativity (Robinson & Aronica 2015; Wagner, 2006). This must be taken seriously and with a sense of great purpose for educators because the challenges students face are becoming more complex (Robinson & Aronica, 2015). In the United States, the Partnership for 21st Century Learning (2016) proposed what are considered to be important skills for students to possess to be successful in meeting such challenges. The Partnership was established in 2002 and represents many business and educational organizations such as Dell, Apple, Microsoft, and the National Education Association (NEA; Formanack, 2008; Robinson & Aronica, 2015). "The Partnership believes schools must go beyond basic competency by weaving in 21st century interdisciplinary themes that are critical to success but not typically emphasized in schools today" (Formanack, 2008, p. 28). The partnership has offered what has come to be known as the Four Cs and

encourages educators to integrate them into classroom practices. The Four Cs are critical thinking, communication, collaboration, and creativity (Formanack, 2008; Partnership for 21st Century Learning, 2016).

Creativity is one of the Four Cs educators find most challenging to address (Partnership for 21st Century Learning, 2016). This is no doubt because of the different contexts in which creativity can be defined (Plucker, Begehtto, & Dow, 2004). For the purposes of education, creativity is a skill students should cultivate to address the challenges of problem finding, problem solving, divergent thinking, and the creation of new ideas and products (Runco, 2007). The challenge in promoting the development of creativity in schools comes in the fact that it is a difficult construct about which to find consensus (Partnership for 21st Century Learning, 2016).

Understanding creativity. Creativity is challenging to define (Runco, 2007). Scholars suggest creativity involves the production of something original and useful (Robinson & Aronica, 2015; Runco, 2007). Children are considered creative, yet in a different sense than adults because their creativity does not always result in a product (Runco, 2007). Children are not bound by their past experiences, routines, or expectations as adults sometimes are (Runco, 2007). The way creativity is expressed has a lot to do with why it is so hard to define (Runco, 2007). There is much diversity in how creativity is expressed, and it can play a role in all aspects of life from business, education, arts, and sciences to everyday common endeavors that require problem solving (Runco, 2007).

There is also great diversity in understanding how individuals acquire and grow in creativity. According to Runco (2007), all individuals have creative potential but not everyone demonstrates creativity. Potential depends on both our natural tendencies and

our environment (Runco, 2007).

> Each of us has potentials to fulfill, but the range of potentials varies from individual to individual. That, again is the contribution of biology, genes, and nurture. This same biological contribution is apparent in the trends and stages of development. (Runco, 2007, p. 40-41)

One interesting trend in development of creativity has been identified in the literature as the "fourth grade slump" (Torrance, 1967, p. 3). According to theories of stage development from Piaget and Kohlberg, children begin to follow the conventions of culture beginning around age eight or nine (Runco, 2007). Torrance (1967) identified this as a time when students begin to be less creative in their language and reasoning to fit the norms and expectations of their parents and teachers. "The conventional child is a conformist in the sense that he or she follows social expectations and imitates typical behaviors of his or her peers. This inhibits self-expression and creativity" (Runco, 2007, p. 41). Runco stated that certain types of creative thinking require strategies that go beyond conventional thinking such as those of scientists making new discoveries. Independent thinking beyond normal expectations help to form creative ideas (Runco, 2007).

Creativity is also linked to student motivation according to Buchanan, Harlan, Bruce, and Edwards (2016). Students who have more freedom to explore their own learning interests tend to be more motivated and open to new ideas. "Student motivation is linked to the students perceived value or meaning in the academic work at hand. It is connected to student interest specifically where interest carries both affective and cognitive components" (Buchanan et al., 2016, p. 29). Motivation is also a key part of engagement. Students motivated by their own curiosity, questions, and imaginations are

generally more engaged in learning (Buchanan et al., 2016).

Henriksen and Mishra (2014) discussed some of the challenges in understanding where creative ideas come from. The writers noted myths related to creativity: "Creativity has often been thought of as an elusive and mystical force – emerging from burst of insight available only to certain fortunate individuals" (Henriksen & Mishra, 2014, p. 15). Henriksen and Mishra disputed this myth and noted creativity deals with the way individuals see old or known things in a new way. Background knowledge is therefore essential to the building of creative ideas through variations of prior schema depicted in new and novel ways (Henriksen & Mishra. 2014). Henriksen and Mishra noted it is the job of educators to help students build upon their prior experiences and broaden their perspectives so they can develop new and novel ideas.

Creativity is also differently expressed depending on the culture from which it originates (Runco, 2007). Because there is great variation in how it is expressed, creative potential is also hard to define (Florida, 2007; Runco, 2007). Creativity is a form of human capital that when tapped into has great potential for many situations (Runco, 2007). Runco (2007) suggested study of creativity is extremely difficult because the creative process is multifaceted and requires an eclectic approach to understand it.

In opposition to claims that creativity is difficult to define, Cropley (2000) disagreed. He stated it is not hard to define because such a great deal of research has been done on the subject. This began with the historical address by J. P. Guildford to the American Psychological Association in 1950 where he spoke of the need for the study of creativity (Cropley, 2000). Cropley posed a working definition of creativity as an interaction between aptitude and process in an environment where a product is produced that is considered both novel and useful. This aligns with the Robinson and Aronica

(2015) definition that creativity brings forth something of value. Cropley's point for educators was how the theoretical understandings of creativity are applied in school settings.

Cropley's (2000) definition was not unlike the definitions given by other researchers on the subject (Robinson & Aronica 2015: Runco, 2007; Sternberg, 2006). Henry (2009) looked at definitions of creativity and the importance of understanding them before applying them in educational settings. Henry cited Bailin who said, "if we are not clear about what is meant by creativity, we may end up sacrificing creativity precisely in the process for trying to foster it" (p. 1). Henry went on to describe how creativity has been defined through the years from four perspectives: the creative person, the creative process, the creative environment, and the creative product.

Four P approach to creativity. Rhodes (1961) was the first to describe the Four P approach to understanding creativity. Rhodes referred to creativity as evidenced through the personality and refers to "intellect, temperament, physique, traits, habits, attitudes, self-concept, value systems, defense mechanisms and behavior" (p. 306). Process applies to "motivation, perception, learning, thinking, and communication" (Rhodes, 1961, p. 307). Rhodes used the word "press" to represent environment and described creativity relating to it through the relationship between human beings and the environment. The product of creativity is the item that is created; and according to Rhodes, it may be physical, tangible, or idea related.

According to Kaufman and Beghetto (2009), creative product is the most widely understood aspect of creativity probably because there is something concrete or tangible to evaluate. The product is what is yielded by the person through process and is ultimately impacted by the press (Kaufman & Beghetto, 2009). Often, the person may or

may not be considered creative due to the cultural context in which he or she is operating.

Four C approach to creativity. Kaufman and Baghetto (2009) discussed the 4C model of creativity that goes beyond what has been referred to as Big-C creativity and little-c creativity. Big-C creativity is the type of creativity considered groundbreaking within a field, while little-c creativity is that which is considered every day (Kaufman & Baghetto, 2009). Two additional forms of creativity added to this by Kaufman and Baghetto (2009) were mini-c creativity which is considered part of the learning process and Pro-c creativity which is considered to be at a professional level.

Teaching creativity. Sternberg (2006) believed students could be taught to think more creatively. Other researchers agreed with this premise (Berrett, 2013; Hirsch, 2010; Hunsaker, 2005; Lin, 2011; McWilliam & Dawson, 2008; Robinson & Aronica, 2015). The investment theory developed by Sternberg (1995) stated,

> Creatively gifted people share characteristics, including certain styles of thinking motivation and the right environment. It is consistent, however, with many theories of creativity that teachers would do well to read. . . . Creative thinkers buy low and sell high. That is they propose ideas that are like undervalued stocks, ideas that are often summarily rejected by the public at large and viewed by others as odd, counterproductive, or even foolish. Many people simply do not realize—and often do not want to realize—that these ideas may be valid and perhaps superior to the way they think. (p. 80)

Creativity is a balance of synthetic, analytic, and practical abilities; and educators need to think about all three as very important (Sternberg, 1995). Synthetic ability is the ability to synthesize new ideas and make connections not thought of before. Analytic ability is the analysis of ideas also known as critical thinking with an evaluative element.

Practical ability is the ability to realize abstract ideas in real world ways (Sternberg, 1995). Sternberg (1995) developed strategies related to his Investment Theory that educators might consider to promote creativity. Table 1 displays 12 strategies Sternberg presented to apply his theory to the classroom.

Table 1

Sternberg's Investment Theory Strategies

1.	Serve as a role model for creativity.
2.	Encourage questioning of assumptions.
3.	Allow mistakes.
4.	Encourage sensible mistakes.
5.	Design creative assignments and assessments.
6.	Let students define problems themselves.
7.	Reward creative ideas and products.
8.	Allow time to think creatively.
9.	Encourage tolerance of ambiguity.
10.	Point out creative thinkers invariably face obstacles.
11.	Be willing to grow.
12.	Recognize that creative thinkers need to find nurturing environments

(Sternberg, 1995, pp. 81-84).

Measuring creativity. Pioneers in the field of measuring creativity include Guilford (Runco, 2007) and Torrance (Sternberg, 2006). Both were concerned with the measurement of divergent thinking (Runco, 2007; Sternberg, 2006). According to Runco (2007), J. P. Guildford was the president of the American Psychological Association and is known for his 1950 presidential address on the subject of creativity. He spoke of creativity as a natural resource and encouraged its development to help society. He spent 35 years studying it objectively; and much of his work is still influential in the field, especially related to convergent and divergent thinking. He posed that divergent thinking leads one to many different possibilities for solving a problem or finding an answer, while convergent thinking leads to one correct or accepted response. The numerous and varied responses may be described in terms of "fluency (the number of ideas), originality

(the number of unusual or unique ideas), and flexibility (the number of different categories implied by the ideas)" (Runco, 2007, p. 9).

E. Paul Torrance was a highly acclaimed developmental psychologist and one of the most recognized names in all of creativity research (Sternberg, 2006). He outlined creativity as a process where one has tried to solve problems by coming up with new solutions, testing them out, and then sharing the results (Millar & Dahl, 2011). He is known for the development of the TTCT which is used to assess a person's capacity for creativity (Torrance, 1974). The test is considered highly reliable and is the most used test of its kind across the world (Scholastic Testing Services Testing, 2016).

Torrance (1974) focused on solutions through divergent thinking. According to Runco (2007), divergent thinking is not the same thing as creative thinking, but they are related because it tells us something about the processes a person may be going through cognitively that lead to novel solutions and new ideas. "Divergent thinking tests are the most commonly used estimate of the potential for creative thought" (Runco, 2007, p. 10). According to Runco, it is convergent thinking that dominates most of the activities in traditional schools, meaning knowledge is valued based on one correct answer. This sharply differs from the kinds of divergent thinking Torrance saw value in and sought to measure through his instrument (Runco, 2007).

Creativity research. The nature of creativity and lack of consistent definitions have led many to seek to learn more about how it applies in educational settings. Numbers of researchers have studied creativity in very different ways (Kaufman, 2009; Runco, 2007; Sternberg, 2006; Torrance, 1967; Weisberg, 2015). Paul Torrance's instrument, the TTCT, has become one of the most widely used instruments for measuring creativity in individuals (Scholastic Testing Services, 2016). The research

behind this instrument spans the scope of 4 decades (Dahl et al., 2011). Torrance conducted a longitudinal study that began in the late 1950s and early 1960s. The students originally tested with his instrument for predicting creativity are still being studied (Dahl et al., 2011).

Beyond the Torrance test, others have also sought to study how to nurture and assess creativity in educational settings, but searching for studies on the assessment of creativity at the elementary school level proves to be challenging. A recent search yielded a study on the assessment of creativity in the United Kingdom in the field of art and design business. Penaluna and Penaluna (2009) explored the question of how to assess creativity in entrepreneurial learning at the postsecondary level. The findings of this study were "an assessment of ideas generation, innovation, and opportunity recognition are central to developing and learning entrepreneurial behaviors. There are clear parallels between the pedagogic approaches from design disciplines and the learning outcomes advocated in generic curriculum development for entrepreneurship" (Penaluna & Penaluna, 2009, p. 718).

A study of the effect of science activities used for fostering creativity in Turkish preschool children was another exploration of the issue (Mirzaie, Hamidi, & Anaraki, 2009). Much attention has been given to understanding the concept of creativity and less toward understanding how to assess it.

> The classical and contemporary views of creativity differ with respect to the nature of such aspects of creativity as 'insight' and with respect to the distribution of a capacity for creative activity within the population. But there is little disagreement between these views of creativity on the centrality of the generative processes of problem posing and problem solving in creative activity. (Mirzaie et

al., 2009, p. 82)

Mirzaie et al. (2009) noted researchers such as Torrance and Taylor both worked to develop ways to measure creativity; however, today many teachers assess creativity in a formative manner by monitoring work, discussion, and behaviors.

Makerspaces

Definitions of makerspaces. *The Makerspace Playbook* defines makerspaces as "physical spaces for people, including kids, to work together and review their projects. Making can happen anywhere—on a kitchen table or in a high-end Fab Lab, a living room or a garage, a school or a community center" (Hlubinka et al., 2013, p. 11). Many variations of makerspaces have grown worldwide (Cooper, 2013). The variety of makerspaces means there are no standard lists of equipment, activities, or designs for the spaces. The creative nature of makerspace entities means each makerspace can be as unique as the makers who use it. Makerspaces may resemble labs, art studios, or shop classes but do not represent one type of space. "Diversity and cross-pollination of activities are critical to the design, making and exploration process" (Cooper, 2013, p. 1). Flexible design is the best design when it comes to makerspaces. This is because the activities are constantly evolving. According to Cooper (2013), *The Makerspace Playbook* and other makerspace groups list tools and materials that can be considered. As the popularity of makerspaces has grown so have the opportunities for companies to profit. Commercial makerspace kits can be purchased from several suppliers (Hlubinka et al., 2013). School budgets often do not have means to purchase commercial kits. Many rely on donations and recycling programs as primary sources of materials (Hlubinka et al., 2013).

Makerspaces are areas where people come together to work on personal projects

(Fleming, 2015). Within these spaces, people can share tools, expertise, and ideas. (Benton et al., 2013). The term makerspace is intentionally broad and open-ended to avoid conceptual limitations (Holman, 2015). These are spaces where people can come to meet, socialize, and create. According to Barniskis (2014), these makers' interests often revolve around technology, science, and electronics but not always. A variety of activities can happen in a makerspace including sewing, welding, building, sculpting, wiring, painting, paper, and cardboard crafts (Hlubinka et al., 2013).

> For example, the Milwaukee Makerspace offers tools, mills, kilns, sewing and embroidery machines, and welding equipment, all in a large space with an industrial-sized crane. Some of the recent activities there include sewing one's own craft apron, creating a no-rules pinewood derby track and cars similar to the ones Boy Scouts use, and sharing all sorts of projects with the public on the builder's night out weekly events. (Barniskis, 2014, p. 7)

Despite the vast differences in the offerings of makerspaces, most do share some common features. In most cases, these spaces offer informal opportunities for learning, encourage collaboration, help to develop problem-solving and exploration skills, and help to facilitate activities that involve creating (Britton, 2012, ; Krueger, 2014; Maker Media, 2016). The components of makerspaces also differ depending on the audience of makers, funding, physical space, and goals of those in charge of running or maintaining the venue. According to Dale Dougherty, founder of Maker Media, successful makerspaces should do the following: promote learning through playful exploration, integrate naturally with art and science, and offer materials and tools that equip them to create (Krueger, 2014). Table 2 displays some of the variations of makerspaces found all around the world.

Table 2

Variations of Makerspaces

Fab Lab	Fab Lab is short for a fabrication laboratory equipped with digital technology that enables people to create products. The term came out of MIT and is credited to Dr. Neil Gershenfeld (Fab Foundation, 2016).
Hackerspace	Hackerspaces apply to spaces where people join to work communally with others who share similar interests that revolve around technology and digitalization. These places are social in nature and focus on media (Benton et al., 2013).
TechShop	TechShops are like hackerspaces and Fab Labs but charge fees for usage. Most allow users access to equipment, software and space for working. These businesses also offer training and technical support at a cost (Benton et al., 2013).
Library Makerspaces	Areas within public, school, and academic libraries where space has been reconfigured to meet the changing needs of patrons. These spaces can look different depending on the situation and resources available. Areas may include open spaces with tables that facilitate group projects and collaboration. The spaces may include computers, tools, building materials, and technical supplies. In libraries across the country, makerspaces offer access to all members of the community (Barniskis, 2014).
School Makerspaces	"To define a school makerspace by its purpose in the simplest of terms, it is a place where young people have an opportunity to explore their own interests; learn to use tools and materials, both physical and virtual; and develop creative projects" (Fleming, 2015, p. 5).

Growth of the Maker Movement led to the development of makerspaces as places for creative making to happen. These can be both physical and virtual. They can be workshop-like settings or they can be set in libraries and media centers. Some are commercial and others are parts of schools or other public settings (Hlubinka et al., 2013). The increasing participation in makerspaces involves "all kinds of people in

interconnected communities, defined by interests and skills online as well as local efforts to convene those who share common goals" (Hlubinka et al., 2013, p. 2). These ideas are at the heart of the Maker Movement and contribute to the communal making experiences that have become quite prevalent across the United States.

The Maker Movement. Humans have always made things. Since the dawn of man, people have been creators. Whether out of necessity, boredom, or an innate desire, people have always been makers (Halverson & Sheridan, 2014). The frame of reference of the Maker Movement described here is a much more recent and specific situation that began in the first decade of the 21st century (Halverson & Sheridan, 2014). "The maker movement refers broadly to the growing number of people who are engaged in the creative production of artifacts in their daily lives and find physical and digital forums to share their processes and products with others" (Halverson & Sheridan, 2014, p. 496).

The Maker Movement described in the literature began around 2006 (Maker Media, 2016). It was at this time that Maker Media emerged as a global network of creative entities focused on the concept of production versus consumption (Maker Media, 2016). According to Techopedia (2016), the Maker Movement represents the trend toward do-it-yourself (DIY) or do-it-with-others (DIWO) processes.

The individuals who create are known as makers. Makers use a variety of materials, resources, and gadgetry to create unique products (Techopedia, 2016). There are endless possibilities for makers; and as the movement grows, so do the bounds of the types of creations. In the initial stages of the movement, much of the emphasis was on recycling electronics; however, emphasis on building new creations out of any type of media is the goal (Techopedia, 2016).

Another component of the Maker Movement is the emergence of Maker Faires.

Maker Faires are events designed to showcase the making of many makers. *Make Magazine* is the largest corporate sponsor of the trademark events that occur in major cities all across the United States (Maker Media, 2016). Mini-Maker Faires also occur in smaller communities. These events happen in places where makerspaces are located. A typical Maker Faire can last from 1 to several days.

> Makers of all ages convene for one fantastic weekend to show off a spectacular array of projects that combine arts, craft, engineering, food, health, music, creative reuse, performance, science, and technology. Rockets to robots, felting to beekeeping, pedal-power to mobile muffin cars, hardcore hardware to silly software — you never know what you'll see. (Hlubinka et al., 2013, p. 2)

The Maker Movement attracted a great deal of notoriety in 2014 when the White House hosted its first ever Maker Faire (The White House, 2016). In 2014, President Barack Obama called on leaders to promote elemental innovation from the ground up by encouraging American making. In a presidential proclamation in 2015, he spoke of providing more opportunities for students to engage in making programs involving fabrication skills. Obama also noted the importance of the continued growth of the Maker Movement as a catalyst for invention and entrepreneurialism (The White House, 2016).

According to Bevan, Gutwill et al. (2014), "the maker movement celebrates creativity, innovation, and entrepreneurship through the design and construction of physical objects" (p. 28). There is a growing culture in modern society towards creating, hands-on making, crafting, designing, and inventing. Common activities involved are electronics, textiles, robotics, wood work, digital fabrication, welding, and computer programming (Peppler & Bender, 2013).

Activities in makerspaces. The types of activities offered in a makerspace are dependent on the tools and materials available as well as the desires of those using the space. Large pieces of equipment can be costly, so some spaces are limited in what experiences they can provide. Recycled materials are often used because they are cost effective and offer a green option for items that might otherwise end up in a landfill (Young Adult Library Services Association, 2016). Hlubinka et al. (2013) suggested partnerships be pursued with local community groups and businesses that may help fund resources. The Young Adult Library Services Association outlined a number of project categories and examples of creations that can happen in a Makerspace. These are described in Table 3. Other sources include similar and additional projects and are noted as well. Some involve commercially purchased products, while others can be made from simple and common items.

Table 3

Makerspace Activities

Sewing
Wearables
Knitting
Paper crafts
Card making
Bicycle repair
Computer programming
Electronics
Robotics
Engineering
Construction
Sculpture

(Hlubinka et al., 2013).

Many of the making activities focus on STEM and STEAM related concepts and themes. Makerspaces are a way to tie creativity in with science (Bevan, Petrich et al., 2014). These kinds of activities can help students not only develop science skills, but

they can also be socializing activities as well (Bevan, Petrich et al., 2014).

> Productive science learning identities are crucial for students choosing to pursue science academically, professionally, and through lifelong engagement. STEM-rich maker activities are powerful places for this identity work because they can accommodate a wide variety of interests and experiences, they blend intellectual and socioemotional engagement, and they provide opportunities for young people to develop, pursue, persist with, and accomplish original ideas and solutions in which they can take pride and ownership. (Bevan, Petrich et al., 2014, pp. 28-29)

Collaboration in making. The common thread in a makerspace is the fact they are communal in nature (Thomas, 2014). Collaboration is a very important part of the makerspace experience and is what makes it different from working on crafts, art, or computers in isolation (Thomas, 2014). The relationships that develop among makers provide a layer of support and expertise not available when one creates alone (Fleming, 2015).

Makerspaces can also lead to entrepreneurial opportunities. This country needs methods to support creative risk-taking to prosper economically (Florida, 2007). Economic prosperity depends on the creative talent within our people (Benton et al., 2013). Many of the problems facing our nation in the diverse and ever-changing global economy can only be solved through thinking critically and challenging old ideas. This relates to the ideas of Florida (2007) and what he referred to as the need for creative capital. Schools and communities need to establish more effective methods of producing a new generation of innovators (Benton et al., 2013; Fleming, 2015). Makerspaces may be an environment where creative solutions will flourish (Thomas, 2014).

Makerspaces in schools. Student success in the future requires preparation for

the global society. NEA (2010) introduced Preparing 21st Century Students for a Global Society. This document follows the model developed by the Partnership for 21st Century Learning by focusing on the Four Cs: critical thinking and problem solving, communication, collaboration, and creativity and innovation (NEA, 2010). The document stated there is "a critical need for innovation" (NEA, 2010, p. 6). The changing workforce is the catalyst for a different focus in our schools. There is also a need for deeper kinds of learning according to the Partnership for 21st Century Learning (2016). Educational makerspaces have the potential to promote and inspire deeper kinds of learning through student-driven methods (Kurti et al., 2014.

Facilitating 21st century learning requires new opportunities, structures, and tools. Fleming (2015) believed makerspaces can meet this need. This is because makerspaces go beyond the typical classroom environment and provide more open-ended, flexible spaces where students can adapt to meet their own learning goals (Fleming, 2015). Maker education follows the principles of constructivist education (Kurti et al., 2014. More specifically, it aligns with the constructionist theory of learning where students create products that engage them in meaningful learning (Fleming, 2015; Halverson & Sheridan, 2014; Papert, 1993).

Another way makerspaces prepare students for the future is through the potential for entrepreneurship and STEM focus. STEM jobs are likely to be prevalent in the future (Bevan, Gutwill et al., 2014). The tinkering experiences makerspaces provide can incite creativity and innovation (Martinez & Stager, 2013). Bevan, Gutwill et al. (2014) conducted a study involving both researchers and practitioners that posed tinkering helps to promote creativity and problem solving promoting STEM learning experiences. STEM tinkering activities help learners to develop scientific principles using "technical

tools, processes, and phenomena. Physical phenomena or concepts such as balance, forces, motion, light, electricity and magnetism, resonance, symmetry, and others (depending on the activity design) are core-building blocks for the development and construction of the learner's idea" (Bevan, Gutwill et al., 2014, p. 99). The study concluded that making is a potentially useful method to engage learners in tinkering which will enhance learning (Bevan, Gutwill et al., 2014).

Implementing makerspaces in schools. There are a number of resources available for the implementation of a makerspace within a school including steps taken to get started. The first thing to be considered is the actual space where the making will happen (Hlubinka et al., 2013). Hlubinka et al. (2013) suggested making the most of any usable space common to the faculty and students. Repurposing unused space or using spaces temporarily can work. Some spaces to consider might be the computer lab, the library, or the cafeteria because these are generally considered shared spaces anyway (Fleming, 2015). The following are steps suggested by Kurti et al. (2014):

1. Observe the students to determine their interests.
2. Review the curriculum and school programs to find compatibilities and possible augmentations to offer makerspace.
3. Consider national and global trends in technology and culture.
4. Identify themes in steps 1-3 to use in the makerspace.
5. Set aside space and bring in tools and parts.
6. Create an environment promoting student ownership of the makerspace.
7. Continue assessing, redesigning and adding new tools every semester to endure a relevant, growing experience. (p. 23)

It is hard to take on such a project as implementing a makerspace all alone. A committee

or team working together on implementation can make the experience more positive. It is also necessary to have the support of the administration in the school setting. There may be a need for schedule adjustments and other access granted to establish a makerspace. Successful makerspaces have happened where there has been backing of the principal and teachers (Kurti et al., 2014).

The role of the library media specialist. Library media specialists can have a critical role in the development of makerspaces in schools (Bowler, 2014). The library is one of the common spaces in a school where making can naturally occur. This is due to the openness of the area as well as the access to technology. Makerspaces allow natural inquiry experiences which are the cornerstone of many library programs (Fleming, 2015). According to Fleming (2015), the Maker Movement coincides nicely with the existing missions of many libraries. With the onset of digitalization, many libraries are shifting in how space is used. No longer must libraries be exclusively brick and mortar buildings or rooms to house print materials. Space once dedicated to stacks now hosts a variety of communal endeavors (Fleming, 2015).

STEM related tinkering, building, collaboration, and invention thrive in modern libraries. Makerspaces within school libraries are ideal spaces for these kinds of 21st century skills to be developed (Bevan, Gutwill et al., 2014). School librarians have a unique and important role in this (Fleming, 2015). According to Fleming (2015), "Library Media Specialists have the scope and the affordances to enable activities that, in so many ways, step outside the relative rigidity of the classroom canon" (p. 44).

Inspiring creativity. There is also the idea of how environmental influence affects creative thinking and behavior (Runco, 2007). Whitehouse (2009) noted teachers can either support or squelch creativity. If teachers model divergent thinking, they

overtly model creativity as something of value (Runco, 2007). Teachers who are overly critical and evaluative model the opposite (Runco, 2007). Runco (2007) stated intrinsic motivation encourages creativity more than extrinsic rewards and can lead the student to follow his or her own means of expression without pressure. According to Runco, "Creativity results from particular cognitive processes, attitudes, values, motivation, and affect. It has been said that attitudes represent the most malleable part of the creativity complex" (p. 192). Attitudes are important and educators should think about this when giving assignments that are intended to get students thinking creatively (Runco, 2007).

Rationale for makerspaces in school settings. Thomas (2014) stated young children should be given the tools they need to become makers. Makers are defined by Thomas as

> quite simply, makers make things. Some build robots, some sew clothes, some prepare food, some design tools, some construct houses. "Maker" isn't a new title conveyed after passing some test or degree program; rather, it is a self-identification. It's also not, by any stretch of the imagination, a new concept. (p. 1)

Students who are given the chance to become makers are given the chance to become innovators (Thomas, 2014). Making gives students the opportunity to express their creativity (Thomas, 2014). Thomas described the qualities that can be developed in children who are given the opportunity to make: curiosity, playfulness, risk, responsibility, persistence, resourcefulness, generosity, and optimism. The Partnership for 21st Century Learning (2016) suggested similar qualities to be developed in students to optimize opportunities for a successful future.

Makerspaces are places where students can practice the development of these

kinds of skills (Hlubinka et al., 2013). If students do not have opportunities to build, construct, take apart, and put back together again in a physical way will not be able to become good at doing so. Ideas without opportunity for realization never become more than ideas (Thomas, 2014).

Constructionist Theory

Constructionism. Makerspaces have a natural connection to the concept of constructionism (Donaldson, 2014). The theory of constructionism derives from the constructivist view of learning associated with Piaget (Hjorth & Wilensky, 2014). It focuses on learning as a process where learners build their own knowledge based on the world around them. Constructionist theory is associated with the work of Seymour Papert from MIT. Papert was one of the early pioneers of artificial intelligence and is most known for his work on how technology impacts learning (MIT Media Lab, 2016). His work with Piaget in the late 1950s influenced his ideas about technology and learning (Blikstein, 2013). In 1980, he published *Mindstorms: Children, Computers and Powerful Ideas* which at the time was a very progressive work featuring his ideas about how children can learn through constructing and creating using technology (Blikstein, 2013).

The constructionist approach is associated with constructivism, but there are major differences. Piaget's view of knowledge as a structure upon which cognitive operations can be built is extended to experiences that depend on building something physical; however, Piaget's model was based on the importance of building cognition within the individual (Hjorth & Wilensky, 2014). Constructionism requires an external feature through which learners construct and share their thinking in social groups (Hjorth & Wilensky, 2014). The physical model has an important function in constructionism, where the model in constructivism may be internal (Hjorth & Wilensky, 2014). Much of

Papert's work focused on technology and how students build knowledge using computers (Papert, 1993).

Constructivism and constructionist theory. The two theories are somewhat related, but there are inherent differences in constructivism and constructionist theory (Ackermann, n.d.). Both constructivism and constructionism involve construction of knowledge, but the difference lies in the environment (Hruby, 2001). Further explanation of the distinction between constructivist and constructionist thinking might be explained as "while constructivism deals with knowledge formation in the head, constructionism deals with knowledge formation outside the head between participants in a social relationship" (Hruby, 2001, p. 48).

Constructivists believe that knowledge is constructed by an individual through experiences (Karagiorgi & Symeou, 2005). "Constructivism proposes the existence of many levels of abstractions for knowledge construction" (Karagiorgi & Symeou, 2005, p. 18). Piaget's stages of development are constructs which are the result of operations that we carry out repeatedly (Karagiorgi & Symeou, 2005).

Another way of understanding how constructionism differs from constructivism is to look at it through the lens of multiple intelligences. Gardner (2008) is known for his theory of multiple intelligences and explained what he termed interpersonal and intrapersonal intelligences. "Interpersonal intelligence allows one to understand and work with others. Intrapersonal intelligence allows one to understand and work with oneself" (Gardner, 2008, p.18). Constructivism resembles intrapersonal intelligence and constructionism relates to interpersonal abilities.

Constructionism can be described simplistically as "learning by making," according to Papert and Harel (1991, para 1). Papert and Harel noted this definition

appears simple; but truly, it is not. According to Papert and Harel, there is no consensus on the one best way to learn. Individuals therefore learn by building what works for him or her, and the products of learning should be his or her own. Constructionism, therefore, involves an external product or process tangible in the perception of the learner (Papert & Harel, 1991). Makerspaces provide opportunities for the process to drive inquiry through construction of a tangible project. Papert's theories are related to this idea (Papert & Harel, 1991).

Building as learning. Constructionism is the theoretical framework behind makerspaces based on the ideas of Papert because makerspaces are student centered and focused around the process of building, making, or creating something tangible (Papert & Harel, 1991). "Makerspaces provide youth with a place to imagine, design, create, construct, and express ideas. Both individual and collaborative products emerge as children tinker and invent" (Lamb, 2015, p. 56). The principles of design, engineering, and building are related to constructionist theory (Lindeman & Anderson, 2016). Hands-on, physical building with such materials as blocks and Legos enable students to develop important skills that apply to both building and creativity. "Block building helps children develop concepts about balance, friction, tension, and gravity. . . . Empowered by success, (students) often challenge themselves with more complex designs" (Van Meeteren, 2015, p. 30). Makerspaces allow for STEM experiences such as engineering and building (Fleming, 2015). Van Meeteren (2015) stated that how teachers set up building experiences for children is important for developing engineering skills. Materials provided, parameters of the problem, and the inclusion or exclusion of information are important parts of the process (Van Meeteren, 2015). When these types of experiences are presented in groups, students encourage each other to practice

engineering habits.

> They use creativity to design the structure—flipping, rotating, or rearranging a block or a track. Perseverance and optimism are the result when a child moves a block or track incrementally until the system is successful…Children develop social skills so they can keep building and learning together. (Van Meeteren, 2015, p. 31)

Constructionism in makerspaces. According to Kurti et al. (2014), "educational makerspaces and maker education have the potential to revolutionize the way we approach teaching and learning. The maker movement in education is built upon the foundation of constructionism, which is the philosophy of hands-on learning through building things" (p. 8). Students construct their own knowledge alongside other learners in a makerspace (Kurti et al., 2014). As the students work together to meet challenges, they are all actively engaged in both learning and teaching new things to others (Karagiorgi & Symeou, 2005; Kurti et al., 2014).

Summary

This study examined the impact of makerspaces on the creative potential of students who are exposed to them weekly in an elementary school media center. Creativity has been noted to be an important construct for students to cultivate (Robinson & Aronica, 2015; Runco, 2007). Makerspaces are designed for students to have participatory experiences in making new things (Hlubinka, et al., 2013). The opportunities in a makerspace can be very open-ended and range from artistic endeavors using basic materials to highly technical projects using software, electronics, and mechanical equipment (Fleming, 2015). STEM-related activities find a natural fit in makerspaces.

> STEM-rich maker activities are powerful places for this identity work because they can accommodate a wide variety of interests and experiences, they blend intellectual and socioemotional engagement, and they provide opportunities for young people to develop pursue, persist with, and accomplish original ideas and solutions in which they can take pride and ownership. (Bevan, Petrich et al., 2014, p. 29)

Constructionist theory relates to this because the development of the ideas in makerspaces can lead to student construction of knowledge within groups of makers (Sheridan et al., 2014).

The next chapter focuses on the methodology involved in this action research study. This is an embedded mixed-methods action research study that explored the problem of how to increase creativity in students. The research questions focused on to what extent exposure to makerspaces in a school media center impacts creativity, whether there is an association between student scores on the TTCT and teacher ratings of creativity on the SRBCSS, and teacher perceptions of student creativity after the students are exposed to makerspaces. The researcher analyzed three data points to help make the determination of the impact of makerspaces in Chapter 4. Chapter 5 discusses the conclusions and directions for further study.

Chapter 3: Methodology

Purpose

The purpose of this action research study was to determine if makerspaces in an elementary school library might influence the creativity of fifth-grade students at an elementary school located in the piedmont region of a state in the southeastern United States. For the purposes of this study, the school site will not be named to protect the confidentiality of the study participants. The study took place during the first semester of the 2016-2017 schoolyear. Students were exposed to makerspaces in a school media center where they were given opportunities each week to work in a space where they could make things alongside other students. The materials included Lego WeDo Robotics and software, littleBits circuitry components, and other art materials. The format of the makerspaces experiences was open-ended. Content themes, creative problems, and challenges were given weekly to scaffold students; however, students picked the projects they wished to work on. Materials were available to all students to use for the creation of projects and solutions. Creativity was the focus of the study because this construct was identified as an important skill for students to cultivate and should be considered in schooling (Partnership for 21st Century Learning, 2016; Robinson & Aronica, 2015).

Establishing makerspaces. Makerspaces were implemented in the school during the 2015-2016 school year through the joint efforts of the media coordinator, administrators, and a volunteer committee representing the stakeholders in the school. The group became a subcommittee of the Media Technology Advisory Committee which is a standing committee within the school charged with making decisions regarding the school library media program. The group met and established the vision, goals, and

expectations for establishing makerspaces at the school. This information is displayed in Appendix A. The team also spent time researching and gaining knowledge regarding makerspaces as most group members were not familiar with the concept. The Makerspaces Playbook for Schools is a comprehensive reference the group used as a resource for getting started (Hlubinka et al., 2013). This text was published by the founders of *Make Magazine* which is the group credited for the launch of the Maker Movement in 2006 (Hlubinka et al., 2013). A grant was written by the media coordinator for funding to initiate a makerspace. The school was awarded $1,500.00 which was used to purchase the Lego and littleBits materials. Other paper, cardboard recyclables, and art materials were collected. Space for storing and accessing materials was established within the media center. The group determined stations would be available for students to use. The stations all had STEM/STEAM-related themes including robotics, computer coding, and moveable and recyclable art. Table 4 displays the materials available in the media center makerspaces involved in this study.

Table 4

Makerspaces Materials Used in the Study

Legos
Lego WeDo kits
Lego software
littleBits magnetic circuitry
Cardboard, construction paper and Styrofoam
Recycled plastics and other materials
Fabric
Clay
A variety of arts and crafts materials

This study began at the beginning of the 2016-2017 schoolyear. This was the second year of makerspaces at the school involved in the study. During the first year of implementation, third-grade students piloted the program based on time available in their

schedule. Students in the pilot group were first oriented to the materials in each station and then given the chance to work at their station of choice once weekly. Kindergarten, first- and second-grade students were introduced to a portion of the materials in the makerspaces during their regularly scheduled media classes and had opportunities to use the spaces once per week. This was also based on their scheduled time in the media center during the first year of implementation.

The researcher began to implement makerspaces for current study during the 2015-2016 school year after receiving a grant to purchase materials students could use for creative projects. The space in the media center where makerspaces were available was an alcove with access to an interactive Promethean Board, tables with surfaces for students to use dry erase markers, vertical Lego stations, Lego tubs, electronic devices, and craft materials. Students had access to these materials during their weekly classes in the media center.

The activities in the setting of the makerspaces were open-ended. According to Sternberg (1995), creative work comes in different forms. Numerous models exist that intend to enhance creativity in students (Partnership for 21st Century Learning, 2016). Many of these were referred to in the literature review in Chapter 2. Elements of several models were drawn from by the researcher. One example of this was the Four P model first developed by Rhodes (1961). According to this model, four components are person, process, product, and environment (Rhodes, 1961). The model focused on creativity as multi-dimensional (Partnership for 21st Century Learning, 2016). The makerspace model in this study was designed by the researcher to align components of the Four P model (Rhodes, 1961) with the Four Cs from the Partnership for 21st Century Learning (2016). Collaboration, communication, critical thinking, and creativity stand as the pillars of

activity in the makerspaces. The activities in the makerspaces setting involved in this study also integrated STEM principals and content areas. According to Bevan, Gutwill, Petrich and Wilkinson, (2014), STEM activities can synthesize different subjects and interests along with engagement to promote further inquiry. The types of materials and activities available for fifth-grade students in the makerspaces were purposefully connected to their science and social studies curricula. Weekly open-ended themes such as ecosystems, weather, bionics, games, and challenges were offered during makerspaces sessions to make connections to content area units of study. Suggestions for projects and activities were only given at times by the facilitator of the makerspaces (the media coordinator, also the researcher) to scaffold students who struggled to come up with ideas; however, students were not instructed or given specific tasks. The open-ended nature of the sessions was purposeful to determine if the materials and activities encouraged or enhanced the creativity of the students, independent of the researcher. A common thread within the makerspaces activities encouraged in this study was the focus on higher order thought process such as those described in four of the six levels of the Revised Bloom's Taxonomy (Marzano & Kendall, 2007). Table 5 shows the verbs, materials, and situations inherent in the top four levels of Bloom's revised taxonomy as well as potential activities and products aligned with activities content areas themes and challenges the students participated in during the 12-week study.

Table 5

Revised Bloom's Taxonomy Aligned with Fifth Grade Content Themes and Makerspaces Activities

Bloom's Level	Applying	Analyzing	Evaluating	Creating
Verbs	solve, show, use, illustrate, construct, examine, classify, choose, interpret, make, put together, change, apply produce, translate	analyze, distinguish, examine, compare, contrast, investigate, categorize, identify, explain, separate, advertise, take apart, differentiate, subdivide, deduce	judge, select, choose, decide, justify, debate, verify, argue, recommend, assess, discuss, rate, prioritize, determine, critique, evaluate, criticize, estimate, defend	create, invent, compose, predict, plan, construct, design, imagine, propose, devise, formulate, combine, hypothesize, originate, add to, forecast,
Materials and Situations	diagrams, sculptures, illustrations, dramatizations, forecasts, problems, puzzles, organizations, classifications, rules, systems, routines	surveys, questionnaires, arguments, models, displays, demonstrations, diagrams, systems, conclusions, reports, graphed information	recommendations, self-evaluations, group discussions, debates, trials, standards, editorials, values	experiments, games, songs, reports poems, speculations, creations, art inventions, drama rules
STEM and other Content Themes	ecosystems, engineering, area and perimeter	area and perimeter, colonial inventions	weather, editorial writing	forces and motion
Makerspaces Ideas Constructed by Students	construct cardboard models, papier-mache, scrapbooks, maps, photography, make puzzles, clay, coding, murals	blue prints, coding, Lego models, constructing with cardboard, collages, sewing, electronics, wiring	weather machines, commercials, video productions	roller coaster models, creating games, puzzles, musical instruments, Lego robotics

(Anderson & Krathwohl, 2001).

Description of Research Design and Approach

This study was an embedded mixed-methods action research design. Action research is inquiry-based investigations of educational problems and situations within the practitioner's own educational setting (Efron & Ravid, 2013). "Action research is a distinct kind of research that is different from other traditional educational research. It is constructivist, situational, practical, systematic and cyclical" (Efron & Ravid, 2013, p. 7). Action research is constructivist because the researchers involved are focused on generating knowledge and making decisions to build new ideas (Efron & Ravid, 2013). Action research is situational because the context of the study involves the researcher directly (Efron & Ravid, 2013). Action researchers select problems and questions that need to be investigated in the real-world context they work in, thus making it practical in nature (Efron & Ravid, 2013). The research is systematic when it is carefully and intentionally planned to yield valid and reliable results (Efron & Ravid, 2013). Action research is cyclical because it begins and ends with questions and new knowledge that may start another strain of research (Efron & Ravid, 2013).

The steps in the action research process were considered dynamic because there were many unknown variables that the researcher addresses within the context of the study (Creswell, 2014; Efron & Ravid, 2013). However, Efron and Ravid (2013) have identified six cyclical steps in the action research process. Figure 1 shows these steps.

Figure 1. Action Research Steps (Efron & Ravid, 2013).

The researcher began by establishing the problem which is step one of Efron and Ravid's (2013) model. The problem the researcher wanted to explore was how to increase students' creative potential. The researcher wished to know whether makerspaces could help students be more creative. Creativity was the root issue and served as the catalyst for establishing makerspaces. Step two in the model was to research the situation and collect evidence. The researcher did this by reviewing the literature related to makerspaces and creativity. The researcher also established constructionism as a theoretical framework. Step three was to design the study. The study was an embedded mixed-methods study incorporating the collection and analysis of both quantitative and qualitative data. Two quantitative data points were collected. The first was gathered through the administration of a pre and postcreativity assessment of students using makerspaces. The second one was gathered through a survey of the

students' teachers' perceptions of the creativity levels of the students after their exposure. The qualitative data came from open-ended responses given by the teachers.

Step four of the cycle occurred during and after the study was conducted. The data were analyzed and interpreted in step five. Microsoft Excel software was used to conduct statistical tests of the quantitative data, and the qualitative data was coded for themes. Once the analysis was complete, the results were shared as step six (Efron & Ravid, 2013). According to Creswell (2014), mixed-methods research involves

> the collection of both qualitative (open-ended) and quantitative (closed-ended) data in response to research questions or hypotheses. It includes the analysis of both forms of data. The procedures for both qualitative and quantitative data collection and analysis need to be conducted rigorously (e.g., adequate sampling, sources of information, data analysis steps). The two forms of data are integrated in the design analysis through merging the data, connecting the data, or embedding the data. These procedures are incorporated into a distinct mixed methods design that also includes the timing of the data collection (concurrent or sequential) as well as the emphasis (equal or unequal) for each data base. (p. 217)

This research was an embedded-design model. This type of approach to action research is described by the form (quantitative or qualitative) dominating the study (Creswell, 2014; Efron & Ravid, 2013). "One approach is nested within the larger method of data collection. Either the nested or the dominating approach may be qualitative or quantitative" (Efron & Ravid, 2013, pp. 46-47). This study represented a QUAN(qual) model which Creswell (2014) described as one that "nests one or more forms of data (quantitative or qualitative or both) within a larger design (e.g., a narrative study, an ethnography, an experiment)" (p. 288). This study was focused on the

quantitative results of a pre and postassessment of student creativity followed by a quantitative analysis of teacher rating scales of the students to support or contrast with the prior results. The qualitative data point used was an open-ended questionnaire that was coded for themes to provide insight to the data revealed by the quantitative measures.

Research Questions

The researcher investigated three questions. The first two were evaluated quantitatively, and the third was evaluated qualitatively.

1. To what extent does student exposure to makerspaces in an elementary school media center have an impact on student scores on the TTCT?
2. To what extent is there an association between student scores on the TTCT and teacher ratings of creativity on the SRBCSS?
3. What are teacher perceptions of student creativity after student exposure to makerspaces in an elementary school media center?

Population

The participants in the study included 70 fifth-grade students ranging in age from 9-11 years old as the sample population that received the treatment of makerspaces. The students were heterogeneously grouped in five homeroom classes. The students attending the elementary school where the study took place ranged from prekindergarten to Grade 5. The location was a suburban community located 20 miles from a major city in the southeast region of the United States. The school was a Title 1 school where 62% of the population qualified for free or reduced lunch. This status enabled the school to receive federal funding for reducing class size and providing other programs to support student achievement. The demographics of the sample population are shown in Table 6.

Table 6

Sample Population of Fifth Graders by Age and Race

Homeroom	Age 9	Age 10	Age 11	White	Hispanic	African-American	Asian	Total
1	1	12	1	6	8	1	0	15
2	0	13	1	6	5	1	1	13
3	0	11	2	5	7	1	0	13
4	1	13	0	6	8	0	0	14
5	0	13	2	6	4	3	2	15

The homeroom teachers of the students were also included in the study. Their perceptions were quantitatively measured using the SRBCSS. They were also given an open-ended questionnaire as a qualitative data collection instrument. The teachers were informed in advance that their participation was voluntary and that they could withdraw from the study at any time. Table 7 displays information about the teacher population.

Table 7

Fifth-Grade Teacher Information

Teacher	Gender	Race	Years of Experience	Years Teaching Fifth Grade	Advance Degree Y/N	Number of Students
1	F	W	8	4	N	15
2	F	W	14	5	N	13
3	F	W	25	2	N	13
4	F	W	11	5	N	14
5	F	W	17	6	Y	15

Students in the school remained in self-contained classrooms with the same teacher for most of the school day including instruction of the core subjects: English and language arts, mathematics, science, and social studies. Students went outside of the regular classroom to participate in special area classes with certified specialists in the areas of physical education (PE), art, music, computers, and media once per day on a rotating schedule. These special area classes lasted 45 minutes.

One reason the researcher selected the fifth grade to participate in this study is because of the research done by Torrance (1967) noting students around the age of 8 or 9 often show a slump in creative behavior. This phenomenon has been called the "fourth grade slump" (Torrance, 1967, p. 3). According to developmental psychologists such as Piaget and Bruner, this is the time when students are shifting from the preconventional stage of development to the conventional stage where they become more likely to conform rather than diverge in their thinking and behavior (Runco, 2007). The researcher hypothesized if students around this age were exposed to makerspaces and given the chance to enhance their creativity, perhaps the slump might be avoided.

The researcher in this action research study was the media coordinator. The student sample selected was a convenience sample consisting of all fifth-grade students in the school. The teacher sample population consisted of each teacher assigned to a fifth-grade class. There were five fifth-grade classes in the school. A convenience sample is a group available for the treatment without having to alter the normal routine to participate in the study (Creswell, 2014).

Independent Variable

The treatment in this case was the exposure to makerspaces which served as the independent variable. According to Creswell (2014), independent variables are the variables that influence the outcomes. Makerspaces was the treatment variable in the study because there was the potential for exposure to influence the outcomes of student creativity. Makerspaces was an experience all students in the school were exposed to weekly as part of the normal routine. This routine continued for the duration of the study without altering the schedule or amount of time the students were exposed to makerspaces. All fifth graders participated in makerspaces during their media class once

per week for 45 minutes. Another 45 minutes per week was also provided for these students to partake in makerspaces in addition to their special area media class. This was accomplished by allowing the students to come to makerspaces during their extra recess time on the day they had PE in the gym. The students did not lose any opportunity for physical activity because recess on these days was in addition to PE in the gym.

Dependent Variable

Creswell (2014) described the dependent variable as depending on the independent variable. These are the outcomes of the treatment. The quantitative scores from the TTCT, the data collected from the SRBCSS, and the qualitative results of the teacher questionnaire given to measure student creativity was the variable. The study was mixed methods, so both quantitative and qualitative outcomes were considered.

Data Collection Instrumentation and Materials

Three forms of data were collected for the purposes of this study. The first two data points were quantitative and the third was qualitative. The first type of data collected assessed students' creative potential using the TTCT. According to Scholastic Testing Services (2016), the TTCT is one of the most well-known, highly reliable tests of creative thinking ability in the world. The test has two equivalent forms that can be used for pre and posttesting (Cramond et al., 2005; Scholastic Testing Services, 2016). The test was developed Paul Torrance, a psychologist and one of the foremost theorists about creativity (Runco, 2007). This test was given to students as a pre and postassessment before and after their exposure to makerspaces for a period of 12 weeks. Permission to use this instrument was granted by Scholastic Testing Services (Appendix B). The researcher also followed all Board of Education policies regarding the access and use of student records (Appendix C.)

The second type of data collected was from the homeroom teachers of the students in the study. The teachers were asked to rate each of their students using the creativity portion of the SRBCSS. Also known as the Renzulli Scales, this instrument is designed as a rating scale for teachers to assess characteristics of students for identification in gifted and talented programs (Fioriello, 2016). This test was purchased from Prufrock Press and is copyrighted material. The portion of the scales related to creativity was used for teachers to gauge their students' creativity levels after the students were exposed to makerspaces. These scales were developed by Joseph Renzulli, an educational psychologist who is known for his work related to the study of creativity in gifted and talented students (Runco, 2007). Within the scales, there is a section with nine statements specifically rating creativity as a characteristic of students to be evaluated. Teachers were asked to rate each student on these nine statements related to creativity.

The third data point for this study was qualitative. An open-ended questionnaire was given to the teachers of the students. The questionnaire addressed teacher perceptions of student creative experiences in the makerspaces. The instrument included their assessment of the value of creative experiences for their students. A pilot of the instrument was given to teachers of another grade level at the school to establish validity. Results from the questionnaire were coded for themes (Creswell, 2014).

Quantitative Data

TTCT. The TTCT is available through Scholastic Testing Services. The test used was a test of figural analysis. Students were asked to draw and write titles and descriptions (Scholastic Testing Services, 2016). The test is published in two forms so there is the capability for pre and posttesting (Scholastic Testing Services, 2016).

According to Scholastic Testing Services (2016), the figural portion of the test is

designed for all levels of students, kindergarten through adults. Three activities using pictures were given to students to assess fluency, elaboration, originality, resistance to premature closure, and abstractness of titles (Scholastic Testing Service, 2016). The figural part of the TTCT took 30 minutes to administer and complete. The test was professionally scored by Scholastic Testing Service. Standardized scores were provided for mental characteristics including emotional expressiveness, internal visualization, storytelling articulateness, extending or breaking boundaries, movement or action, humor, expressiveness of titles, richness of images, synthesis of lines or circles, fantasy, and unusual visualization (Scholastic Testing Services, 2016). Two different types of norms were available: grade related or age related (Scholastic Testing Services, 2016). Norm tables with standardized scores and national percentiles were provided. Also of interest is the creative index that classified the five standardized scores and 13 creative strengths (Scholastic Testing Services, 2016).

The process for collecting the TTCT data involved administration of a pre and postform of the test to the 70 students involved in the study. Prior to administration of the pretest (Form A), the researcher met with the students in homerooms and explained the purpose of the study, what the study entailed, and requested their participation. Students received both a student assent letter (Appendix D) and a parent consent letter (Appendix E). The letters outlined the study and informed the students and their parents that participation was totally voluntary with no penalty for not participating. Students and parents were also oriented about makerspaces and were told despite their participation in the data collection, students would still have access to makerspaces as part of the regularly planned curriculum. The students were informed that their participation would be anonymous and no one including their teachers would have access

to their scores on the TTCT unless the students wished for them to and informed the researcher of this in writing. The students were also told the scores would not in any way be reflected in their grades or other forms of regular school assessments. It was made clear that students could withdraw from the study at any time without retribution. All forms were distributed 10 days before the administration of the test per district policy. Teachers of the students were also oriented regarding the project prior to the start of the school year. Each signed an assent form (Appendix F) outlining the study, his or her role, and that participation was voluntary.

The pretest was given during the third week of school before the makerspace activities began with the students. The test was given to each homeroom separately. Test security was maintained as the forms were kept locked in a secure location prior to administration of the test. Students did not have prior access to the test nor coaching on how to take the test. The test was administered by the school's Academically and Intellectually Gifted (AIG) teacher who had been trained to give tests of this nature. The groups were also monitored by a proctor. The test administrator read directly from the manual, kept time accordingly, and handled all the procedural duties for giving the test.

The test was divided into three sections to test the components of fluency, originality, elaboration, abstractness of titles, and resistance to premature closure. The students were given 30 minutes to complete the test. The format of the test involved drawing and writing (Scholastic Testing Service, 2016).

After the completion of the pretest, the students were then exposed to 12 weeks of makerspaces as the treatment phase of the study. Twice weekly, the students had 45 minutes to engage in open-ended activities designed to promote higher order thinking (Marzano & Kendall, 2007). The STEM-related theme activities connected to the fifth-

grade academic content standards. No specific projects were assigned, and grades were not given. Students did receive oral feedback based on their participation and behavior as they worked collaboratively and made products. Student work was displayed in the makerspace area and students were encouraged to reflect on their experiences and share ideas with others. Students created works of kinetic art, cardboard sculptures, simple cars, machines, coding programs, videos, games, Lego robots, mazes, marble runs, puzzles, models, toys, jewelry, and murals. At the end of the semester (and the completion of the 12-week period), the students were given Form B of the TTCT as the posttest to see whether there had been growth in creativity measured by this instrument since the administration of Form A (the pretest). Forms A and B are aligned and parallel in tested constructs related to creativity (Scholastic Testing Service, 2016). The tests were then shipped to Scholastic Testing Services for professional scoring by trained assessors. Scholastic Testing Services published the test and provided scoring services. The results were tabulated, and the testing materials and data were returned to the researcher. The results included individual and group score reports for both Forms A and B. These score data are included as Appendix G. The researcher then performed a statistical analysis of the TTCT data using a paired sample *t* test to determine if there was a statistically significant difference between the pre and postassessment.

SRBCSS. The SRBCSS is a rating scale for teachers generally used for the evaluation of students for gifted and talented programs in schools (Fioriello, 2016). The SRBCSS examined teacher opinions of their students' abilities in the areas of learning, motivation, creativity, leadership, art, music, drama, communication, and planning (Renzulli et al., 2010). For the purposes of this study, the section with nine statements related to creativity was used and analyzed. The scales were completed by the five

teachers of the fifth-grade students who were exposed to makerspaces.

The second data point was the perceptions of the homeroom teachers of the fifth graders involved in the study. Teachers were asked to assess student creativity based on the SRBCSS. At the end of the 12-week treatment period, each teacher completed a rating scale for each of her students using the section of the SRBCSS related to creativity characteristics. This instrument was developed by Renzulli et al. (2010) and is often used as a screening instrument for gifted education programs (Renzulli et al., 2010). The format was a Likert-like rating scale that posed statements for which the teacher gave each student a rating of the behavior demonstrated as never, very rarely, rarely, occasionally, frequently, and always. Each child's rating was scored separately by adding the column totals and assigning a weight to each column. The sum of the weighted column totals was determined to obtain the score for each dimension of the scale. The statements related to imagination, sense of humor, nature of responses, risk-taking, diverse perspectives, flexibility, mental activity, and conformity (Renzulli et al., 2010). Groups score data from the SRBCSS was tabulated (Appendix H). The statistical analysis of this data set was completed by determining if there was a correlation between student posttest results of the TTCT Form B when compared to their teachers' assessment of each student on the creativity section of the SRBCSS.

To complete the comparative analysis of the TTCT Form B and the SRBCSS, a Pearson's R correlation was determined. The researcher chose to use these two instruments based on the similarity of the constructs each evaluates within the students. Table 8 highlights the connections between the instruments.

Table 8

Connections between the TTCT and SRBCSS

TTCT Construct	SRBCSS Construct	Connection
Fluency	Mental Activity/ Nature of Responses	Quantity of Ideas
Originality/ Abstractness of Titles	Conformity	Novelty of Ideas
Elaboration	Flexibility	Descriptive Capacity of Ideas
Resistance to Premature Closure		Follow through of Ideas

(Renzulli et al., 2010; Scholastic Testing Service, 2016).

Qualitative Data

The final data point was the qualitative component. The embedded mixed-methods QUAN(qual) design of the study allowed for the qualitative data to add description, explanation, and support to the quantitative results (Creswell, 2014). The researcher coded responses from an open-ended questionnaire for themes related to creativity. The questionnaire was developed by the researcher and piloted with a group of teachers whose students had been exposed to makerspaces prior to the study. Predetermined themes were considered prior to the development of the open-ended questionnaire. The predetermined themes were developed based on the key components of creativity defined and described by the Partnership for 21st Century Learning (2016). These themes were communication, collaboration, novelty, and value. The questions sought to get teachers to elaborate on their perceptions of their students' creative capabilities. Four open-ended questions were crafted to elicit the responses from the five homeroom teachers involved in the study. The questions are displayed in Table 9.

Table 9

Makerspaces Open-ended Teacher Questionnaire

Question	Response
1	After your experience of having your students participate in makerspaces please give examples of how makerspaces has impacted your students' ability to communicate new ideas effectively with others in a group.
2	After your experience of having your students participate in makerspaces please give examples of how makerspaces has impacted your students' ability to act on creative ideas.
3	After your experience of having your students participate in makerspaces please give examples of how makerspaces has impacted your students' ability to come up with new ideas.
4	After your experience of having your students participate in makerspaces please give examples of how makerspaces has impacted your students' ability to come up with new ideas that are worthwhile.

The qualitative questionnaire was coded for themes using Tesch's eight steps in the coding process to analyze and code the data (Creswell, 2014). The researcher began by reading the questionnaires and recording words and phrases which repeated and related to one another. This was done to get a sense of the descriptions (Creswell, 2014). The second step in the process was to re-read each document word by word (Creswell, 2014). The researcher went through each document word by word and considered the underlying meaning. These thoughts were recorded and can be found in Appendix I. Next, the researcher developed a list of topics and clustered similar ones together. The topics were then grouped by frequency, uniqueness, or lack of fit. The list of topics was abbreviated as codes and written next to the corresponding units as described in Tesch's eight steps of the coding process (Creswell, 2014). Categories were developed based on the frequency of times they were coded. Similar topics and overlap between them were considered. A list of final categories was determined by grouping related topics.

The questionnaire was comprised of questions to help gauge the perceptions of the teachers with regard to the level of creativity they found in their students after their exposure to makerspaces. These questions were developed based on the key components of creativity as defined and described by the Partnership for 21st Century Learning (2016): communication, collaboration, novelty, and value. The questions also related to Torrance's key constructs of fluency, flexibility, elaboration, originality, and resistance to premature closure (Torrance, Ball, & Safter, 1992). These are the key ideas that are covered on the TTCT.

The responses to the questions were coded for themes related to creativity consistent with the quantitative assessments. Coding the data involved looking for key ideas represented by the responses. Creswell (2014) stated that as categories emerge, the researcher can analyze the data to look for codes on topics that fit naturally, codes that are not expected, and codes that are unusual. Creswell also mentioned that the researcher can approach coding in three ways. The first was is to let the codes emerge as the information is collected. The second way is to use predetermined codes and then fit the data to them. The third way is to use a combination of the emerging and predetermined codes. The researcher used a combination of emerging and predetermined codes because the constructs in the questionnaire were specifically aligned to the constructs in the TTCT and the SRBCSS.

The overall goal of the questionnaire was to determine if teachers thought makerspaces were a worthwhile endeavor for their students. A pilot questionnaire was given to teachers of a different grade level of students also participating in makerspaces not included in the quantitative data analysis. A copy of this questionnaire is available in Appendix J.

Validity and Reliability

Creswell (2014) stated steps should be taken to insure the process of research is both valid and reliable. Data were triangulated from three data points as one way to meet this goal. The first two measures of data were quantitative and measure the creative behaviors of students from two different perspectives (student and teacher) before and after the exposure to makerspaces. The third measure was qualitative and sought to expand on teacher perceptions of the students to descriptively determine what kind of impact makerspaces had on students.

The instruments chosen have documented reliability and validity. One reason the TTCT is considered a highly valid and reliable measure is due to the results of a 40-year longitudinal study that Torrance began in 1958. Torrance tracked the students over several decades. He administered the TTCT to students in Minnesota between 1958 and 1964. He followed their progress in high school and beyond through follow-up questionnaires to see if students who scored high on the test demonstrated creative behaviors later in life. He found that there was statistically significant impact proving the predictive value of the instrument. His first follow-up of students found

> all of the creativity predictors . . . to be significant at the .01 level. By combining the scores on the creativity test battery administered in 1959 into a total creativity score to predict the combined creativity criteria derived in 1971, a canonical correlation of .51 was obtained for the full sample. (Cramond et al., 2005, p. 285)

Administration of the TTCT was handled in a secure fashion. A qualified administrator handled the administration and scoring of the test at the school site. The researcher was not involved directly in the administration and scoring of the testing.

The SRBCSS is also widely used and proven. Renzulli et al. (2010) analyzed the

components of the instrument using SPSS-S. Kaiser's criterion for estimating eigenvalues was used. The SSBCSS administration manual stated that four factors comprise the constructs of the instrument: learning, creativity, motivation, and leadership.

> The creativity factor described the degree to which students exhibited various creativity characteristics. A student with a high rating on this factor would exhibit characteristics such as the ability to generate many ideas (fluent thinking), the ability to generate unique ideas (original thinking), and a willingness to fantasize and manipulate ideas. (Renzulli et al., 2010, p. 13)

Renzulli et al. found

> the item composition of the empirically extracted factors was nearly the same as the item composition of the four a priori factors. We found minor differences on three items. Items 14 and 19 loaded on both Factor 1 (learning) and Factor 2 (creativity). Item 36 loaded most strongly on Factor 4 (motivation), but loaded almost as strongly on Factor 3 (leadership), which was judgmentally perceived to be a Leadership item. In summary, the derived factors were nearly identical to the judgmental factors, providing strong support for the construct validity of the scales. (p. 13)

Table 10 displays the factors and their correlations.

Table 10

Factor Intercorrelation Matrix from the Oblique Rotation (N=572)

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1: Learning	1.00			
Factor 2: Creativity	.46	1.00		
Factor 3: Leadership	.26	.25	1.00	
Factor 4: Motivation	-.55	-.25	-.28	1.00

(Renzulli et al., 2010, p. 15).

Renzulli et al. (2010) also determined the instrument was reliable by computing Chronbach's alpha reliability estimates for the four scales: learning, creativity, leadership, and motivation. The alpha reliability coefficients for the learning, creativity, motivation, and leadership factors were r = .91, r = .84, r = .90, r = .87, respectively. The alpha reliability for the instrument as a whole was r = .97. These coefficients provide strong support for the internal consistency of the instrument.

The qualitative questionnaire that was given to the teachers of the students in the study aimed to collect descriptive data that were coded for themes of the perceptions of teachers and the impact that makerspaces have on their students. The questionnaire was piloted with a group of teachers of another grade level whose students were also exposed to makerspaces to establish validity. Each teacher's responses were compared to the predetermined themes as well the answers of each other. To insure the questions were valid, the researcher asked the respondents if their ideas aligned with the themes. To insure the themes were reliable, the researcher determined which questions had at least a rate of 75% related responses (or three of the four teachers answering the pilot questionnaire with consistent ideas). This helped the researcher to determine interrater reliability (Creswell, 2014). Table 11 shows the results of the interrater response analysis and how the four questions used in the final questionnaire were chosen.

Table 11

Interrater Reliability of the Pilot Questionnaire – Similar Responses

Question	Teacher 1 Response	Teacher 2 Response	Teacher 3 Response	Teacher 4 Response	Teacher 5 Response
1	Yes	Yes	Yes	Yes	100%
2	Yes	No	Yes	Yes	75%
3	Yes	Yes	Yes	Yes	100%
4	Yes	Yes	Yes	Yes	100%
5	No	Yes	No	Yes	50%*
6	Yes	Yes	No	No	50%*

Note. *Questions not chosen for final questionnaire.

The responses for four of the questions had at least 75% of the responses related to each other. Two questions had less than 75% of the responses related to each other. Questions 1-4 were chosen for the final questionnaire to be used in the study.

Data Collection

The researcher used a convergent methods design involving embedded mixed methods. According to Creswell (2014), this method involves combining both quantitative and qualitative data collection methods and then analyzing them to see if the results confirm or disprove each other.

> The key assumption of this approach is that both qualitative and quantitative data provide different types of information—of then detailed views of participants qualitatively and scores on instruments quantitatively—and together they yield results that should be the same. (Creswell, 2014, p. 219)

The quantitative data collected were pre and posttest scores from the TTCT. Prior to the exposure to makerspaces, the test was administered to the sample population. The figural analysis instrument was administered by a qualified test administrator and proctor. After the completion of the preassessment using the TTCT, the students were exposed to makerspaces in the school library twice per week for 12 weeks. After 12 weeks (24

sessions), the students were given another form of the assessment. The assessment provided two mirrored versions for pre and postanalysis Forms A and B (Scholastic Testing Services, 2016). In addition, quantitative data from the teachers of the students were gathered using the SRBCSS. The teachers completed the rating scale which was scored yielding a numerical ranking.

The qualitative data collected an open-ended questionnaire to share data related to their perceptions of how makerspaces influenced their students' creativity. This qualitative measure was intended to gauge teacher impressions about the impact of makerspaces on the creative output of their students. The researcher developed the questionnaire to align with the skills identified as essential by the Partnership for 21st Century Learning (2016). Under the section on creativity, these categories were identified: thinking creatively, working creatively with others, and implementing innovations. The questions also related to fluency, elaboration, originality, and flexibility of ideas (Torrance, 1992).

Data analysis

According to Creswell (2014), "the challenge in a convergent mixed methods design is how to actually converge or to merge the data" (p. 222). In the case of this study, there were two quantitative databases analyzed and compared to the qualitative data in a side-by-side comparison. The data from the TTCT and the SRBCSS were compared first. Then the data from the teacher questionnaire were compared to the quantitative results. "Mixed methods writers call this a side-by-side approach because the researcher makes the comparison within a discussion, presenting first one set of findings and then the other" (Creswell, 2014, p. 222).

The quantitative data were analyzed using Microsoft Excel software. The pre and

postscores from the TTCT were analyzed using a paired sample *t* test. The purpose of this dependent sample *t* test was to compare the means on a single dependent variable (Urdan, 2011). The paired sample was the data from the pre- and post-TTCT administrations. The researcher looked for differences in the results of student scores that could possibly be linked to the treatment of makerspaces.

The data from the SRBCSS were analyzed using the Pearson product-moment correlation coefficient (Pearson's R). The researcher looked for the population sample's scores on two variables at the same time. The first data point variable was the scores from the post-TTCT (Urdan, 2011). The second variable was the scores for each child on the SRBCSS the teachers completed for the students in their homerooms after the exposure to makerspaces. The researcher wanted to know what kind of correlation might have existed between student performance on the TTCT and teacher perceptions on the SRBCSS. The researcher determined whether there was a correlation by looking at the direction and strength of the correlation coefficients (Urdan, 2011).

The qualitative questionnaire was coded for themes. The questionnaire was developed to align with the concepts of creativity from the Partnership for 21st Century Learning (2016), the concepts on the TTCT, and the four key areas identified on the SRBCSS. According to Creswell (2014), researchers may use predetermined codes or may look for codes which emerge. The researcher used a combination of both because it seemed probable the open-ended responses of the teachers might elicit themes beyond those predetermined by the alignment of the questionnaire. The researcher used Tesch's Eight Steps in the Coding Process to analyze and code the data (Creswell, 2014). The steps are displayed in Table 12.

Table 12

Tesch's Eight Steps in the Coding Process

Step 1	Get a sense of the whole. Read all the transcriptions carefully. Perhaps jot down some ideas as they come to mind as you read.
Step 2	Pick one document (i.e., one interview)-the most interesting one, the shortest, the one on the top of the pile. Go through it, asking yourself, "What is this about?" Do not think about the substance of the information but its underlying meaning. Write thoughts in the margin.
Step 3	When you have completed this task for several participants, make a list of all topics. Cluster together similar topics. Form these topics into columns, perhaps arrayed as major, unique, and leftover topics.
Step 4	Now take this list and go back to your data. Abbreviate the topics as codes and write the codes next to the appropriate segments of the text. Try this preliminary organizing scheme to see fi new categories and codes emerge.
Step 5	Find the most descriptive wording for your topics and turn them into categories. Look for ways of reducing your total list of categories by grouping topics that relate to each other. Perhaps draw lines between your categories to show interrelationships.
Step 6	Make a final decision on the abbreviation for each category and alphabetize these codes.
Step 7	Assemble the data material belonging to each category in one place and perform a preliminary analysis.
Step 8	If necessary, recode your existing data.

(Creswell, 2014, p. 198).

The researcher used the information gathered from the coding to look for connections between the open-ended questionnaire and the findings of the TTCT and the SRBCSS data to provide more description and explanation of the results.

Measures for Ethical Protection

Creswell (2014) outlined the types of ethical issues that occur in mixed-methods research and cautioned researchers to anticipate issues and plan how they might be

addressed appropriately. Prior to the study, the researcher obtained permission to use the site where the researcher works with the population to be studied. The study took place during regularly scheduled classes and did not go beyond the scope of activities normally planned for the students. Makerspaces were implemented in the school prior to the study and most likely will remain in place in some form or fashion for some time. The researcher informed the parents of the fifth-grade students as well as the teachers, faculty, and staff at the school regarding the purpose of the study. The informed consent form for parents outlined the purpose, procedures, and description of the pre and posttest experience. The student assent form also ensured confidentiality and privacy (Efron & Ravid, 2013).

The researcher also submitted an application to the university's Institutional Review Board (IRB). The standards set forth for ethics and professionalism were adhered to. The researcher reviewed the policies set forth by the school district regarding standards for research ethics and collection of data from students. Students signed a letter of assent. Letters of permission were obtained to use the testing instruments selected in line with policies set forth by the school's Board of Education. The students involved gave written assent, and their parents were asked to complete an informed consent form. The teachers of the students also signed an assent to participate.

Summary

This embedded mixed-methods action research study was used to determine the creative impact of makerspaces in an elementary school media center. The sample group consisted of fifth-grade students enrolled in a Title 1 elementary school. The feedback from the study was used to inform future decision making related to the use of makerspaces in the school. Two quantitative instruments were compared with qualitative

responses from a teacher questionnaire to determine the effectiveness of the makerspaces.

Chapter 4 reviews the data collected and presents the findings from their analysis. Results from the dependent variable *t* test, the Pearson's R test, and the coded data from the teacher questionnaire were synthesized to look for patterns and themes.

Chapter 4: Results

Introduction

This chapter provides the results of an action research study on the impact of makerspaces in an elementary school media center. This mixed-methods study investigated the use of makerspaces and how creativity of the fifth-grade students involved in the study was impacted. The study was an embedded mixed-methods design and included three different data points within the larger design (Creswell, 2014).

The mixed-methods approach included two quantitative data collection instruments and one qualitative instrument. The instruments used were the TTCT and the SRBCSS. The TTCT was given to students participating in the study as a pre and postassessment. A statistical analysis using a paired sample *t* test calculated the pre and postdata using Microsoft Excel. The SRBCSS was given to the teachers of the students after they participated in makerspaces in the school media center twice weekly for 12 weeks. A Pearson's R correlational analysis was used to compare the postassessment scores from the TTCT with the data from the SRBCSS. The qualitative instrument was a questionnaire developed to examine perceptions of the teachers of the students involved in the study. This was done to determine whether teacher perceptions and feedback supported the use of makerspaces as a means for helping students become more creative. The questionnaire was piloted with a group of teachers (whose students had been exposed to makerspaces prior to this study) during the semester before the treatment for this study began. After refinement, the questionnaire was given to the teachers of the students in the study upon completion of the 12-week treatment. Tesch's Eight Steps in the Coding Process (Creswell, 2014) was used to analyze the questionnaire data and code for themes to further explain the quantitative data. This chapter includes descriptions of the

participants in the study, the setting for the study, and the data collection methods. This is followed by an analysis of results based on the research questions which framed the study.

Data Analysis Strategy

The strategy for data analysis was to use both quantitative and qualitative data to determine if any or all had positive results in terms of the effectiveness of makerspaces. The quantitative results focused on two dimensions: growth of student creativity and then the association of that growth with teacher perceptions of student creativity. Microsoft Excel spreadsheets were used to statistically analyze the data and complete calculations for a paired sample *t* test and a Pearson's R correlational analysis. The qualitative results were then used to add further descriptions to either support or rebuke the quantitative finding. The researcher used Tesch's Eight Steps in the Coding Process to analyze an open-ended questionnaire completed by the teachers.

Findings

The results of each data point were analyzed by their application to each of the three research questions that framed the study. Each data point aligned with one of the research questions. Using the embedded mixed-methods QUAN(qual) allowed for the qualitative data to further describe and explain the quantitative results (Creswell, 2014). The research questions and the analysis of results are presented in the following section.

Research Question 1: To what extent does student exposure to makerspaces in an elementary school media center have an impact on student scores on the TTCT*?* Table 13 shows the results of a paired sample *t* test for differences in student scores on the pre- and post-TTCT. The statistical analysis compared the results of Form A and Form B. The test was administered to the students in the study using Form A

before the first week of their participation in makerspaces. Form B was given to the students after 12 weeks of participation in makerspaces.

Table 13

Paired t Test for Differences in Student Scores on Pre- and Post-TTCT

	Form A (Pre)	Form B (Post)
Mean	102.2714286	105.7428571
Variance	231.4469979	178.0778468
Observations	70	70
Pearson Correlation	0.343292758	
Hypothesized Mean Difference	0	
Df	69	
T Stat	1.767117125	
P(T<=t) one-tail	0.040815274	
T Critical one-tail	1.667238549	
P (T<=t) two-tail	**0.081630547**	
T Critical two-tail	1.994945415	

The statistical analysis of the data showed the students taking similar forms of the TTCT as a pre and postassessment scored a higher mean on Form B, the postassessment; however, the two independent samples did not differ from each other significantly in their average scores on the TTCT. This means that the difference was not greater than what one would expect to see between two samples or the standard error (Urdan, 2011). According to Urdan (2011), if the P value is less than an alpha value of .05, the null hypothesis is rejected. In this case, the P value using a two-tail analysis .08 was greater than .05, so the null hypothesis was true and the difference in the mean of the pre and postsample was not considered statistically significant.

The researcher reviewed the individual test scores of the students and noted one outlier score that seemed to skew the data. The student in question dropped 43 points from the pretest to the posttest. The researcher also noted that this student was absent for four of the sessions when the class had opportunity to participate in makerspaces. When

the researcher completed a paired sample *t* test for the group again excluding the outlier score, the P value changed; and the two-tail analysis resulted in a P value of .03 which would qualify the difference as significant because the value is less than the alpha value of .05. The results of the second *t* test are reported in Table 14.

Table 14

Paired t Test for Differences in Student Scores on Pre- and Post-TTCT Excluding Outlier Score

	Form A (Pre)	Form B (Post)
Mean	102.1304348	106.2753623
Variance	233.4386189	160.5554135
Observations	69	69
Pearson Correlation	0.392835396	
Hypothesized Mean Difference	0	
Df	68	
T Stat	2.213768099	
P(T<=t) one-tail	0.015101014	
T Critical one-tail	1.667572281	
P (T<=t) two-tail	**0.030202028**	
T Critical two-tail	1.995468931	

In addition to analyzing the data of the entire group, the researcher also disaggregated the data by gender and ethnicity. Tables 15 and 16 show the pre and postresults of the students when grouped by gender. Tables 17, 18, and 19 show the analysis of the data based on the ethnicities of the group.

Table 15

Paired t Test for Differences in Student Scores on Pre- and Post-TTCT for Girls

	Form A (Pre)	Form B (Post)
Mean	104.875	108.84375
Variance	266.4354839	176.7167339
Observations	32	32
Pearson Correlation	0.334101928	
Hypothesized Mean Difference	0	
Df	31	
T Stat	1/300181063	
P(T<=t) one-tail	0.101561538	
T Critical one-tail	1.695518783	
P (T<=t) two-tail	**0.203123076**	
T Critical two-tail	2.039513446	

Table 16

Paired t Test for Differences in Student Scores on Pre- and Post-TTCT for Boys

	Form A (Pre)	Form B (Post)
Mean	99.81578947	103.4210526
Variance	201.6678521	169.2233286
Observations	38	38
Pearson Correlation	0.284110496	
Hypothesized Mean Difference	0	
Df	37	
T Stat	1.36286365	
P(T<=t) one-tail	0.09058149	
T Critical one-tail	1.68709362	
P (T<=t) two-tail	**0.181162981**	
T Critical two-tail	2.026192463	

Table 17

Paired t Test for Differences in Student Scores on Pre- and Post-TTCT for African-American Students

	Form A (Pre)	Form B (Post)
Mean	82.33333333	95.5
Variance	131.0666667	138.3
Observations	6	6
Pearson Correlation	-0.05348	
Hypothesized Mean Difference	0	
Df	5	
T Stat	1.914568	
P(T<=t) one-tail	0.056859	
T Critical one-tail	2.015048	
P (T<=t) two-tail	**0.113718**	
T Critical two-tail	2.570582	

Table 18

Paired t Test for Differences in Student Scores on Pre- and Post-TTCT for Hispanic Students

	Form A (Pre)	Form B (Post)
Mean	102.3125	108.125
Variance	187.8346774	152.1774194
Observations	32	32
Pearson Correlation	0.285005493	
Hypothesized Mean Difference	0	
Df	31	
T Stat	2.106505772	
P(T<=t) one-tail	0.021676664	
T Critical one-tail	1.695518783	
P (T<=t) two-tail	**0.043353329**	
T Critical two-tail	2.039513446	

Table 19

Paired t Test for Differences in Student Scores on Pre- and Post-TTCT for White Students

	Form A (Pre)	Form B (Post)
Mean	103.9310345	104.4137931
Variance	172.8522167	204.9655172
Observations	29	29
Pearson Correlation	0.267693628	
Hypothesized Mean Difference	0	
Df	28	
T Stat	0.156190422	
P(T<=t) one-tail	0.438501808	
T Critical one-tail	1.701130934	
P (T<=t) two-tail	**0.877003616**	
T Critical two-tail	2.048407142	

Research Question 2: To what extent is there an association between student scores on the TTCT and teacher ratings of creativity on the SRBCSS? Table 20 shows the correlation values when comparing student postassessment scores from the TTCT and their teachers' ranking of each child's creativity characteristics on the SRBCSS. Each homeroom teacher filled out a ranking form resulting in an individual score for each child. That score was compared with the TTCT Form B to note any correlation.

Table 20

Correlation Analysis of TTCT Scores and SRBCSS Scores

Multiple R	**0.395783608**
R Square	0.156644665
Adjusted R Square	0.14424238
Standard Error	7.087559792
Observations	70
Df	68
P	<.05 (alpha =.05)

The TTCT scores were compared to the SRBCSS scores using Pearson's R test. Using the correlation value of r>+/-0.05, the statistical analysis showed a value of

r=.395783608 denoted a positive correlation between teacher rankings of students on the SRBCSS and students postassessment scores on the TTCT (Urdan, 2011).

Research Question 3: What are teacher perceptions of student creativity after student exposure to makerspaces in an elementary school media center?

The qualitative questionnaire was coded for themes using Tesch's eight steps in the coding process to analyze and code the data (Creswell, 2014). Those steps were described in Chapter 3. Categories were developed based on the frequency of times they were coded. Similar topics and overlap between them were considered. A list of final categories was determined by grouping related topics. The researcher determined there were three major categories, and the codes were denoted by the first three letters of each category. These categories are displayed in Figure 2.

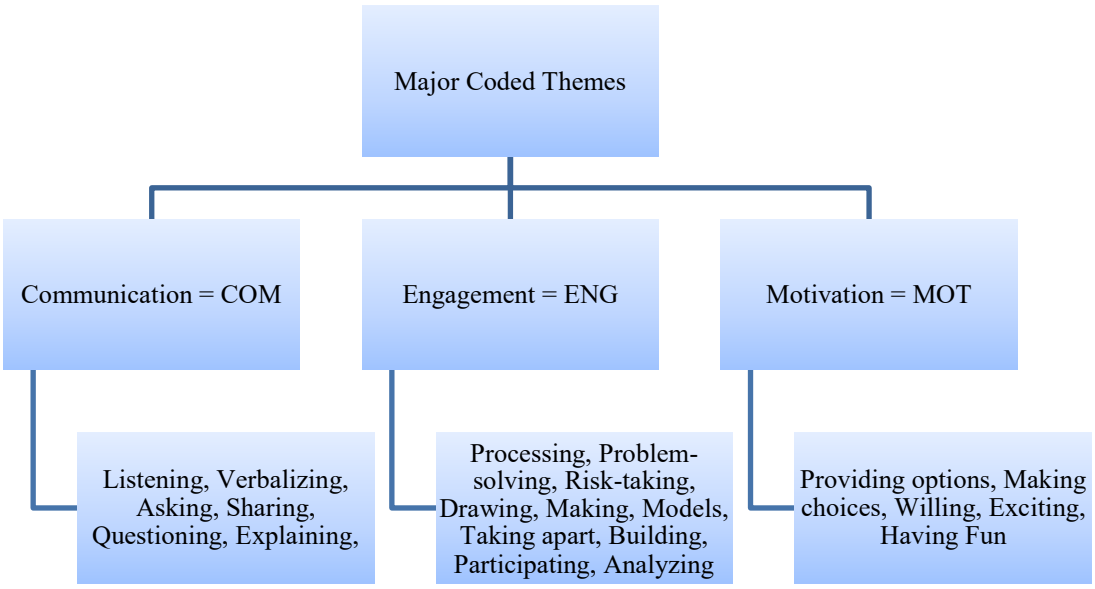

Figure 2. Major Coded Themes from the Open-ended Teacher Questionnaire.

The researcher reviewed each teacher's questionnaire carefully and looked for themes which seemed to repeat themselves among the five teachers' responses. The researcher then went back and determined whether the responses included ideas in alignment with the predetermined themes that framed the questions on the questionnaire. Specifically, the theme of communication seemed to appear the most. While the predetermined themes of collaboration, value, and novelty were not explicitly stated in the raw data, indirect connections can be made to these themes. The comments directly related to the three themes (communication, engagement, and motivation) are reported in Tables 21, 22, and 23.

Table 21

Teacher Questionnaire Responses Related to Communication

Teacher	Response
1	"The students are more verbal with creative ideas. I have noticed that they are more in character when we do Social Studies simulation diaries."
2	"From discussion, they can build off of an idea to find a way to make it work."
2	"My class seems to be willing to share ideas for how to solve a problem and not worry about being right or wrong."
3	"I hear them asking others, 'What do you think?' Their conversations include responses to others such as 'Oh yeah! I like that.'"
4	"Some students can clearly communicate with others now. The listening skills of many students have improved. They also take turns talking and validating each other's ideas and thoughts."
5	"Students are better able to communicate new ideas effectively in problem-solving during Math. They are now more confident in trying new attempts at approaching problems knowing that it is okay to fail and learn from mistakes."

Table 22

Teacher Questionnaire Responses Related to Engagement

Teacher	Response
1	"Students are very excited whenever they hear they are going to get to use creative thinking. They became very excited when we began to do creative dioramas of an ecosystem. Their work products became very engaging to them."
2	"My class has become very good at brainstorming ideas no matter how far-fetched they are."
3	"They certainly are not afraid to try. Hands on activities seem to be less intimidating for them from when they are given more traditional assignments."
3	"They seem to think out loud through a process and think about what obstacles they might face."
4	"Students researched information on certain ideas to make sure information is accurate and more detailed."
4	"Some students have presented me with different ideas for doing class projects."
5	"When given the opportunity, students follow through on their ideas. Having materials gives them both ideas and a means for completing their ideas."

Table 23

Teacher Questionnaire Responses Related to Motivation

Teacher	Response
1	"I had a group that got very excited when they had to figure out how to create a pond as part of our ecosystem unit. They seemed motivated by the task itself."
1	"Students enjoyed problem solving and finding new strategies to answer questions or suggest different strategies from their peers."
2	"My class seems to be willing to share ideas."
3	"I've loved hearing how excited they get."
4	"Students came up with consequences for their behavior when necessary."

Summary

Action research data were collected to determine if makerspaces in an elementary school media center had an impact on student creativity. To measure this, a mixed-methods approach was used. Two quantitative data sets were collected followed by a quantitative collection of data using an open-ended questionnaire with the teachers of the students in the study. The first quantitative data point was to determine if there was growth on a creativity test given pre and posttreatment phase. The instrument used was the TTCT. The statistical analysis used was a *t* test to determine if there was a significant difference in the pre and posttest. The researcher noticed an outlier score from one student in the data and decided to complete the *t* test twice: the first time including all students in the sample, and the second time excluding the outlier score. The results of the first *t* test including all students in the sample showed there was growth; however, the P value was greater than the alpha score of .05, so the null hypothesis was true and the difference in the means of the pre and postsamples is not considered statistically significant. The second *t* test was completed without the outlier score and resulted in the

P value of .03 which is less than the alpha score of .05. The null hypothesis in this case was false, and the results would be considered statistically significant when the outlier score was excluded.

Further disaggregation of the data showed no significance in growth comparing the pre and posttest scores based on gender. There were also no significant gains in scores when comparing ethnic groups individually except for the Hispanic group. The mean of the pre-TCTT scores for the Hispanic group was 102.3125. The mean of the post-TCTT scores for the same group was 108.125. The results of the paired sample *t* test for this data set resulted in a P value of .043353329 which is less than the alpha of .05. This showed significant growth in creativity scores on the TTCT for the Hispanic group.

The second quantitative data point was a comparison between student scores on the postadministration of the TTCT and their teacher's ranking of them on the SRBCSS, an instrument used by teachers to rank student creativity. The statistical analysis for this data set was completed by using a Pearson's R test for correlation. Using the correlation value of r>+/-0.05, the statistical analysis showed a value of r=.395783608 denoting a positive correlation between teacher rankings of students on the SRBCSS and student postassessment scores on the TTCT.

The final set of data considered was the descriptive information provided by teacher open-ended responses on a questionnaire related to their students' creativity. The descriptive data were coded for themes using Tesch's Eight Steps for Decoding Data (Creswell, 2014). Three themes emerged from teacher examples of how their students displayed creativity. They found examples of their students' creativity to be related to student communication, engagement, and motivation. The embedded mixed-methods

design enabled the researcher to use the qualitative data to further support and explain the results of the quantitative analysis. In this case, the descriptive data offered insight into t teacher perceptions of their students' creativity in the areas of communication, engagement, and motivation. The results of these data are further discussed in Chapter 5.

Chapter 5: Discussion

Introduction

The purpose of this chapter is to discuss the results of an action research study completed to determine if makerspaces in an elementary school media center had an impact on student creativity. Makerspaces in this study involved space and materials in a communal environment where students could freely imagine and make at will (Lamb, 2015). Constructionist theory suggests students learn through physical construction and ideas evolve through hands-on, real-world processes (Papert & Harel, 1991). The researcher used a mixed-methods action research model to investigate the creative impact makerspaces had on students in a maker environment. The study involved 70 fifth graders at a Title 1 school in the southeastern United States. The students were exposed to makerspaces twice weekly for 12 weeks as part of their regularly planned curriculum. The embedded mixed-methods design used three data points: two quantitative and one qualitative. These methods were used to investigate how makerspaces impacted the students.

Interpretation of the Findings

The researcher interpreted the findings of the study by analyzing student growth in their creative capacity as well as teacher perceptions of student creativity. The researcher looked at the students individually and as a group. The researcher also considered the ratings and comments of the teachers with regard to student creativity. Data collected addressed the three research questions from the study. Discussion of these findings ~~a~~re reported here.

Research Question 1: To what extent does student exposure to makerspaces in an elementary school media center have an impact on student scores on the

TTCT? Seventy students were assessed on Form A of the TTCT prior to their 12-week, twice weekly exposure to makerspaces. The students also took Form B of the test after the treatment to determine if there were gains in student creativity as measured by the TTCT. A paired sample *t* test was used and found the mean score to be higher for Form B (the postassessment); however, the two independent samples did not differ from each other significantly. In this case, the P value using a two-tail analysis was .08, which is greater than .05. This meant the null hypothesis was true, and the difference in the mean of the pre and postsample was not considered statistically significant. Upon review of the individual student data, the researcher found that one student's score was an outlier. The student in question dropped 43 points between the pre and postassessment which may have distorted the range of the scores. After investigating further, it was also noted that the student was absent for four of the weekly sessions. When considering the data excluding this one student's scores, the *t* test resulted in a significant P value using a two-tail analysis, P=.03, which meant the gains were considered significant.

The researcher also disaggregated the data by gender and ethnicity to gain further insight into specific groups of students. The results of the paired sample *t* tests for girls and for boys independently did not show significant gains; neither did the results of the same type of analysis when considering the ethnic groups for African-Americans and Whites. There was however a significant result for growth between the pre and posttest results for Hispanic students. The P value using a two-tail analysis was P=.04, meaning the growth was considered significant for the Hispanic subgroup.

The analysis of the growth in student scores suggests students can grow creatively when provided with scheduled makerspace time. Environments such as the makerspaces in the media center involved in this study can provide opportunity for students to engage

in activities such as those described in the literature review and methodology. The environment in this study allowed time, space, and materials where students could construct not only products but also grow creatively. This thought aligns with constructionist philosophy also described in the literature review (Ackermann, n.d.; Blikstein, 2013; Donaldson, 2014; Hjorth & Wilensky, 2014; Papert, 1993; Papert & Harel, 1991; Whitehouse, 2009). Further evidence of the connection to constructionism lies in the fact the students were given the opportunity to participate in creative making activities with others (Hruby, 2001). This is important because it represents a shift in the traditional role of the media center from quiet storehouses of information to active learning centers. The media center in the study became an environment where creativity had a chance to incubate through makerspaces. The creative growth of the students involved was positive.

Research Question 2: To what extent is there an association between student scores on the TTCT and teacher ratings of creativity on the SRBCSS?

Upon completion of the 12-week treatment period, the five homeroom teachers of the students in the study completed a ranking of each student using the SRBCSS. The section the teachers completed was a Likert-type rating scale. The scale scores were tabulated and the means of the SRBCSS and the TTCT posttest were analyzed using Pearson's R test for correlation. Using the correlation value of r>+/-0.05, the statistical analysis showed a value of r = .395783608 and denoted a positive correlation between teacher rankings of students on the SRBCSS and student postassessment scores on the TTCT (Urdan, 2011). This meant there was a relationship between how the teachers rated student creativity and how they performed on the post-TTCT. This is important because creativity tests have been criticized for their subjectivity (Kim, 2010; Plucker et

al., 2004). The positive correlation between the opinions of the teachers on the SRBCSS and the results of the students on the TTCT support the idea that the teachers had related understanding of their students' creative capabilities. This means that the growth evidenced by the TTCT is supported by teacher scores on the SRBCSS.

Research Question 3: What are teacher perceptions of student creativity after student exposure to makerspaces in an elementary school media center? An open-ended questionnaire was used to explore the five teachers' perceptions of their students' creativity after the students had been exposed to makerspaces in an elementary school media center twice weekly for a period of 12 weeks. The questionnaire probed into teacher ideas related to how makerspaces had impacted their students' creativity. The questions were structured around themes from the research used to evaluate creativity: communication, collaboration, novelty, and value (Partnership for 21st Century Learning, 2016). Teacher responses from the questionnaires were coded for themes using Tesch's Eight Steps for finding coded data themes (Urdan, 2011). The three major themes that evolved from teacher data as they described their students were communication, engagement, and motivation. Teacher comments added descriptive support for the quantitative data.

Communication. The Partnership for 21st Century Learning described communication as one of the four important skills needed to be successful in the future.

> The (P21) Framework emphasizes effectively using oral, written, and nonverbal communication skills for multiple purposes (e.g., to inform, instruct, motivate, persuade and share ideas); effective listening; using technology to communicate; and being able to evaluate the effectiveness of communication efforts – all within diverse contexts. (Dilley, Fishlock & Plucker, n.d., p. 1)

Communication was also cited as a critical component of the makerspaces environment and is a key element in what distinguishes makerspaces from other creative environments such as workshops and studios (Fleming, 2015; Hlubinka et al., 2013; Koh & Abbas, 2015). Responses from each of the five teachers on the questionnaire addressed communication in relationship to their students' creativity. The researcher noticed teacher comments related to communication and the application of creative practices such as fluency of ideas. Teacher 5 shared the following comment on the questionnaire: "Students are better able to communicate new ideas effectively in problem-solving during Math. They are now more confident in trying new attempts at approaching problems knowing that it is okay to fail and learn from mistakes." The makerspaces environment in the study encouraged communication and communal effort. This aligns with constructionist theory which emphasizes that students can gain insight from working with others (Donaldson, 2014; Papert,1993; Papert & Harel, 1991; Whitehouse, 2009).

Engagement. The Glossary of Education Reform (2016) stated, "student engagement refers to the degree of attention, curiosity, interest, optimism, and passion students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education" (para 1). Teacher 5 made the following comment on the questionnaire: "When given the opportunity, students follow through on their ideas. Having materials gives them both ideas and a means for completing their ideas." According to this teacher, the materials gave the students the means for development of creative ideas. This is an essential component of constructionist theory (Halverson & Sheridan, 2014; Papert & Harel 1991). The physical making is the catalyst for inquiry in makerspaces. This leads to the development of new knowledge. Teachers affirmed this as they reported how students were driven to research

about the things they were making.

Motivation. Motivation can be defined as the cause for why someone does something (Center on Education Policy, 2012). Motivation can be considered in at least four different dimensions according to the Center on Education Policy (2012). Motivation may be influenced by a person's belief that he or she is capable of something, his or her sense of control or autonomy, whether there is interest or value in completing a task, and whether there are rewards (internal or external) for doing something (Center on Education Policy, 2012). Teacher 1 commented, "I had a group that got very excited when they had to figure out how to create a pond as part of our ecosystem unit. They seemed motivated by the task itself." According to this teacher, the joy of the process motivated some of her students to come up with creative ideas. The researcher in this study often used design challenges to motivate students. The researcher found trial and error as the primary method the students used for problem solving such challenges when working in makerspaces. Without the physical materials, the process would have been difficult for the students. The students developed their plans based on the supplies available. When their ideas did not work, they then began to think beyond what was in front of them and request additional items because they were motivated by the challenge.

The three emerging themes do overlap. As Teacher 1 commented, "The students are more verbal with creative ideas. I have noticed that they are more in character when we do Social Studies simulation diaries." This comment pointed to the theme of communication through student verbal participation, yet also related to engagement because the students seemed to be interacting on a more intense level by getting in character with the subjects of the historical diaries they were creating. Engagement as a theme also overlapped with motivation and was evidenced by the comments of Teacher

3: “I’ve loved hearing how excited they get when they know they can offer other possibilities to the group. The talking gets loud and animated, but in a productive way.” The noise level reflected student excitement, and the teacher valued the productivity and engagement.

Implications for Practice

The results of this study suggest there are reasons to consider implementing makerspaces in media centers to promote creativity in students. The quantitative results of the comparison between the pre- and post-TTCT scores showed with the exclusion of one outlier score, there was statistical significance in the growth of creativity scores before and after exposure to makerspaces. Students with opportunities to construct and build may find their creative ideas develop when physical resources are available for them to work with (Papert & Harel, 1991). Papert (1993) suggested construction of ideas relies on something tangible, but it is more than that. Papert also wrote about how students he observed in a junior high school art class might approach other tasks such as mathematics in a constructionist environment: “It allowed time to think, to dream, to gaze, to get at new idea and try it and drop it or persist, time to talk, time to see other people’s work and their reaction to yours” (Papert & Harel, 1991, para 10). This kind of environment is the embodiment of makerspaces. Makerspaces in media centers have the potential to positively impact student creativity. This notion suggests new and unconventional uses of traditional library space.

The inclusion of makerspaces in school media centers and libraries may support connections to the growth of 21st century skills such as the Four Cs: communication, collaboration, critical thinking, and creativity (Partnership for 21st Century Learning, 2016). Makerspaces provide opportunities for all four of these skills to be enhanced.

Communication in the media center can be accessed through print, digital, and human interaction when students research and share their creations. In order to collaborate, the communal aspect of makerspaces must be present. Critical thinking is used as students work on challenges or engage in problem solving or refining innovations. All of this supports creative expression (Bowler, 2014).

The second body of quantitative data collected showed a positive correlation between student scores on the TTCT and teacher perceptions of their creative abilities evidenced on the SRBCSS. This showed teacher perceptions aligned with the results of the TTCT. This speaks a case for the reliability and validity of the results of the TTCT. It also gave the teachers a new tool to use for formative data collection. Another recommendation is for teachers to use tools such as the SRBCSS to evaluate their individual students so they might know them better as creative learners. The type of data teachers may gain from this form of assessment could give a better picture of each student holistically versus relying solely on more traditional, summative forms of assessment. According to Robinson and Aronica (2015), the challenges of the future demand a different kind of schooling and this includes how we prepare and assess children.

The final set of data was qualitative and gathered for gaining more descriptive information regarding student experiences with makerspaces from the perspective of their teachers. The feedback from an open-ended questionnaire was coded for themes that emerged based on teacher observations of students involved with makerspaces. Three major themes were communication, engagement, and motivation.

The first theme involved was communication. Papert and Harel (1991) suggested learning happens by making in a way that is communal. This aligns with constructionist

theory that learning is a social process focused around something physical. In makerspaces, the activity can be social. The making can be discussed, questioned, talked about, and commented on. This involves communication. The recommendation is to implement makerspaces in libraries and media centers that have traditionally been quiet spaces. This nontraditional use of libraries and media centers may bring about new ways of looking at such common areas in schools. Advances in technology, digitalization, and less dependency on print materials have changed the physical needs of media center environments. Less space is needed for stacks of books, and more space is needed for collaboration (Sobolik et al., 2014; Stanley, 2011). To meet the needs of students and use space effectively, the recommendation is to transform dead space into active learning environments facilitated through makerspaces.

The next two themes the teachers suggested in the qualitative data were engagement and motivation. The recommendation regarding these themes is to allow learning to be student driven. The teachers commented on how the students transferred their inquiry to engagement related to classroom projects. In makerspaces, the activities were both student centered and based loosely on content by means of themes, scenarios, and challenges presented by the facilitator. In this way, curricular needs were met while still providing tools for students to use for their own inquiry. When students were given the physical tools, materials, and opportunities needed right there in front of them, it sparked ideas, interest, and engagement (Papert, 1993).

This tied directly into the third theme of motivation. The teachers commented on changes in student energy levels and how excited they got about what they were creating. The power of engagement was fueled by the motivation of the students. Csikszentmihalyi (1997) would call this creative flow. This is the term described an

optimal experience because of deep task engagement coupled with the feeling of well-being. The experience of the work intrinsically motivates the students to stick with the task (Csikszentmihalyi, 1997).

The positive results of the study suggest media coordinators, teachers, and others who work with students at this level might incorporate the types of activities students were exposed to in makerspaces to see similar gains. The constructionist methods used in the makerspaces enabled students to grow creatively. Specific recommendations for those working to incorporate makerspaces based on the researcher's experiences would be

1. Find support within the building or organization among peers and colleagues who share the same vision and enthusiasm for constructionist learning methods. This includes administrative support.
2. Designate an adequate space for the activities to occur. This includes storage and room for equipment.
3. Start with small groups or grade levels.
4. Gather materials and resources.
5. Communicate with classroom teachers regarding curriculum connections, ideas, and projects that may carry over from the makerspace to the regular classroom.
6. Provide students with time for their own inquiry-based research to occur.
7. Document the process of implementing the makerspace through reflective writing, photography, and videography highlighting what works and does not work.

Limitations

Limited time for makerspaces was the major limitation the researcher faced. The schedule for the school was set in advance by the administration and was beyond the control of the researcher. The students in the targeted population initially were to only have media once weekly as a special area class for the first semester of the year. This limited the study to 12 weeks. The researcher worked proactively with the teachers to find an extra 45 minutes in the schedule each week for students to participate on the day they had PE as a special area class. This freed up student recess time for an additional weekly session for each class in makerspaces. This resulted in 242 sessions instead of 12. There were also scheduled and unscheduled interruptions such as assemblies, fire drills, and practice for a program that occurred during the same time block on a few occasions. In these cases, time missed was rescheduled.

Recommendations for Further Study

This study focused on the impact of makerspaces on student creativity in an elementary school environment. The following recommendations are presented for future research based on the conclusions of this study.

1. The treatment phase of the study could be lengthened to give students more time to engage in makerspaces. Increasing the session time to 1 hour instead of 45 minutes may give students more time to complete activities and allow incubation time for creativity. Additional sessions could be added to give students more opportunities to participate. The schedule constraints at the school involved were noted as a limitation of this study.
2. The study could be replicated with focus on different variables. Schools of varying demographic and socioeconomic status might be compared to provide

further insight. The study could also be done at the secondary level to see if age or maturity level comes into play. In addition, the study could be looked at from the context of gender.

3. Research related to makerspaces and creativity in settings other than educational venues could be done to see if location or context makes a difference in the creative abilities of the makers.
4. Research could be done to determine if the amount of formal structure present within the makerspace setting impacts creativity. Formal structure would mean that activities were predetermined by a teacher or facilitator versus an open-ended environment where students are totally self-directed.
5. The results of disaggregation of scores based on ethnicity showed that the Hispanic subgroup made significant gains on the TTCT, while the other two subgroups (African-American and White) did not. Further research to investigate how creative teaching practices and makerspace environments impact Hispanic learners may prove insightful.

Reflection

The need for creative thinkers in our world is rarely disputed as evidenced by the abundance of literature related to creativity and learning (Benton et al., 2013; Brecknock**,** 2003; Partnership for 21st Century Learning, 2016; Robinson & Aronica, 2015). Creative thinkers are needed to solve problems, develop innovations, and allow prosperity (Florida, 2007; Robinson & Aronica, 2015). Traditional school models based on 19th and 20th century scenarios are mismatched when applied to life in the 21st century (Robinson & Aronica, 2015). Makerspaces represent a different model of learning based on constructionist learning theory (Hruby, 2001; Papert, 1993; Papert &

Harel, 1991). Makerspaces may be one way to address the problem of supplying our world with more creative thinkers by providing an environment where creativity can flourish.

Makerspaces are a growing trend in libraries and media centers. According to Moorefield-Lang (2015), makerspaces are encouraging us to think about the use of space in libraries in new ways. Library and media center services are constantly changing in purpose and methods of delivery; this brings about new challenges for media coordinators (Moorefield-Lang, 2015). Makerspaces fit well in the media center environment because they make use of physical space once was used for other purposes. Media centers also provide a knowledge pool of resources for inquiry (Fleming, 2015; Moorefield-Lang, 2015;). Thinking of libraries in new ways means changing mindsets.

> Libraries are not what they used to be. State-of-the-art media centers no longer resemble the quiet, whispering environments of yesterday. Many have transformed into bustling workrooms utilizing every form of technology available. Well-planned media centers can help prepare students for the changing world of technology they will soon enter. (Horner, 2000, p. 48)

Makerspaces can be much more than spaces for crafts and technology. Makerspaces in libraries can encourage collaboration, problem solving, building, investigations, and playful learning (Moorefield-Lang, 2015). These types of activities are aligned to constructionist theory (Papert, 1993; Papert & Harel, 1991). Hooper (1998) noted that as students construct their own procedures, objects, and processes, their grasp of new ideas develops. Students engage their thinking as they physically build things. In addition, when done in community with others, student ideas are reinforced and refined in the process (Hooper, 1998).

Makerspaces naturally lend themselves to constructionist theory and the development of creative ideas. Lemons (2011) noted that creativity cannot be studied in isolation. "External variables such as social, cultural, and economic factors must be considered when explaining why, when, where, and how new ideas are created" (Lemons, 2011, p. 756). Thomas (2014) wrote about the communal power of makerspaces and stated,

> the final form of the artifacts, be they robots or clothing, wasn't where the power was coming from. Rather, it was through the community that was forming as people got together to make things, help each other, and then show off what they had made. (p. 3)

Makerspaces can be constructionist environments if physical making of products spark the learning process in a communal environment. The processes involved in the makerspaces environment analyzed in this study support creative practices described in research related to the Four P approach to creativity. As described in Chapter 2, the Four P approach refers to creativity as evidenced through the person, the process, the press (environment), and the product (Rhodes, 1961). Kaufman (2009) stated most of the time the product is what is emphasized in how we look at creativity, but the other areas are just as important. In makerspaces, all components of the Four P model of encouraging creativity are supported.

The results of this study support the emphasis on the person, process, environment, and the product through activities students may engage in during makerspace time. The students were given opportunities to their own creative thinking as individuals and as members of a group. This refers to the development of the creative person. The process was foundational for allowing this. Students were guided to solve

problems through a process of questioning, gathering of information or materials, trying out their ideas, reflecting, and then refining them. This process was facilitated through the environment where materials such as Legos, littleBits, cardboard, and arts and crafts items were accessible and choices were given. The materials not only enabled the students to complete products but also helped motivate them to try new things (Kaufman, 2009).

An interesting result of this study showed a significant difference in the pre- and post-TCTT results for Hispanic leaners while no statistical significance for the other two groups. Further exploration of this result may develop into new research to investigate why. The researcher-inferred differences in the form of the test may have been a factor. The form of the TTCT given was the figural analysis and did not rely as heavily on language. This form of expression may have been to the benefit of students with English language deficits. This result was noted in the prior section of this chapter as a topic for further research.

Conclusion

Makerspace environments are a potentially powerful tool for the incubation and fruition of creativity in our students. According to Moorefield-Lang (2015), makerspaces bring together innovation, creation, and critical thinking within a communal learning environment. Makerspaces provide a place where students can develop critical thinking, collaboration, communication, and creativity (Partnership for 21st Century Learning, 2016).

Finally, makerspace environments provide a shift from traditional classroom experiences toward ones that may ready students for the challenges of the future. Sawyer (2015) discussed economic competitiveness as a motivator as to why schools should

foster creativity.

> Increasingly sophisticated information technology is spreading the scope of automation into sectors of the economy that formerly required active human involvement, including increasingly advanced service and knowledge work. This development is making obsolete those job categories that do not involve active, daily creativity. (Sawyer, 2015, p 3.)

This study showed the value in one type of makerspace environment at the elementary school level. The researcher of study found through action research that makerspaces are positive learning environments for supporting the creative development of students. The positive growth of the students was statistically significant except for one outlier score. There was a positive correlation between the creative potential of the students evidenced on the TTCT and the perceptions of the teachers in the study. The comments of the teachers supported the use of makerspaces as a creative learning environment. In moving forward, makerspaces should be considered as an option in school media centers. The findings of this study suggest schools and districts might consider implementing makerspaces as a venue to promote creativity.

References

Ackermann, E. (n.d.). Piaget's constructivism, Papert's constructionism: What's the difference? Retrieved from http://learning.media.mit.edu/content/publications/EA.Piaget%20_%20Papert.pdf

Anderson, L., & Krathwohl, K. (2001). *A taxonomy for learning, teaching and assessing, abridged edition*. Boston, MA: Allyn and Bacon.

Antonenko, P. & Thompson, A. (2011). Preservice teachers' perspectives on the definition and assessment of creativity and the role of web design in developing creative potential. *Education and Information Technologies, 16*(2), 203-224. doi:http://dx.doi.org.ezproxy.gardner-webb.edu/10.1007/s10639-009-9112-1

Bailey, C. (2015). An artist's argument for STEAM education. *The Education Digest, 81*(1), 21-23.

Bajarin, T. (2014). Why the maker movement is important to America's future. *Time.* Retrieved from http://time.com/104210/maker-faire-maker-movement/

Ballard, S. (2016). *Eloping the vision: An L4L job description for the 21st century*. Retrieved from http://www.ala.org/aasl/sites/ala.org.aasl/files/content/guidelinesandstandards/learning4life/resources/09_NovDec_Ballard.pdf

Barniskis, S. (2014). Makerspaces and teaching artists. *Teaching Artist Journal, 12*(1), 6-14. doi:10.1080/15411796.2014.844621

Benton, C., Mullins, L., Shelley, K., & Dempsey, T. (2013). *Makerspaces: Supporting an entrepreneurial system*. East Lansing, MI: EDA University Center for Regional Economic Innovation.

Berrett, D. (2013). Creativity: A cure for the common curriculum. *The Education Digest, 79*(2), 13-20. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1440072055?accountid=11041

Bevan, B., Gutwill, J., Petrich, M. & Wilkinson, K. (2014). Learning through STEM-rich tinkering: Findings from a jointly negotiated research project take up in practice. *Science Education, 99*(1), 98-120.

Bevan, B., Petrich, M. & Wilkinson, K. (2014). Tinkering is serious play. *Educational Leadership, 72*(4), 28-33.

Blikstein, P. (2013). Seymour Papert's legacy: Thinking about learning, and learning about thinking. Retrieved from https://tltl.stanford.edu/content/seymour-papert- s-legacy-thinking-about-learning-and-learning-about-thinking

Bowler, L. (2014). Creativity through maker experiences and design thinking in the education of librarians. *Knowledge Quest, 42*(5), 59-61. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1525974588?accountid=11041

Brecknock, R. (2003). Creative capital: Creative industries in the creative city. Retrieved from http://esvc000225.wic048u.server-web.com/news/articles/Creative_Capital_Brecknock_2003.pdf

Britton, L. (2012). The makings of makerspaces, part 1: Space for creation not just consumption. *School Library Journal*. Retrieved from http://www.thedigitalshift.com/2012/10/public-services/the-makings-of-maker-spaces-part-1-space-for-creation-not-just-consumption/

Buchanan, S., Harlan, M., Bruce, C., & Edwards, S. (2016). Inquiry based learning models, information literacy, and student engagement: A literature review. *School Libraries Worldwide, 22*(2), 23-39. doi:http://dx.doi.org.ezproxy.gardner-webb.edu/10.14265.22.2.03

Canino-Fluit, A. (2014). School library makerspaces: Making it up as I go. *Teacher Librarian, 41*(5), 21-27.

Center on Education Policy (2012). What is motivation and why does it matter? Retrieved from Teachers.net/lessons/posts355htmlwww.teachers.ash.org.au/ reserachshills/daltonhtm

Claymier, B. (2014). Teaching 21st century skills through an integrated STEM approach. *Children's Technology and Engineering*, *18*(4), 5. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1533428628?accountid=11041

Coffman, T. (2013). *Using inquiry in the classroom: Developing creative thinkers and information literate students* (2nd ed.). Lanham, MD: Rowman and Littlefield Education.

Cooper, J. (2013). Designing a school makerspace. *Edutopia.* Retrieved from http://www.edutopia.org/blog/designing-a-school-makerspace-jennifer-cooper

Cornish, E. (2004). *Futuring: The exploration of the future.* Bethesda, MD: World Future Society.

Cox, E. (2009). The collaborative mind: Tools for 21st-century learning. *MultiMedia & Internet@Schools, 16*(5), 10-14. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/229763400?accountid=11041

Cramond, B., Matthews-Morgan, J., Bandalos, D., & Zuo, L. (2005). A report on the 40-year follow-up of the Torrance tests of creative thinking: Alive and well in the new millennium. *The Gifted Child Quarterly, 49*(4), 283-291, 356-357. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/212102914?accountid=11041

Creswell, J. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches.* Thousand Oaks, CA: Sage.

Cropley, A. (2000). Defining and measuring creativity: Are creativity tests worth using? *Roeper Review, 23*(2), 72-79. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/206697675?accountid=11041

Csikszentmihalyi, M. (1997). *Creativity: Flow and the psychology of discovery and invention*. New York, NY: Harper Perennial.

Dahl, C., Dunn, C., Gorlin, C., Kwiat, D., Postlethwaite, D., Schwarzrock, T., & Young, J. (2011). Personal reflections on creativity by Torrance kids. *ATA Magazine, 91*(3), 26-29. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/859257580?accountid=11041

Dilley, A., Fishlock, J., Plucher, J. (n.d.) What we know about communication: Part of the 4Cs research series. Retrieved from: http://www.p21.org/storage/documents/docs/Research/P21_4Cs_Research_Brief_Series_-_Communication.pdf.

Donaldson, J. (2014). The maker movement and the rebirth of constructionism. *Digital Pedagogy Lab*. Retrieved from http://www.digitalpedagogylab.com/hybridped/constructionism-reborn/

Educause. (2013). ELI7 things you should know about makerspaces. Retrieved from: https://net.educause.edu/ir/library/pdf/eli7095.pdf

Efron, S., & Ravid, R. (2013). *Action research in education: A practical guide*. New York, NY: The Guildford Press.

Erikson, P. (2013). Full steam ahead. *American School and University.* Retrieved from http://asumag.com/facility-planning/full-steam-ahead

Fab Foundation (2016). *What is a fab lab?* Retrieved from http://www.fabfoundation.org/fab-labs/what-is-a-fab-lab/

Fioriello, P. (2016). *What are the Renzulli scales and how are they used with gifted children?* Retrieved from http://yourgiftedtalentedchild.com/renzulli-scales/

Fleming, L. (2015). *World of making: Best practices for establishing a makerspace for your school.* Thousand Oaks, CA: Sage.

Florida, R. (2007). *The flight of the creative class.* New York, NY: Harper Collins. Retrieved from www.21stcentury skills.org

Formanack, G. (2008). The importance of language: The partnership for 21st century skills and AASL standards. *School Library Media Activities Monthly, 25*(1), 28-30. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/237138702?accountid=11041

Gardner, H. (2008). *Multiple intelligences: New horizons*. New York, NY: Basic Books.

Glossary of Education Reform (2016). Student Engagement. Retrieved from http://edglossary.org/student-engagement/

Guilford, J. (1950). Creativity. *American Psychologist*, *5*(9), 444-454. doi:10.1037/h0063487

Guyotte, K, Sochacka, N. Costantino, T, Waither, J., & Kellam, N. (2014). STEAM social practice: Cultivating creativity in transdisciplinary spaces. *Art Education*, *67*(6), 12-19. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1639851482?accountid=11041

Halverson, E., & Sheridan, K. (2014). The maker movement in education. *Harvard Educational Review, 84*(4), 495-504, 563, 565. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1642662200?accountid=11041

Henriksen, D., & Mishra, P. (2014). Twisting knobs and connecting things: Rethinking technology and creativity in the 21st century. *Tec Trends, 58*(1), 15-19. doi:http://dx.doi.org.ezproxy.gardner-webb.edu/10.1007/s11528-013-0713-6

Henry, J. (2009). Enhancing creativity with M.U.S.I.C. *Alberta Journal of Educational Research, 55*(2), 199-211. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/758657463?accountid=11041

Hirsch, R. (2010). Creativity: Cultural capital in the mathematics classroom. *Scientific Research, 1*(3), 154-161.

Hjorth, A., & Wilensky, U. (2014). Redesigning your city: A constructionist environment for urban planning education. *Informatics in Education*, *13*(2), 197-208. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1673608022?accountid=11041

Hlubinka, M., Dougherty, D., Thomas, P., Chang, S., Hoefer, S., Alexander, I., & McGuire, D. (2013). *The makerspace playbook: School edition.* San Francisco, CA: Maker Media.

Holman, W. (2015). Makerspace: Toward a new civic infrastructure. Retrieved from https://placesjournal.org

Hooper, P. (1998). *They have their own thoughts: Children's learning of computational ideas from a cultural constructionist perspective* (Order No. 0800324). Available from ProQuest Dissertations & Theses Global: The Humanities and Social Sciences Collection. (304488084). Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/304488-84?acciybtud=11041

Horner, K. (2000). Today's media centers/libraries: Changing roles, changing spaces. *School Planning & Management, 39*(2), 48. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/195025059?accountid=11041

Hruby, G. (2001). Sociological, postmodern, and new realism perspectives in social constructionism: Implications for literacy research. *Reading Research Quarterly, 36*(1), 48. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/212123121?accountid=11041

Hunsaker, S. L. (2005). Outcomes of creativity training programs. *The Gifted Child Quarterly, 49*(4), 292-299, 356. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/212095541?accountid=11041

Kalil, T. (2012). *Extreme marshmallow cannons: How the government and private sector can turn kids on to science through making.* Retrieved from http://ww.slate.com/articles/technolgy/future_tense/2012/06/every_child_a_maker how_the_government_and_private_sector_can_turn_kids_on_to_science_and_ engineering_through_making_html

Karagiorgi, Y., & Symeou, L. (2005). Translating constructivism into instructional design: Potential and limitations. *Journal of Educational Technology & Society, 8*(1).

Kaufman, J. (2009). *Creativity 101*. New York, NY: Springer Publishing Company.

Kaufman, J., & Beghetto, R (2009). Beyond big and little: The four C model of creativity. *Review of General Psychology, 13*(1), 1-12.

Kim, K. (2010). *Can we trust creativity tests? A review of the Torrance Test of Creative Thinking (TTCT).* Retrieved from http://dx.doi.org/10.1207/s15326934crj1801_2

Koh, K. & Abbas, J. (2015). Competencies for information professionals in learning labs and makerspaces. *Journal of Education for Library and Information Science, 56(2*), 114-129. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1708167894?accountid=

Krueger, N. (2014). Create a school makerspace in 3 simple steps. ISTE International Society for Technology in Education. Retrieved from https://www.iste.org/explore/ArticleDetail?articleid=103

Kuhlthau, C. C. (2010). Guided inquiry: School libraries in the 21st century. *School Libraries Worldwide, 16*(1), 1-12. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/217762150?accountid=11041

Kurti, R., Kurti, D., & Fleming, L. (2014). The philosophy of educational makerspaces part 1 of making an educational makerspace. *Teacher Librarian, 41*(5), 8-11. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1548230083?accountid=11041

Lamb, A. (2015). Makerspaces and the school library part 1: Where creativity blooms. *Teacher Librarian, 43*(2), 56-59, 63. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1774309640?accountid=11041

Lego Education (2013). Lego(R) education evolves STEM learning with the next generation Lego Mindstorms(R) education EV3 platform. *Education Letter,* 64. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1269675593?accountid=11041

Lemons, G. (2011). Diverse perspectives of creativity testing: Controversial issues when used for inclusion into gifted programs. *Journal for the Education of the Gifted, 34*, 742-772. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1355870039?accountid=11041

Lichtenstein, G., Lyons, T., & Kutzhanova, N. (2004). Building entrepreneurial communities: The appropriate role of enterprise development activities. *Journal of the Community Development Society*, *35*(1), 5-24.

Lin, Y. (2011). Fostering creativity through education: A conceptual framework of creative pedagogy. *Creative Education*, *2*(3), 149-155.

Lindeman, K., & Anderson, E. (2016). Using blocks to develop 21st century skills in preschool. *Teaching Young Children, 9*(3), 24-26. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1818046580?accountid=11041

Maker Media. (2016). Impact of the Maker Movement. Retrieved from http://makermedia.com/wp-content/uploads/2014/10/impact-of-the-maker-movement.pdf

Martinez, S., & Stager, G. (2013). How the maker movement is transforming education. Retrieved from http://www.weareteachers.com/hot-topics/special-reports/how-the-maker-movement-is-transforming-education

Marzano, R., & Kendall, J. (2007). The *new taxonomy of educational objectives.* Thousand Oaks, CA: Corwin Press.

McWilliam, E., & Dawson, S. (2008). Teaching for creativity: Towards sustainable and replicable pedagogical practice. *Higher Education, 56*(6), 633-643. doi:http://dx.doi.org.ezproxy.gardner-webb.edu/10.1007/s10734-008-9115-7

Millar, G., & Dahl, C. (2011). The power of creativity. *ATA Magazine, 91*(3), 16-21. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/859257579?accountid=11041

Mirzaie, R., Hamidi, F., & Anaraki, A. (2009). A study on the effect of science activities on fostering creativity in preschool children. *Journal of Turkish Science Education, 6*(3), 81-90. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1659735335?accountid=11041

MIT Media Lab. (2016). *Seymour Papert.* Retrieved from http://web.media.mit.edu/~papert/

Moorefield-Lang, H. (2015). Change in the making: Makerspaces and the ever-changing landscape of libraries. *Tec Trends, 59*(3), 107-112. doi:http://dx.doi.org.ezproxy.gardner-webb.edu/10.1007/s11528-015-0860-z

National Education Association. (2010). *Preparing 21st century students for a global society: An educator's guide to the four "Cs."* Retrieved from http://www.nea.org/assets/docs/A-Guide-to-Four-Cs.pdf

Padovan, F. (2015). Growing up STREAM. Momentum, 46(4) 52-53, 13. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/173361532?accountid=11041

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer.* New York, NY: Basic Books.

Papert, S., & Harel, I. (1991). Situating Constructionism. Retrieved from: http://web.media.mit.edu/~calla/web_comunidad/Reading-En/situating_constructionism.pdf

Peppler, K., & Bender, S. (2013). Maker movement spreads innovation one project at a time. *Phi Delta Kappan, 95*(3), 22. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1445186267?accountid=11041

Partnership for 21st Century Learning. (2016). *4Cs research series*. Retrieved from http://www.p21.org/component/content/section/9

Penaluna, A., & Penaluna, K. (2009). Assessing creativity: Drawing from the experience of the UK's creative design educators. *Education & Training, 51*(8), 718-732. doi:http://dx.doi.org.ezproxy.gardner-webb.edu/10.1108/00400910911005262

Pink, D. (2006). *A whole new mind.* New York, NY: Berkley Publishing.

Plucker, J., Beghetto, R., & Dow, G. (2004). Why isn't creativity more important to educational psychologists? Potentials, pitfalls, and future directions in creativity research. *Educational Psychologist*, *39*(2), 83-96.

Renzulli, J., Smith, L. White, A., Callahan, C., Hartman, R., Westberg, K., Gavin, M., Reis, S., Siegle, D., Reed, R. (2010). *Scales for rating the behavioral characteristics of superior students: Technical and administration manual* (3rd ed.). Waco, TX: Prufrock Press.

Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappan, 42*(7), 306-307. Retrieved from https://www.jstor.org/stable/20342603?seq=1#page_scan_tab_contents

Robinson, K., & Aronica, L. (2015). *Creative schools: The grassroots revolution that's transforming education*. New York, NY: Viking.

Robinson, A., & Stern, S. (1998). *Corporate creativity: How innovation and improvement actually happen*. San Francisco, CA: Berrett-Koehler Publishers.

Rose, L. & Lin, H. (1984). A meta-analysis of long term creativity training programs. *Journal of Creativity Behavior. 18*(1), 11-22.

Ross, A. (2016). *The industries of the future*. New York, NY: Simon & Schuster.

Runco, M. (2007). *Creativity theories and themes: Research, development and practice*. Burlington, MA: Elsevier Academic Press.

Sansing, C. (2015). The big potential of LittleBits. *School Library Journal, 61*(2), 10. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1648644732?accountid=11041

Sawyer, K. (2015). A call to action: The challenges of creative teaching and learning. *Teachers College Record, 117*(10). Retrieved April 22, 2017, from http://www.tcrecord.org/library

Scholastic Testing Service. (2016). Gifted education: Torrance test of creative thinking. Retrieved from http://www.ststesting.com/ngifted.html

Sheridan, M., Halverson, R., Litts, K., Brahms, L., Jacobs-Priebe, L., & Owens, T. (2014). Learning in the making: A comparative case study of three makerspaces. *Harvard Educational Review, 84*(4), 505-531, 563-565. Retrieved from http://ezproxy.gardner-webb.edu/login?url=http://search.proquest.com.ezproxy.gardner-webb.edu/docview/1642662257?accountid=11041

Simon, M. (2011). *Dissertation and scholarly research: Recipes for success.* Seattle, WA: Dissertation Success, LLC.

Sobolik, J., Russell, E., Klatt, H., Thompson, D., Jones, K., & Wieczorek, S. (2014). Exciting times: A transformation of media centers, media specialists, and learning A district's philosophy. *Teacher Librarian, 41*(4), 21-25.

Stanley, D. (2011). Change has arrived for school libraries. *School Library Monthly, 27*(4), 45-47

Sternberg, R. (1995). Investing in creativity: Many happy returns. *Educational Leadership, 53(4),* 80-84.

Sternberg, R. (2006). The nature of creativity. *Creativity Research Journal*, 18(1), 87-98.

Techopedia. (2016). Technology dictionary. Retrieved from www.techopedia.com

Thomas, A. (2014). *Making matters*. Sebastopol, CA: Maker Media.

Tierney, J. (2015). How makerspaces help local economies. Retrieved from http://www.theatlantic.com/technology/archive/2015/05/makerspaces-are-remaking-local-economies/390807/

Torrance, E. (1967). Understanding the fourth-grade slump. Retrieved from http://files.eric.ed.gov/fulltext/ED018273.pdf

Torrance, E. (1974). *Torrance tests of creative thinking: Norms-technical manual.* Lexington, MA: Ginn.

Torrance, E. (2008). *Torrance tests of creative thinking: Streamlined scoring guide for figural forms a and b.* Bensenville, IL: Scholastic Testing Service, INC.

Torrance, E., Ball, O., & Safter, H. (1992). *Torrance tests of creative thinking: Streamlined scoring guide for figural forms a and b.* Bensenville, IL: Scholastic Testing Service, INC.

Urdan, T. (2011). *Statistics in plain English* (3rd ed.). New York, NY: Routledge.

Van Meeteren, B. (2015). Engineering in preschool? The children are already working on that! *Teaching Young Children, 8*(3), 30-31

Wagner, C. (2006). Partners for progress: Creating global strategies for humanity's future. *The Futurist, 40*(6) 54-58.

Weisberg, R. (2015). On the usefulness of value in the definition of creativity. *Creativity Research Journal*, *27*(2), 111-124.

Weisgrau, J. (2015). School libraries and makerspaces: Can they coexist? Retrieved from www.edutopia.org/blog/school-libraries-makerspaces-coexist-josh-weisgrau

The White House. (2016). *A nation of makers*. Retrieved from https://www.whitehouse.gov/nation-of-makers

Whitehouse, D. (2009). Designing learning spaces that work: A case for the importance of history. *History of Education Review, 38*(2), 94-108. doi:http://dx.doi.org.ezproxy.gardner-webb.edu/10.1108/08198691200900016

Young Adult Library Services Association. (2016). Making in the library tool kit. Retrieved from www.ala.org/yalsa

Appendix A

Vision, Goals and Expectations for Makerspaces

Makerspaces at [redacted] Elementary

Vision for makerspaces at [redacted]

Makerspaces at [redacted] are creative spaces in the media center accessible to all students and teachers where student may come to work collaboratively or independently on projects guided by their own interests, problems and/or inquiry. A variety of media will be accessible including technology and art materials students may use to invent, design, explore, create, build, and innovate.

Goals for Student Makers

- Develop divergent thinking skills
- Understand and apply design thinking
- Work collaboratively with others
- Develop long range goals
- Develop the ability to solve complex challenges that combine concepts
- Develop perseverance

Expectations for Makers

These are the behavior expectations for students using makerspaces. Each student signs this contract at the beginning of the year.

> **The Maker's Promise:**
> As a maker, I promise…
> - I will be in control of myself and my equipment.
> - I will work cooperatively with others in my space.
> - I will clean up after myself.
> - I will be safe.
> - I will make things that are appropriate for school.
> - I will challenge myself to problem-solve.
> - I will use my time wisely

Appendix B

Permission to Use Research Materials

SCHOLASTIC TESTING SERVICE, INC
Celebrating Achievement Since 1953
PERMISSION TO USE RESEARCH MATERIAL

Date: May 31, 2016
From: Scott A. Rich, J.D.
Sales Director
Scholastic Testing Service, Inc.
480 Meyer Road
Bensenville, IL 60106-1617
Phone 800-642-6787 Fax 866-766-8054
srich@ststesting.com

To: Janet Blair Austin, Ed.D. Candidate
Curriculum and Instruction
Gardner-Webb University
110 S Main St.
Boiling Springs, NC 28017
Phone 704-242-2986
blairteachaustin@gmail.com

This agreement hereby grants permission to purchase and research certain material (hereinafter referred to as "Material") owned by Scholastic Testing Service, Inc. (hereinafter referred to as "Publisher"), for subsequent use in a research study conducted by Janet Blair Austin within the Department of Curriculum and Instruction, Gardner-Webb University, Boiling Springs, NC.

By executing this agreement, the undersigned agrees to abide by all terms, condition and provisions as stated herein.

1. The Name of the Material which permission to research is being sought: "Torrance Test of Creative Thinking, Thinking Creatively with Pictures, Figural Edition Form A and Form B; and ancillary materials including by not limited to manuals of direction, norms-technical manuals and manuals of scoring and interpreting," by E. Paul Torrance, Ph.D.
2. That the Publisher's copyright to and ownership of the Material shall be maintained by Janet Blair Austin throughout the term of this agreement, in accordance with the US Copyright Act, 17 U.S.c. 101-810
3. That the undersigned hereby agrees to appropriately administer, securely hold, and securely store the Material at all times.
4. That the use of the Material shall be limited to research purposes only.
5. That the undersigned hereby acknowledges that Scholastic Testing Service, Inc., solely hold the copyright to the Torrance Tests of Creative Thinking Test Booklets, Manuals of Directions, Manuals for Scoring and Interpreting Results, Norms-Technical Manuals, and any additional ancillary materials all of which have been provided and/or sold to Janet Blair Austin research purposes, according

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Signed: Janet Blair Austin, 7-28-16

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Appendix C

Board of Education Policy Regarding Student Records

STUDENT RECORDS 4-14
Page 1 of 8

All student records will be current and maintained with appropriate measures of security and confidentiality. The principal is responsible for meeting all legal requirements pertaining to the maintenance, review and release of records retained at the school.

A. Annual Notification of Rights
The superintendent/designee is responsible for providing parents or eligible students (those at least 18 years old or married) with annual notification of their rights under the Family Educational Rights and Privacy Act (FERPA). The notice must contain all information required by federal law and regulations, including the following:

1. the right to inspect and review the student's educational records and the procedure for exercising this right;
2. the right to request amendment of the student's educational records that the parent or eligible student believes to be inaccurate, misleading or in violation of the student's privacy rights, and the procedure for exercising this right;
3. the right to consent to disclosures of personally identifiable information contained in the student's education records, except to the extent that FERPA authorizes disclosure without consent;
4. the type of information designated as directory information and the right to opt out of release of directory information;
5. that the school district releases records to other institutions that have requested the information and in which the student seeks or intends to enroll;
6. the right to opt out of releasing the student's name, address and phone number to military recruiters or institutions of higher education that request such information;
7. a specification of the criteria for determining who constitutes a school official and what constitutes a legitimate educational interest if the school discloses or intends to disclose personally identifiable information to school officials without consent;
8. notification if the school system uses contractors, consultants, volunteers or similar persons as school officials to perform certain school system services and functions that it would otherwise perform itself; and
9. the right to file complaints with the Family Policy Compliance Office in the U.S. Department of Education.

The school district does not have to individually notify parents or eligible students of their rights, but must provide the notice in a reasonable manner likely to inform the parents and eligible students of their rights. Effective notice must be provided to parents or eligible students who are disabled or whose primary or home language is not English.

B. Review, Release of Records to Parent, Guardian or Eligible Student
A parent or eligible student will be allowed access to the student's records upon proper request. A formal review of a student's complete records will be conducted only in the presence of the principal/designee and must be conducted within 45 days of the written request. School personnel will not destroy any educational records if there is an outstanding request to inspect or review the records.
A parent or eligible student has the right to challenge an item in the student record believed to be inaccurate, misleading or otherwise in violation of the student's privacy rights. The principal shall examine a request to amend the student record and respond in writing to the person who challenges the record. If the final decision is that the information in the record is not accurate, misleading or otherwise in violation of the privacy rights of the student, the principal shall inform the parent or eligible student of the right to place a statement in the record commenting on the contested information in the record or stating why s/he disagrees with the decision of the school system.

C. Release of Records to Others
Student's records will be released promptly when a student transfers to another school and in other circumstances specifically permitted by law. Student's official record will also include notice of any suspension for a period of more than 10 days (6 days for Condensed Academic Terms) or of any expulsion under General Statute 115C-391 and the conduct for which the student was suspended or expelled. Written permission by a parent or eligible student is required for the release of a student's records in any other circumstance. Such release must specify the records to be released, the purpose of the release and to whom they are to be released.
Directory information on students may be utilized by the school district, individual schools or organizations and parental permission is not required for the release of directory information provided that the parent or eligible student has received proper notice and opportunity to object. The following information is considered to be directory information:

1. student's name 2. address 3. telephone listing 4. date and place of birth
5. participation in officially recognized activities and sports

6. weight and height of members of athletic team 7. dates of attendance
8. diplomas, certification and awards received 9. electronic mail address
10. photograph 11. grade level
12. most recent previous school or education at institution attended by the student
13. pictures or videos taken on buses, school grounds, in school buildings and at school activities unless the picture or video may reveal confidential information about a student

The board strongly discourages the release of directory information to any outside organizations which have requested the information for their own purposes, including commercial organizations. Decisions to provide directory information to outside organizations must be approved by the superintendent/designee.
As required by law, the names addresses and telephone numbers of secondary school students shall be released, upon request, to military recruiters or institutions of higher learning, whether or not such information is designated as directory information by the school system. Students and/or their parents, however, may request that the student's name, address and telephone number not be released without prior written parental consent. Through the provision of a copy of this policy parents are notified of the option to make a request and that the school system shall comply with any requests made. Students with recognized exceptionalities will be accorded all rights in regards to their records as provided by state and federal law, including the Individuals with Disabilities Act.

Records cannot be withheld from a valid request by a parent, eligible student or school for any reason, including in order to collect fines assessed to the parent or student. Students or their parents, however, may request that the student's directory information not be released without parental consent. Such request should be made in writing annually to the school principal within the first month of school.

D. Procedures to Expunge a Discipline Record
To have a suspension of greater than ten days (6 days for condensed academic terms) or an expulsion expunged from a student's official record, one of the following persons must submit a written request to the Superintendent or his/her designee:

1. The student's parent, legal guardian, or custodian; or
2. The student, if the student is at least 16 years old or is emancipated.

The Superintendent/ designee shall expunge from the record the notice of suspension or expulsion if the following criteria are met:

1. The student either graduates from high school or is not expelled or suspended again during the two year period commencing on the date of the student's return to school after the expulsion or suspension.
2. The Superintendent/designee determines that the maintenance of the record is no longer needed to maintain safe and orderly schools. 3. The Superintendent/designee determines that the maintenance of the record is no longer needed to adequately serve the child. In the absence of a request as outlined above, the Superintendent may expunge from a student's official record any notice of suspension or expulsion provided all of the above criteria are met.

E. Surveys

The school system must obtain prior consent of a parent or eligible student before the student is required to participate in any Department of Education-funded survey, analysis or evaluation that reveals information concerning the following "protected topics":
1. political affiliations or beliefs of the student or the student's parent;
2. mental or psychological problems of the student or the student's family;
3. sex behavior and attitudes;
4. illegal, antisocial, self-incriminating and/or demeaning behavior;
5. critical appraisals of other individuals with whom respondents have close family relationships;
6. legally recognized privileged or analogous relationships, such as those of lawyers, physicians and ministers;
7. religious practices, affiliations, or beliefs of the student's parent; or
8. income (other than that required by law to determine eligibility for participation in a program or for receiving financial assistance under such program).

Parents will be informed by the school at the beginning of the year of any survey instrument being distributed to students of which they are aware, however at the very least no fewer than ten-10 days in advance. Such notification will include information regarding students' rights in not answering questions related to the eight-(8) above items and safeguards to protect student privacy should the survey instrument include any of those items. Collection, disclosure, or use of directory information of students and/or parents will not be for purposes of marketing or

selling beyond the school community (i.e. PTSA, Booster Clubs, Student Council, etc.). The school system will take measures to protect the identification and privacy of students participating in any survey concerning any of the protected topics.
Parents may inspect, upon request, any survey instrument created by a third party before the survey is administered or distributed to students. Parents may opt for their students not to participate in such surveys. Parents may also inspect such survey instruments after they are administered.

F. Definition of Parent and Eligible Student For purposes of this policy, the term parent includes a natural parent or guardian or an individual acting as a parent in the absence of a parent or guardian.

If the parents of a student are separated or divorced, both parents have access to the student's records as provided in this policy, unless the school district has been provided with evidence that there is a court order, state statute, or legally binding document that specifically revokes these rights.

For purposes of this policy, an eligible student means a student who has reached 18 years of age or is attending an institution of postsecondary education. The rights afforded to parents under this policy transfer to an eligible student. However, parents may still have access to the records as long as the student is "dependent" (i.e., claimed by the parent for federal income tax purposes). Eligible students wishing to prevent access to records by their parents must furnish to the principal information verifying that the student is not a dependent of his/her parents. If a parent of a student who is at least 18 and no longer attending a school within the district wishes to inspect and review the student's records, he/she must provide information verifying that the student is a dependent for federal income tax purposes. A student under age 18 may have access to student records only upon consent of his/her parents.

G. Records of Missing Children Upon notification by a law enforcement agency or the North Carolina Center for Missing Persons of a child's disappearance, the school shall flag the record of any child who is currently or who was previously enrolled in a school and who is reported as missing. If the missing child's record is requested by another school system, the principal shall provide notice of the request to the superintendent and the agency that notified the school that the child was missing. The principal shall provide the agency with a copy of any written request for information concerning the missing child's record. Any information received indicating that a student transferring into the system is a missing child must be reported to the superintendent and the North Carolina Center for Missing Children.

H. Records Received from the Department of Social Services The Department of Social Services may disclose confidential information to the school system in order to protect a juvenile from abuse or neglect. Any confidential information disclosed under these circumstances must remain confidential and may only be redisclosed for purposes directly connected with carrying out the school system's mandated educational responsibilities.

I. Records of Students Participating in the North Carolina Address Confidentiality Program

Records of students participating in the North Carolina Address Confidentiality Program must show only the substitute address provided by the Address Confidentiality Program and must not be released to any third party other than a school to which the student is transferring, or as otherwise provided by law. When transferring the record of a student participating in the North Carolina Address Confidentiality Program to a school outside of the system, the transferring school may send the files to the Address Confidentiality Program participant (parent or guardian) via the substitute address provided by the Address Confidentiality Program.

J. Record of Access

The principal or designee will maintain a record in each student's file indicating all persons who have requested or received personally identifiable information from a student's record and the legitimate reason(s) for requesting or obtaining the information. This requirement does not apply to requests by or disclosure to parents, eligible students, school officials, parties seeking directory information, a party seeking or receiving the records under a court order or subpoena that prohibits disclosure, or those individuals with written parental consent.

K. Destruction of Records

School officials may only destroy student records in accordance with state and federal law and the Records Retention and Disposition Schedule for Local Education Agencies. Upon notifying parents, student records may be destroyed when they are no longer needed to provide educational services to the student or to protect the safety of the student or others. Student records must be destroyed if the parent or eligible student requests their destruction and such records are no longer needed to provide educational services to the student or to protect the safety of the student or others. Student records may not be destroyed if there is an outstanding request to inspect the particular records.

L. Records of Military Children

School administrators shall comply with any regulations pertaining to the records of military children developed by the Interstate Commission on Educational Opportunity for Military Children.

In addition, children of military families, as defined by law, are entitled to the following:

1. For Students Leaving the School System In the event that official educational records cannot be released to the parents of military children who are transferring away from the school system, the custodian of records shall prepare and furnish to the parent a complete copy of unofficial educational records containing uniform information as determined by the Interstate Commission. When a request for a student's official records is received from the student's new school, school officials shall process and furnish the official records to the new school within 10 days or within such time as is reasonably determined by the Interstate Commission.

2. For Students Enrolling in the School System Upon receiving an unofficial education record from the student's previous school, school administrators shall enroll the student and place him/her in classes as quickly as possible based upon the information in the unofficial records, pending validation by the official records. Simultaneous with the enrollment ad conditional placement of the student, school administrators shall request the official records from his/her previous school.

M. Juvenile Records Any information received from law enforcement or the Department of Juvenile Justice and Delinquency Prevention regarding a felony charge or placement on the sex offender registry will be maintained in a separate, confidential location by the school principal and shall be destroyed once the principal is notified that the court no longer has jurisdiction over the student or if the court grants a petition for expunction of the records. The principal may share juvenile records with individuals who have (a) direct guidance, teaching or supervisory responsibility for the student and (b) a specific need to know in order to protect the safety of the student and others. Persons provided access to juvenile records must indicate in writing that they have read the documents and agree to maintain confidentiality of the records.

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N. Longitudinal Data System

School system administrators will comply with the data requirements and implementation schedule for the North Carolina Longitudinal Data System (NCLDS) and will transfer designated student record data to the system in accordance with the NCLDS data security and safeguarding plan and all other requirements of state law, provided that doing so does not conflict with the requirements of FERPA.

LEGAL REF.: Family Educational Rights and Privacy Act, 20 U.S.C. 1232g, h, 34 C.F.R. pt. 99; Individuals with Disabilities Education Act, 20 U.S.C. § 1411 et. seq.; G.S. 7B-302, 3100; 14-208.18, -208.29, 115C-47(26), 109.3 -402, -403; -391; N.C.G.S. 115C-407.5; 115C391
CROSS REF.: Board Policy 4-3, Code of Student Conduct Board Policy 4-3a, Code of Student Conduct – Elementary Schools Board Policy 4-3b, Code of Student Conduct – Middle/High Schools Board Policy 4-18, Appeals Policy Board Policy 5-8, Parent Involvement
[redacted] BOARD OF EDUCATION APPROVED: 6/7/94 REVISED: 10/5/99 REVISED: 12/7/99 REVISED: 4/3/01 REVISED: 12/2/03 REVISED: 12/6/04 REVISED: 11/13/07 REVISED: 10/21/08 REVISED: 6/1/10 REVISED: 2/5/1

Appendix D

Letter of Student Assent

Appendix D: Student Assent
To: Fifth Grade Students
From: Mrs. Austin, Media Coordinator
Date:

Welcome back to school! I'd like to take time to tell you about a project that you will have the chance to be involved in this year if you chose. Currently, I am working on my doctoral degree at Gardner-Webb University. I am inviting you to participate in a project I am doing through the university. I am doing a study about makerspaces in our media center. A study is a big project where a researcher tries to solve a problem or answer questions. I am going to be the researcher. My questions are about makerspaces and how kids learn. This year all kids in fifth grade are going to be using makerspaces when they come to the media center for their special classes. Makerspaces are centers in the library where you will be working with Legos, computers, science and art materials. Even if you don't want to be a part of the study, you class will still be using makerspaces this year.

If you agree to be in the project, you will be asked to take an assessment before we start makerspaces in September and then again in December. The test is a picture and word test called the Torrance Test of Creative Thinking (TTCT). You will be asked to draw and describe pictures. You will be asked to write some words. The test takes 45 minutes to take and it will be during your media time. You will get a number score on the test, but it will not count for a grade. You and your parents can ask me how you did on the test if you would like to know, but otherwise the information is only used to help me with the study. Your teachers will not use the score for your grades.

If you do not want to take the test you do not have to. You will not get in trouble if you don't take the test. At any time during the test you may stop without penalty. I will use the information to help me with my study about makerspaces, but nothing I use will have your name on it. If you want to know more about this research project, please email me at jaustin5@gardner-webb.edu. This project has been approved by the Institutional Review Board at Gardner-Webb University. Information on Gardner-Webb University's policy and procedure for research involving human subjects can be obtained from Dr. Doug Eury at aeury@gardnerwebb.edu or Dr. Jeffrey Rogers, IRB institutional administrator at Jrogers3@gwu.edu. You will get a copy of this consent form.
Please sign this form if you would like to be part of the project.

Student name:_____
Student signature:_____
Date:_____
Researcher Name:_____
Researcher Signature:_____
Date: _____

Appendix E

Parental Consent Form

To: Parents of Fifth Grade Students
From: Blair Austin, Media Coordinator
Re: Research Study
Date:

I am conducting an action research study to determine the impact of makerspaces impact on creativity in the media center at our school. Makerspaces are creative activity centers where all students will have access to a variety of creative materials where they may imagine, create and build projects based on their own interests. The materials in the makerspaces at our school include:

- Lego WeDo kits and software
- Legos and other blocks
- littleBits magnetic circuitry
- Cardboard, construction paper and Styrofoam
- recycled plastics and other materials
- fabric
- clay
- a variety of arts and crafts materials

The centers are currently stationed in the media center. All students will have experiences using makerspaces throughout the school year, but for the purposes of this study, fourth grade students have been selected to participate. To determine the impact of makerspaces on fourth grade students, a pre and post-creativity assessment will be given. The pre-test will be given in September and the posttest will be given after twelve weeks of exposure to the makerspaces. This study follows a mixed-methods research design. Quantitative data will be collected from students and qualitative data will be collected from their teachers. The quantitative data collection from the fourth-grade students includes the administration of the *Torrance Test of Creative Thinking: Thinking Creatively with Pictures, Figural Edition Form A and Form B.*

- This is a highly valid and reliable test of creative potential.
- The test was developed by renowned researcher and psychologist, Paul Torrance and has been used in schools for over forty years.
- The test is appropriate at all levels, kindergarten through adult.
- It uses three picture-based exercises to assess five mental characteristics that relate to creativity: fluency, elaboration, originality, resistance to premature closure, abstractness of titles.
- Typically, students are asked to identify what pictures of figures represent or to finish drawings that have been started.

- This is a paper/pencil test and lasts approximately 45.
- It is a secure document and not available for review.
- It will be administered by a trained test administrator at the school site during the regular school day.
- Test results will be available to parents upon request.

There are no risks to students in this study. All information is confidential, and no person or school will be identified in the study. All test data will be used by the researcher for the purpose of group analysis. No individual information will be shared or used for any reason beyond the research study, nor will it be shared with school personnel. Makerspaces is currently part of the regularly planned media center curriculum. All fifth-grade students will have the chance to use makerspaces weekly. The only activity beyond the scope of normal school activities involves your child's participation in the *Torrance Test of Creative Thinking (TTCT).* If your child does not take the *TTCT,* this will not change your child's opportunity to use makerspaces. Each child will have makerspaces opportunities during their regularly scheduled media center time each week regardless of participation in the tests. If your child takes the *TTCT*, he or she will have the opportunity to help supply data regarding how makerspaces impacts student creativity. Your child's participation in the *TTCT* is entirely up to you, there is no advantage and no one will hold it against your child if you decide not to allow your child to participate in the *TTCT.* If your child does take part, he or she may stop at any time without penalty. In addition, you may ask to have your child's data withdrawn from the study after the research has been conducted. If you want to know more about this research project, please email me at jaustin5@gardner-webb.edu. This project has been approved by the Institutional Review Board at Gardner-Webb University. Information on Gardner-Webb University's policy and procedure for research involving human subjects can be obtained from Dr. Doug Eury at Gardner-Webb University. You will get a copy of this consent form.

Consent Statement:

I agree to let my child take the *Torrance Test of Creative Thinking: Thinking Creatively with Pictures, Figural Edition Form A and Form B.* I understand my child can withdraw from the study at any time. Blair Austin and other researchers approved by Gardner-Webb University may use the data collected from the test administration for this research project, teacher education, and presentations at professional meetings. I understand that there will be no link to my child's identity.

_____ _____

Signature Date

Appendix F

Teacher Consent Form

July 28, 2016

To: Fifth Grade Teachers
From: Blair Austin, Media Coordinator
RE: Consent to participate in research study- "Making It Matters: Makerspaces' Impact on Creativity in an Elementary Media Center"

Greetings Colleagues:

As part of a research study for my work in the doctoral program at Gardner-Webb University, I am asking for your assistance. This year the media program is going to include makerspace experiences for all fifth-grade students. In order to determine the creative impact these experiences may have on your students, I am asking you assist me in evaluating them. You are the best ones to do this because of the close relationships you build with your students and the work you see them do daily.

Description of the study:

The study is a mixed-methods, action research study. I will be gathering both quantitative data and qualitative data.

Quantitative Data –

- The students that participate will take a pre and post-written creativity assessments. This will be administered during media special area time. The test is called the Torrance Test of Creative Thinking (*TTCT*).
- I will also ask you to assess each student using the Scales for Rating the Behavior Characteristics of Superior Students. (*SRBCSS*). This is a Likert ranking scale that asks for the evaluator to rank the students based on specific attributes related to creativity.

Qualitative Data-

- I will ask you to assess each student on an open-ended questionnaire.

The study will begin in September and will last 12 weeks. You will not be asked to assess your students until after this time. Your participation is entirely voluntary. If you agree to help me, I will train you on how to complete the *SRBCSS*. You will only need to evaluate the students who return written student assent and parental consent. This is completely voluntary for students. All student, teacher, school and district data will be anonymous. Pseudonyms will be used and students will only be identified by number. I will share my findings with you at the conclusion of the study. All data collected will be disposed of in accordance with district policies. You may withdraw from the study at any time.

I really appreciate your consideration of participation in the study. This study has to potential to give us insight on the impact of makerspaces in school media centers.

Teacher Consent Statement:

I agree to participate in the research study entitled: Making It Matters- Makerspaces' Impact on Creativity in an Elementary School Media Center. I will be evaluating students using the Scales for Rating the Behavior Characteristics of Superior Students and an open-ended questionnaire. I understand I may withdraw from the study at any time. Blair Austin and other researchers approved by Gardner-Webb University may use the data collected from the test administration for this research project, teacher education, and presentations at professional meetings. I understand that there will be no link to my identity of the identity of my school or students.

Printed Name:_____Date:_____

School: _____Title:_____

Signature: _____

Appendix G

Torrance Test of Creative Thinking (TTCT) Group Score Data Forms A and B

GRADE SUMMARY FOR: GRADE 05, FORM A

FREQUENCY DISTRIBUTION
Group Summary Statistics (Standard Score)

Score Intervals	Fluency		Originality		Titles		Elaboration		Closure		Average		Creativity Index	
	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
150+	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
140-149	1	1%	0	0%	0	0%	0	0%	4	6%	0	0%	1	1%
130-139	1	1%	0	0%	0	0%	0	0%	19	27%	0	0%	1	1%
120-129	6	9%	0	0%	3	4%	1	1%	13	19%	1	1%	8	11%
110-119	11	16%	1	1%	7	10%	4	6%	10	14%	1	1%	11	16%
100-109	20	29%	1	1%	4	6%	6	9%	5	7%	11	16%	19	27%
90-99	16	23%	4	6%	12	17%	8	11%	15	21%	24	34%	16	23%
80-89	8	11%	8	11%	20	29%	23	33%	2	3%	17	24%	9	13%
70-79	5	7%	13	19%	8	11%	10	14%	1	1%	13	19%	3	4%
60-69	1	1%	9	13%	14	20%	12	17%	1	1%	2	3%	2	3%
50-59	1	1%	19	27%	0	0%	5	7%	0	0%	1	1%	0	0%
<50	0	0%	15	21%	2	3%	1	1%	0	0%	0	0%	0	0%
Mean	99.7		64.6		84.7		81.1		116.1		89.2		102.3	
Stan.Dev.	15.9		18.0		18.4		17.7		19.7		12.8		15.2	

NUMBER OF STUDENTS = 70

GRADE SUMMARY FOR: GRADE 05, FORM B

FREQUENCY DISTRIBUTION
Group Summary Statistics (Standard Score)

Score Intervals	Fluency		Originality		Titles		Elaboration		Closure		Average		Creativity Index	
	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
150+	2	3%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
140-149	3	4%	0	0%	0	0%	0	0%	12	17%	0	0%	0	0%
130-139	8	11%	0	0%	1	1%	0	0%	11	16%	0	0%	0	0%
120-129	10	14%	0	0%	0	0%	2	3%	18	26%	0	0%	13	19%
110-119	19	27%	0	0%	6	9%	7	10%	11	16%	6	9%	16	23%
100-109	17	24%	0	0%	8	11%	14	20%	2	3%	13	19%	22	31%
90-99	4	6%	0	0%	12	17%	10	14%	7	10%	23	33%	10	14%
80-89	4	6%	3	4%	19	27%	17	24%	3	4%	18	26%	5	7%
70-79	1	1%	7	10%	8	11%	14	20%	5	7%	8	11%	3	4%
60-69	0	0%	16	23%	12	17%	4	6%	0	0%	1	1%	1	1%
50-59	1	1%	22	31%	3	4%	2	3%	1	1%	1	1%	0	0%
<50	1	1%	22	31%	1	1%	0	0%	0	0%	0	0%	0	0%
Mean	112.8		57.0		84.3		89.3		118.4		92.3		105.7	
Stan.Dev.	19.6		13.6		17.7		17.1		21.6		11.3		13.3	

NUMBER OF STUDENTS = 70

Appendix H

Scales for Rating the Behavior Characteristics of Superior Students (SRBCSS)

Group Score Data

SRBCSS Group Score Data

Student by Number	Weighted Scores
1	22
2	37
3	52
4	44
5	29
6	23
7	31
8	47
9	41
10	35
11	21
12	38
13	32
14	40
15	37
16	45
17	38
18	46
19	38
20	36
21	42
22	54
23	36
24	35
25	35
26	54
27	37
28	54
29	35
30	34
31	36
32	46
33	23
34	37
35	43
36	35
37	32
38	38

39	42
40	41
41	44
42	42
43	40
44	44
45	39
46	44
47	40
48	38
49	38
50	21
51	48
52	45
53	41
54	41
55	32
56	32
57	39
58	33
59	27
60	45
61	46
62	31
63	31
64	51
65	35
66	31
67	29
68	42
69	38
70	48
Mean	38.22857143

Appendix I

Tesch's Eight Steps in the Coding Process Applied to Open-end Questionnaire Examples

Step	Step as Applied to Questionnaire Data	Examples from the Questionnaire Data
1. Get a sense of the whole. Read all the transcriptions carefully. Perhaps jot down some ideas as they come to mind as you read.	The researcher read the five teacher questionnaires and recorded words and phrases related to the responses.	Descriptive words and frequency Communicate (4) Engaged (1) Follow-through (1) Materials (3) Process (7) Problem-solving (5) Drawing (1) Explanations (3) Models (2) Listen (5) Validate (1) New ideas (6) Verbalize (3) Took risks (4) Options (4) Willingness (1) Flexibility (1) Analyzing (2) Building (1) Interest (1) Excited (4) Enjoyed (4) Participated more (1)
2. Pick one document (i.e., one interview)-the most interesting one, the shortest, the one on the top of the pile. Go through it, asking yourself, "What is this about?" Do not think about the substance of the information but its underlying meaning. Write thoughts in the margin.	The researcher went through each document word-by-word and considered the underlying meaning. These thoughts were recorded.	Communicate – Students were able to discuss ideas with others. Engaged – Students participated and stayed focused on the project. Follow-through – Students finished what they started. Materials – Materials were accessible. Process – Students were active in planning, working and refining projects. Problem-solving – Students solved problems that were meaningful to them. Drawing – Students used drawing to help them think and plan. Explanations – Students were able to elaborate on their thought processes. Models – Students used models to help solve problems as well as constructed models for a variety of purposes.

		Listen – Students' listening skills are developed through working with others. Validate – Students confirmed their ideas as they saw them through. New ideas – New ideas were developed. Verbalize – Students talked about their ideas. Took risks – Students were not afraid of failure and took chances with new ideas. Options – Students found more than one way to do things and made choices. Willingness – Students were willing to participate. Flexibility – Students used existing ideas in new ways or adapted their thinking. Analyzing – Students reflected and looked at parts of their projects. Building – Students physically built things from materials provided. Interest – Students chose their own projects based on what interested them. Excited – Students were upbeat, happy and had positive outlooks. Enjoyed – Students had fun. Participated more – Students were engaged.
3. When you have completed this task for several participants, make a list of all topics. Cluster together similar topics. Form these topics into columns, perhaps arrayed as major, unique, and leftover topics.	A list of topics was made and clustered together in terms of similarity. The topics were then grouped according to frequency, uniqueness or other.	Communication ● Listening ● Verbalizing ● Asking questions ● Explaining Engagement ● Processes ● Problem-solving ● Analyzing ● Building ● Drawing ● Models ● Participating Motivation ● Choices ● Options ● Willingness Risk-taking Problem-solving

		• Analyzing • Work backwards • Questioning
4. Now take this list and go back to your data. Abbreviate the topics as codes and write the codes next to the appropriate segments of the text. Try this preliminary organizing scheme to see fi new categories and codes emerge.	The list of topics was abbreviated as codes and written next to the corresponding units of text.	Communication = COM Engagement = ENG Motivation = MOT Risk-taking = RIS Problem-solving = PRO
5. Find the most descriptive wording for your topics and turn them into categories. Look for ways of reducing your total list of categories by grouping topics that relate to each other. Perhaps draw lines between your categories to show interrelationships.	Categories were developed based on the frequency of times they were coded. Similar topics and overlap between them were considered. A list of final categories was determined by grouping related topics.	Communication Engagement Motivation
6. Make a final decision on the abbreviation for each category and alphabetize these codes.	The researcher determined there were three major categories and the codes were determined by the first three letters of each category.	COM, ENG, MOT
7. Assemble the data material belonging to each category in one place and perform a preliminary analysis.	The data was assembled and organized.	See figure 2
8. If necessary, recode your existing data.	It was not necessary to recode the data	It was not necessary to recode the data.

(Creswell, 2014, p. 198)

Appendix J

Makerspaces Teacher Questionnaire Pilot

Teacher Questionnaire:

After your experience of having your students participate in makerspaces please give examples of how makerspaces has impacted your students' ability to…

Student's Number : _____

1. communicate their own original ideas with others in a group so that their team members understand the meaning of the ideas. (P21, collaboration, communication)

2. Take risks or try out their own ideas to create new products, works, or innovations. (P21, flexibility)

3. develop novel ideas for solving problems, creating innovations or making new creations. (P21, originality)

4. develop multiple ideas for solving problems, creating innovations or making new creations. (P21, fluency)

5. come up with new ideas that are tangible and useful. (P21, value)

6. persevere in testing their own new ideas (P21, resist premature closure)