Let the Wild Rumpus Start!:
Fostering Creative Thinking and Expression among Diverse Learners
through a Makerspace in an International School in China

A doctoral thesis presented
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Abstract

Creativity is a critical skill for the 21st Century Learner. To meet the demands of a technological and globalized future, students need the ability to think critically, problem solve, adapt and innovate, all characteristics of creative individuals. With this understanding, worldwide, nations are quickly revolutionizing their education agendas by adding a “creativity mandate.” However, creativity mandates have yet to manifest in mainstream education, where traditional models of teaching and learning persist. This qualitative case study investigates how creativity can be developed in the traditional classroom. Using Amabile’s (1996) Componential Theory of Creativity as a framework, this study looks closely at how creativity can be fostered through a progressive learning environment, a Makerspace, where “making” replaces the typical standards based instruction of a 5th grade class. At the same time, the study investigates whether students meet their traditional 5th grade curricular outcomes when learning in the Makerspace environment. Further, the context of the study was uniquely situated in an international school in China, where the population was culturally diverse. Western educated students (American, European, and Latin) and East Asian educate students (Chinese, Korean, Japanese) worked and learned alongside each other using an American curriculum. Cross-cultural studies have determined notions of creativity vary among these groups. In addition to the above, the study examined how these differences in creativity, as a result of background educational experiences, impacted the development of creativity within these groups.

Keywords: creativity, Makerspace, cross-cultural creativity, non-traditional learning environments, 21st century learning skills.
Dedication

I dedicate this work to my mom, dad, and sister. We are an immigrant family, my mom from Greece and my dad from the Philippines. They showed me with hard work and dedication, anything is possible. They also planted this idea of East-West conceptualizations of creativity, my dad focused and humble, my mom risk-taking and enthusiastic. I dedicate this to my sister as well, who always tells me I have good ideas and I should do something about it.
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Chapter I: Introduction

“Let the wild rumpus start!”—Max, from Where the Wild Things Are

Problem of Practice

Creativity is an essential skill for the 21st century learner (National Research Council, 2004; Partnership for 21st Century Learning, 2011; Amabile, 1996; Craft, 2005; Pink, 2005; Plucker, Kaufman, & Beghetto, 2013; Simonton, 2000; Zhao, 2012). To meet the demands of a technological and globalized future, students need the ability to think critically, problem solve, adapt and innovate, all characteristics of creative individuals (Partnership for 21st Century Learning, n.d.; Pink, 2005; Wagner & Dintersmith, 2015; Zhao, 2012). The 21st century “Conceptual Age” is a departure from the late 20th century “Information Age” where linear, systemic tasks and outcomes dominated activities, from business ventures to classroom lessons (Pink, 2005). Today, these activities are widely automated or outsourced, easing laborious basic tasks that can efficiently support innovative thinking and problem solving. Dougherty (2012), founder of Maker Media, asserts a “democratization” of making and creating has occurred with easy access to cheap hardware, software, and shared innovation through the Web.

Highlighting and advancing creative thinking, the White House recently hosted a Maker Faire where President Obama proclaimed, “I am calling on people across the country to join us in sparking creativity and encouraging invention in their communities” (White House, 2014). The calling of the “Conceptual Age” has disrupted traditional expectations for success; the 21st century economic, social, and political climate warrants creative enterprise (Wagner & Compton, 2012). It is within this present economic evolution, a global paradigm shift “from manufacturing to knowledge-based to innovation economies” where creative thinking has the opportunity to thrive (Plucker, Kaufman, & Beghetto, 2013, p. 1).
In 1963, Maurice Sendak’s *Where the Wild Things Are* told a tale of the quintessential creative child, Max, who as a result of his mischievous dramatic play is sent to bed with no supper. Max consequently conjures an immense imaginative response where he becomes the king of the Wild Things and directs these fierce beasts courageously in creative expression, announcing, “Let the wild rumpus start!” Today, 21st century businesses and organizations are actively seeking, rather than dismissing, such creative thinking, courage, and dynamism (Pink, 2005). In fact, a “wild rumpus” in research on developing creative thinking and learning has started. The hot topic has manifested in pop-culture, self-help trade books alongside empirical studies on creativity in business administration, entrepreneurship, and psychology (e.g., Csikszentmihalyi, 2009; Gilbert, 2015; Pink, 2005; Robinson, 2011, 2015).

Education policy is quickly shifting with this trend, from policies based on rudimentary achievement scores in core content areas to policies encouraging critical thinking skills for the 21st century (Stewart, 2012). This paradigm shift has been observed mostly outside the United States (Kaufman, Sternberg, and Beghetto, 2010). In China, education ministry formal policies use the word “creativity” in the language of their national education plan (Pang & Plucker, 2013). In fact, Chinese education ministers are looking closely at the American model of education to revolutionize their education policy from a “drill and kill” approach to a problem-based, creative thinking learning model (Bronsom & Merryman, 2010; Miller, 2012; Pang & Plucker, 2013). Across East Asia, high ranking school systems in Singapore, Korea, Hong Kong, Taiwan are not satisfied with their traditional approaches to learning that have garnered top scores on international assessments. These school systems understand the economic advantage of cultivating creative students and have included creativity mandates in their respective education programs (Stewart, 2012; Pang and Plucker, 2013; Hui and Lau, 2010).
Meanwhile, in the U.S., teaching “creativity” has not formally made the national education agenda, yet the Partnership for 21st Century learning includes creativity as one of the key Learning and Innovation Skills among the “4Cs” that include creativity, collaboration, critical thinking, and communication (Plucker, Kaufman, & Beghetto, 2013).

Despite creativity hype and endorsements at the macro level, education research shows classrooms, at the micro level, rarely promote creative thinking and learning. In fact teachers often dismiss creative students as distractions, creative experiences as time consuming and creative outcome as accidental in relation to intended responses on performance objectives (Aljughaiman & Mowrer-Reynolds, 2005; Beghetto, 2010; Schacter, Yeow Meng, & Zifkin, 2006). Research from the UK and Hong Kong demonstrated teachers’ beliefs and low self-efficacy for their own creative potential limited lessons designed for creativity (Chan, 2001; Cremin, 2006). In these studies, teachers understood the value of creative teaching and learning, but felt ill equipped to implement meaningful lessons encouraging imaginative expression. In fact, research indicates current classroom environments actively discourage creative learning and expression as a result of policies emphasizing high stakes testing in core content areas (Berliner, 2009; Robinson, 2006; Schacter et al., 2006). It seems although education ministries have earmarked creativity as an essential skill, classroom conditions have not supported or shown the capacity of harnessing Max’s creative call from Where the Wild Things Are. Instead creative students are, metaphorically, sent to bed without their supper.

Thus, what are the conditions for creativity in the classroom? Research on fostering creativity in schools shows that classroom context and classroom environment matter (Amabile, 1996; Beghetto and Kaufman, 2014; Craft, 2006; Schacter et al., 2006). Further, research on traditional versus alternative pedagogies demonstrates that alternative pedagogies encourage
more creative thinking and expression (Besancon & Lubart, 2007). With this in mind, the Makerspace setting, a conceptually non-traditional learning environment designed to foster innovation (Halverson & Sheridan, 2014) provides an interesting space to study a learner’s engagement with the creative process.

According to the National Research Council (2015) Makerspaces can be categorized broadly into three groups: making as entrepreneurship and/or community creativity (e.g. Do-It-Yourself invention spaces); making as a STEM pipeline and workforce development (e.g. Fablab at Stanford University, Invention Studio at Georgia Tech); and making as inquiry-based educative practice. For this research study, the Makerspace will be considered as “inquiry-based educative practice” occurring in a traditional K-12 school context. Makerspaces for learning and inquiry may take place in libraries, museums, in after-school programs and community settings and in schools. Yet, there is little empirical research on the impact of Makerspaces in K-12 education. However, anecdotal evidence suggests Makerspaces encourage creative thinking and learning for school related objectives (Krueger, 2014). Further, making as an educative practice is certainly not a novel idea. Educators since Maria Montessori (1912), John Dewey (1938), and Loris Malaguzzi (1998) have advocated “making” as an impactful way to construct knowledge. As Bevan, Petrich, and Wilkinson (2015) posit, “If the invitation to creativity is accompanied by intentional structure and guidance, maker activities can be channeled to support deep student learning” (p. 28).

Using the Makerspace as the research study’s context, the purpose of this study is to examine the experiences of a diverse group of learners in a classroom designed for learning that actively fosters creativity in the classroom. This research inquiry is guided by two questions. First, how does a Makerspace foster creativity in a diverse group of students? To understand how
creativity develops over time in a Makerspace classroom it is important to understand students’ self-perceptions on creativity. The research inquiry will prioritize students’ voice and reflections of their experience in the Makerspace. The study will look for evidence of creative learning, thinking, and expression while students engage in activity in the Makerspace. The second research question asks, how does the Makerspace support student learning of traditional objectives? Because the Makerspace experience occurs during the school day, rather than an informal, extra-curricular activity, evidence of meeting traditional objectives is concerning.

As stated, this study will prioritize the student’s perspective since the social context accounts for individual approaches towards creative learning and experience (Amabile, 1983, 1996; Csikszentmihalyi, 1996). For this study, an emphasis on student identity and individual differences is important because the sample student population is uniquely situated in a diverse international school in China, where East Asian educated (Korean, ethnically Chinese, and Japanese) students learn alongside Western educated (American, European, and Latin American) students. The differences in creativity approaches and creative expression between Eastern and Western cultures have gained particular interest as globalization has pushed education policy outside its traditional realm of domestic issues (Hartley & Plucker, 2014; Rudowicz, 2003; Yi, Hu, Scheithauer, & Niu, 2013). Comparative education studies have increasingly influenced national education agendas (Schleicher, 2012). However, the goal is not to compare for better or for worse, but to understand how, despite differences, creative potential may be developed in all learners. In fact, a cross-cultural study can allow for a more meaningful, balanced interpretation of creativity (Rudowicz, 2003). As Giroux (1992) suggests, “In an age of shifting demographics, large scale immigration, and multiracial communities” educators must commit to individual differences as central to schooling (p. 45). In the tradition of a change agent scholar-practitioner,
the research is committed to understanding individual differences within the context of creativity a critical skill for all 21st century learners.

**Significance of the Problem**

While creativity gains worldwide prominence as an essential 21st century skill, lack of creative learning and expression has become a contentious subject in America. Ken Robinson (2015) claims “our schools are killing creativity” with the current focus on national standards and test scores. Berliner (2009) has gone as far as to suggest a “creaticide” as a result of the national policies such as No Child Left Behind (NCLB) and the Race to the Top initiative, where federal mandates require the use of high stakes testing and adaptation of national standards. Berliner (2009) suggests these policies exacerbated the achievement gap, where schools in low-income communities must prioritize test prep rather than exploratory, creative learning. An empirical study on recent Torrance test scores found creativity scores have “inched downward since 1990” (Bronsom & Merryman, 2010). On the other hand, Yong Zhao (2012) lauds American education culture that is characterized by flexibility, freedom, and choice. Zhao (2012) claims the American system and culture of learning has allowed entrepreneurial spirits to thrive rather than wither.

Recently, the U.S. Senate approved the Every Student Succeeds Act 2015 (ESSA), repealing NCLB to the gratification of educators and education policy makers across party lines. The ESSA will transfer education regulation back to the states, where states will decide their own terms for success and need for intervention. The current development is promising for states seeking more freedom to develop their own rigorous programs that also allow for innovation and creativity. Nevertheless, school districts espousing 21st century skills oriented
innovative programs will need guidance on how to foster creative learning environments. This might just require a complete paradigm shift in teaching and learning.

A paradigm shift may be necessary because empirical evidence overwhelmingly suggests American schooling actually suppresses creativity, due to an outdated traditional model of learning (Beghetto, 2007; Dacey & Lennon, 1998; Robinson, 2015; Schacter et. al, 2006; Torrance, 1995). Torrance’s (1995) seminal works on creativity and learning found the more students attended school the less curious they became, as a result of call and response, rote classroom activities. Dacey and Lennon (1998) claimed, “teachers, their peers, and the educational system as a whole all diminish children’s urge to express their creative possibilities” (p. 69). More recently, Beghetto (2007) confirmed, finding teachers actually suppress creative responses, as they typically preferred expected answers versus “distracting” unusual answers. A study by Schacter et al. (2006) observed a sample of schoolteachers’ instruction in an effort to relate creative teaching and student achievement. Results demonstrated the majority of teachers do not implement any teaching strategies that encourage creativity. Further, classrooms with minority and low-performing students received even less creative teaching; instead instruction was dedicated to rote memorization of basic skills (Schacter et al., 2006).

While empirical evidence indicates traditional methods of teaching and learning suppress creative processes, this research study seeks to understand the consequences of breaking from tradition. Inspired by current literature on creative learning spaces (Craft et al., 2014; Davies, Jindal-Snape, Collier, Digby, Hay & Howe, 2013) and anecdotal evidence from Makerspace learning environments (Bevan et al., 2015) the research asks exactly how an experience in such an environment might impact creative processes and outcomes in students. This research has
implications for school districts, campuses, and teachers empowered by the ESSA interested in trying a different approach. Certainly a different approach is warranted.

Creativity is well established as a critical skill for the 21st century (Amabile, 1996; Csikszentmihalyi, 1996; Kaufman & Sternberg, 2010; Pink, 2005; Robinson, 2015; Partnership for 21st Century Learning, n.d.; Wagner & Compton, 2012). Being creative inspires lifelong learning, happiness, innovation, and adaptability to new experiences (Csikszentmihalyi, 1996; Kaufman & Beghetto, 2013; Torrance, 1995; Robinson, 2015; Wagner & Dintersmith, 2015). The National Education Association (NEA) and the Partnership for 21st Century learning promote creativity as a skill needed to be “fully integrated into classrooms, schools, and districts around the country to produce citizens and employees adequately prepared for the 21st century” (NEA, 2015, p. 6). In an open letter to teachers, Secretary of Education Arne Duncan (2011) wrote, “I want to develop a system of evaluation … that measures individual student growth, creativity, and critical thinking.” Schacter et al. (2006) found that student achievement gains in Language Arts, Reading, and Math were highly correlated to classes where teachers taught specifically for creativity. At the classroom level, teaching for creativity has significant benefits for all students, despite ability and individual differences.

Teaching for creativity has implications for success beyond the classroom. Globalization and technology have rapidly and radically increased the transfer of knowledge, ideas, and opportunities, leading to a dramatic change in demographics, economics, and government policies. This shift in global dynamics is pitting student against student on an international level. At a micro level, students compete on core content area achievement scores; while at the macro level, students compete for rewarding careers in the global economy. Nations are quickly reforming or revolutionizing their education policies to ensure the success of their students for
21st century living (Stewart, 2012). United States policy makers, reacting to below average PISA (Program for International Student Assessment) scores, have invested in national Common Core standards, use of high stakes testing, and focus on STEM subjects to ensure competitive advantage (Bybee, 2013; Drew, 2011; Stewart, 2012). The U.S. is essentially emulating education systems from top scoring “Education Giants” (China, Japan, Singapore, Korea) by relying on high stakes testing and national standards to improve international test scores (Zhao, 2012). Zhao (2012) claims this shift is counterintuitive, and loses sight of the strength American education culture that is characterized by choice and freedom, and consequently innovation. Meanwhile, the Asian “Education Giants” are looking closely to the West for a 21st century model of learning (Zhao, 2012). Understanding the pitfalls of a strictly test-driven curriculum, Eastern school systems have initiated policies emphasizing the need for creative teaching, learning, and outcomes.

The research study has significant implication, both domestically and internationally, for education policy and classroom practice that seeks to infuse creative thinking, learning, and expression. Beghetto (2010) states, “Creativity researchers will have to play a key role in helping move creativity from the margins into the mainstream curriculum” (p. 459) calling for more research regarding the connection between learning and creativity. Further, Beghetto (2010) proposes, “creativity researchers must develop, test, and implement new pedagogical models that simultaneously support the development of creative potential and academic learning” (p.459).

In response to this call, this research study intends to explore the implications of a progressive classroom model that has potential to elicit creativity in a diverse group of learners. Specifically, the research will observe a class of Fifth grade students working towards traditional
classroom objectives in a Makerspace setting. The Makerspace experience is an exciting, new, and growing trend in education in both informal and formal learning environments (Halverson & Sheridan, 2014). Yet, to date, there is scant research in the literature on the effect of Makerspaces in a traditional school environment. This study will add empirical evidence to reimagining education with this fresh conceptual space for learning and achievement.

Secondly, the research will conceptualize creativity influenced by background educational experiences. How can a purposefully designed classroom ensure all students, despite differences, learn to think and express creatively while achieving curricular goals? Diversity is an increasing concern, both in the United States and across the globe. Exploring ways to optimize the learning experience to meet the needs of a diverse population will be of particular interest in this study. This inquiry on creative learning in the classroom intends to add to the body of research helping K-12 educators address the exciting, innovative opportunities that 21st century learning demands.

**Positionality**

Positionality is a driving force in research, influencing the direction of the study and potentially impacting results (Carlton Parsons, 2000; Briscoe, 2005). Thus, the scholar-practitioner must self-reflect on biases and identity before conducting research. Acknowledgement of bias while gathering, analyzing, and synthesizing data is critical in conducting an as objective as possible research project. Mindful of my study, I acknowledge themes within the research that intimately resonate with my identity. I identify with the creative person, and as an educator, I have prioritized creative learning and expression for my students.

Positionality is defined as acknowledging identity within social, historical, and personal narratives (Carlton Parsons, 2008; Briscoe, 2005). Carlton Parson’s (2008) model, a synthesis of
Cultural-Historical Activity Theory and the Ecological System’s Theory, is an appropriate reflective framework for this study as I seek to understand identity, culture, and activity within my sample population. Carlton Parsons (2008) describes identity as a system of the micro, meso, and exo circles encompassing an individual’s reality. From the inner-circle, micro perspective, I am a mixed-race, English Language Learner (ELL), first generation minority American with a Greek mother and a Filipino father. I identify closely with a Western (Greek) perspective of creativity and democracy while influenced by Confucian ideals (Filipino) of authority, respect, and tradition. This juxtaposition of conflicting values however did not inhibit my dedication to learning and creative expression. In fact, Confucian ideals kept me focused, while my Western perspective encouraged openness and risk taking. From this view, I believe standardized curricula requirements and creative opportunities for expression are not mutually exclusive; in fact both are necessary for optimal learning and innovative productivity. This belief may influence my observations, as I seek to confirm my bias. Thus, I must proceed with caution, understanding that creative learning may not help students achieve curricular goals.

Second, I believe I have a “capital perspective,” that is I have intrinsic knowledge of the sampled population in my study (Carlton Parsons, 2008). The sample population is described as a group of Third Culture Kids (TCK). Third Culture Kids (TCKs) are ex-patriot students who attend international schools. Similarly, I am a TCK, raised overseas yet learning and experiencing schooling with an American curriculum and American teachers. Although, I have this understanding, I must be acutely aware of my TCK experiences are vastly different from a digital-native, 21st century TCK. Also, while this research identifies students by their ethnicity and passport home countries, I understand the culture of a TCK is unique, and cannot
specifically be compared to students of the same ethnic group raised in their respective home countries.

Synthesizing CHAT with an Ecological systems theory (Carlton Parsons, 2008), I will speak specifically to my ecological environment as a progressive educator in urban settings and international settings. Although these two settings differ in regards to resources and curriculum, teaching students of cultural and linguistic diversity is consistent in my experience as an educator. Teaching diverse students has heightened my interest in understanding how differences impact learning. My appreciation of student differences is a value that aligns closely with progressive models of education, where the whole child drives the curriculum. Thus, my meso- circle of influence includes academics and educators with similar values and I am highly influenced by academic writings of progressive pedagogy. The exo- circle includes federal and/or district education policy affecting schools. The district I currently work in I view as an authoritative body, with a rigid system of accountability that is manifested in scripted curriculum and test taking. Students in this district learn in a “factory production line” system where blocks of time define subject learning, and test scores demonstrate satisfactory output; little time is dedicated to interdisciplinary activity and creative expression. I understand the existing tension between my values and current work setting, and I work within the small space that allows for creative teaching. I acknowledge these circles of influence as comprising my positionality.

Using Carlton Parson’s (2008) model, a synthesis of Cultural-Historical Activity Theory and the Ecological System’s Theory, allows me to understand and reflect on my own perspective and the choices I make regarding the activity in my research. Case study research is the chosen methodology for this inquiry. Yin (2013) notes case study research has been viewed as an inferior form of research practice because subjectivity is implicit in the methodology. Too often
the researcher has been sloppy allowing biases to influence results (Yin, 2013). Thus, intentional and constant reflection on positionality is necessary to establish a rigorous case study.

**Research Questions**

This qualitative research study seeks to understand how creativity, among a diverse group of students, can be developed in a non-traditional classroom. The research will address the following research questions to reach this understanding:

1. How does a Makerspace curriculum, activities, and classroom environment foster creativity in a class of culturally diverse adolescent students?
2. How does a Makerspace curriculum, activities, and classroom environment support student learning of targeted academic subject matter objectives in a class of culturally diverse adolescent students?

**Theoretical Framework**

Although creativity research has gained prominence in several academic (psychology, business, education) disciplines, the construct of creativity remains an elusive concept (Amabile, 1996; Csikszentmihalyi, 1988; Kaufman et al., 2010; Mishra, Henrikson, Mehta, 2015; Tierney & Framer, 2011). For this reason, it is necessary to define creativity through a focused lens. For this study, Amabile’s (1996) seminal framework, The Componential Model of Creativity is the most appropriate framework to ground this study’s investigation. Creativity in Amabile’s framework is viewed as a complex system of influential factors, concerning the individual, the environment, and the experience.

**Creativity conceptualized.** Amabile (1996) conceives creativity as the summation of several components vital to producing creative work. Within this systemic perspective of creativity, Amabile (1996) understands creativity as a production or outcome of ideas that are
“novel” and “appropriate”. To produce creative ideas, an individual must possess four components: 1) Domain-relevant skills; 2) Creativity-relevant processes; and 3) Intrinsic motivation. The fourth component of creativity lies outside the individual and is described as the 4) Social environment (Amabile, 1996). The fourth component model extends Amabile’s (1983) original Componential Theory of Creativity, to include outside influences on the creative process. Amabile, the Edsel Bryant Ford Professor at Harvard Business School, is primarily concerned with creativity within individuals, teams, and organizations within the business sector. However, Amabile has also documented and applied the Componential Theory of Creativity as it relates to the understanding of creativity in children (Hennessey & Amabile, 1987).

![Diagram of Amabile's Componential Theory of Creativity](image)

*Figure 1. Amabile’s Componential Theory of Creativity adapted from Amabile (1996)*

Amabile (1986, 1987, 1996) posits everyone has creative potential and this potential can be realized with the development of domain-relevant skills, creativity-relevant skills, and intrinsic task motivation. Reporting for the NEA in a “What research says to the teacher” series,
Hennessey & Amabile (1987) communicated how the Componential Theory of Creativity can be directly applied in the classroom context.

**Domain-relevant skills.** Domain relevant skills include factual knowledge, expertise, technical skills, and special talents (Hennessey & Amabile, 1987). These are the “raw materials” that a student can tap into throughout the creative process (Amabile, 2012). Traditional education objectives hone domain-relevant skills by teaching the curriculum objectives (content knowledge across subject areas, skills, and strategies) and assessing for achievement through standard tests and activities that demonstrated intended outcomes.

**Creativity-relevant processes.** Creativity-relevant processes include personality traits, cognitive styles, and dispositions attributed to individuals with high-levels of creativity. Empirical evidence suggest creativity-relevant cognitive processes include openness to experience (Csikszentmihalyi, 1996; Perrine & Broderson, 2005); a sense of curiosity (Kashdan & Ficham, 2005); tolerance for ambiguity (Zenasni, Besacon, & Lubart, 2008); confidence in one’s own creativity; driven by a process oriented versus product oriented perspective (Amabile, 1996); intrinsic motivation (Hennessey & Amabile, 1987); and risk-taking (Csikszentmihalyi, 1996; Hennessey & Amabile, 2010). Of significant interest, although creativity has been closely associated with giftedness, research shows that these two constructs should not be equated (Hennessey & Amabile, 2010). As a consequence of this “myth” regarding creative children and giftedness, research on teacher beliefs indicates teachers are inclined to ascribe creative activities to outside the classroom; for example, in extra-curricular programs such as “gifted and talented” coursework (Beghetto & Kaufman, 2010). It is important to note that creativity-relevant processes can be developed in all students because all students have creative potential (Hennessey & Amabile, 1987; Runco, 2013).
**Task motivation.** Intrinsic task motivation is central to engaging in creative production. Amabile (2012) regards intrinsic task motivation as “passion.” Amabile, Hill, Hennessey, and Tighe (1994) described intrinsic task motivation as the drive to do work for the sole purpose of interest and enjoyment. This is significantly more important than extrinsic rewards (Hennessey & Amabile, 1987). In fact, extrinsic motivators such as expected reward, expected evaluation, and competition inhibit creative output (Amabile, 1996). Recent research clarifies aspects of extrinsic motivation that can have a positive effect, such as helpful feedback with useful information, when competence is confirmed, and when the reward suggests recognition of novel performance (Hennessey and Amabile, 2010). Further, precise instruction to “be creative” can increase levels of creative output (O’Hara & Sternberg, 2010). Thus, task motivation pursued strongly through “passion” and intrinsic desires can also be supported through extrinsic feedback from an encouraging creative environment.

**The social environment.** The social environment includes the work environment or the social environment where creativity is manifested. Research on organizational settings has revealed a variety of factors can inhibit or promote creativity (Amabile, 1988; Amabile, Conti, Coon, Lazenby & Herron, 1996; Hennessey & Amabile, 2010). In organizational management literature, creativity is developed in the work place setting by providing a psychologically safe work environment that encourages risk taking and mistakes; by valuing creative work by allowing for “free time” and “independence” to work on projects; and by applying necessary time pressure to complete the creative work where individuals are protected from distractions (Hennessey & Amabile, 2010). Further, setting creativity goals and delivering objective feedback from managers facilitates creative performance. These ideals reflect Davies et al.’s (2013) understanding of creative environments in schools. Through a systemic literature review,
the research team (Davies et al., 2013) found school environments fostering creative
development in students allowed for flexible use of space and time; offered safe and respectful
relationship between teachers and learners; gave students choice of expression and materials;
was open to play; and gave learners autonomy.

Amabile’s (1996) extension of the Componential Model of Creativity to include the
social environment is a significant improvement as creativity research proposes the profound
effects of environmental pressures on the creative individual (Beghetto, 2010; Rudowicz, 2003).
However, Amabile (1996) also falls short here and although acknowledges physical, political,
cultural factors as “other social and environmental influences” (p. 203), Amabile does not
determine specific effects of these influences on creativity.

For the purpose of this research, the social environment component will include
Amabile’s (1996) thoughts on the “work setting” or “classroom setting” as fostering creativity,
but will add cultural background experiences as an additional factor. Cultural influences on
creativity have been widely studied, where culture impacts values, beliefs, and expression
regarding creativity (Weiner, 2000; Pang & Plucker, 2013). Because this research study samples
from a heterogeneous, multi-cultural population it is important to account for cultural variations
while observing for the development of a student’s creativity.

The Componential Model of Creativity (Amabile, 1996) provides a theoretical
framework for creativity where creativity is viewed as a complex system of interrelated parts.
This conception is more valuable than a singular perspective on creativity where creativity can
be quantified as a cognitive skill, observed as a talent, or evaluated by a product or outcome. As
Hennessey and Amabile (2010) posit, “Only by using multiple lenses simultaneously, looking
across levels, and thinking about creativity systematically, will we be able to unlock and use its secrets,” (p. 590).

Summary

In *Where the Wild Things Are* (Sendak, 1963), Max tames the Wild Things that “roar their terrible roars and gnash their terrible teeth” with a magic trick and intense determination. A potential disaster is avoided as Max manipulates the situation successfully and in fact, becomes King of the Wild Things. The story is a simple metaphor to emphasize the potential of the creative mind’s ability to explore, innovate, surprise, and problem solve. Fifty years ago, Sendak (1963) wrote creativity into mischief, but this was a different time. Today, the 21st century environment undoubtedly relates creativity to innovation. Conceivably, it is time to give the creative child the opportunity and space to develop and express this inherent desire to create.
Chapter II: Literature Review

“And the walls became the world all around.”—Maurice Sendak, Where the Wild Things Are

Mindful of the promise creativity holds for the 21st century learner, an investigation of creativity in a multi-cultural group of students is warranted. This research inquiry is guided by three aims. First, it is important to understand an individual’s creativity is a result of a complex relationship between self, experience, and context (Amabile, 2012; Csikzentmihalyi, 1996; Niu & Sternberg, 2003). Thus, the inquiry will consider the individual student’s beliefs on creativity and self-reflection on creative potential. The second objective is to examine the student’s experience in a non-traditional classroom environment, inclusive of space, instruction, and assessment, as an opportunity to encourage creative thinking and expression in all students. In this case, the non-traditional environment is a Makerspace classroom designed for interdisciplinary K-12 students’ learning. Because the learning will take place during the traditional school day, the inquiry will also consider whether or not students meet target subject matter objectives.

The literature review will explore conceptualizations of creativity, how creativity is manifested in the current 21st century classroom, and the role of cultural identity regarding creativity. First, it is important to establish a clear definition and conceptualization of creativity. This will be determined through empirical studies on creativity across disciplines in psychology, sociology, and education. Creativity will be defined in the context of K-12 learning and expression. Second, the literature review will explore creativity and schooling. Research shows K-12 educators are concerned with the commitment involved in encouraging creativity while trying to achieve curriculum standards (Beghetto, 2010). Respectful of this concern, the literature will determine if teaching for creativity and teaching for traditional curriculum
objectives is mutually exclusive as conventional schooling exhibits (Schacter et. al, 2006; Simonton, 2015); or, if truly, as overstated by creativity researchers, creativity development and meeting accountability standards can coexist in the classroom (Beghetto, 2010; Sternberg, 2015). Finally, creativity will be considered in the context of identity, background experience, and culture. This is a significant endeavor because in the K-12 multi-cultural classroom “care must be taken to match curriculum and experiences optimally with an individual’s current level of functioning” (Runco, 2003, p. 320). Thus, exploring distinct notions of creativity among the diverse cultural groups is warranted.

**Perspectives of Creativity**

“That very night in Max’s room a forest grew” Max invents a new world

Creativity is what distinguishes human kind from the natural world (Weiner, 2000). Csikszentmihalyi (1996) profoundly states, “What makes us different- our language, our values, artistic expression, scientific understanding, and technology- is the result of individual ingenuity that was recognized, rewarded, and transmitted through learning” (p. 2). Within this sentiment, creativity is the ultimate source of human development and achievement. The Ancient Greeks claimed divine intervention from the Muses enabled humans to creatively compose and invent (Weiner, 2000). Creative endeavor as a mystical force, sent by God rather than an individual’s effort, permeated through the Middle Ages. Rarely did artists sign their work, and respectfully attributed the art to the hand of God (Weiner, 2000). The Renaissance welcomed a revival in classical antiquity with the study of Ancient Greek and Roman philosophy, art, and science. Although the church patronized the arts and sciences during this time, the Renaissance began to understand creativity as a consequence of the individual’s genius (Weiner, 2000).
Meanwhile, in Eastern societies, ideas on creativity evolved along traditions of collectivism and authority (Niu, 2003). The ancient Chinese believed in the Heaven (Tian), the Way (Tao), or a universal balance (Yin-Yang) where creativity emerged through meditation and Confucian ideas of self-cultivation (Niu & Sternberg, 2003). Novelty was not a feature of creativity in the Asian ideal, creativity was perceived as an extension of tradition, reflecting past models and examples (Weiner, 2000). While Eastern societies related creativity to building upon tradition, Western societies related creativity to “genius” breaking from tradition.

This type of “genius level” creativity, a talent attributed to the fortunate few defined creativity until recently (Niu & Sternberg, 2010). Researchers regard the inception of Western modern day study of creativity to Guilford’s address to the American Psychological Association in 1950, where he called for more attention to creativity (Sternberg, 2015; Weiner, 2002). The response overwhelmingly incited creativity researchers to look for special individual characteristics, manifested in personality (Gough, 1979) or cognitive abilities (Torrance, 1972). From these pioneer studies in creativity research, theories and distinctions on creativity became more complex. At the close of the 20th century, psychologists began to suspect environmental factors as a significant influence on creativity (Niu & Sternberg, 2010). Models of creativity as a complex system, rather than an individual’s genius, began to emerge.

Conceptualizations of creativity as a complex system led to various definitions of the elusive construct, resulting in an inconsistent body of research regarding the topic (Plucker, Beghetto, & Dow, 2004). For this reason, Plucker et al. (2004) suggest that creativity researchers must 1. Define explicitly creativity for the context of the research, 2. Avoid using scores of creativity measures to define creativity (such as divergent thinking assessments), 3. Discuss how the chosen definition compares to other definitions, and 4. Address the question of
creativity for whom and what context (p. 92). Without definition, “creativity becomes a hollow construct - one that can easily be filled with an array of myths, co-opted to represent any number of divergent processes, and further confuse what is (and is not) known about the construct” (Plucker et al., 2004, p.90). Mindful of this suggestion, two specific notions of creativity will guide this research study: 1. Creativity in the individual will be viewed as a system of components according to Amabile’s (1996) Componential Theory of Creativity and 2. The creative product will be defined as Novel, Effective, and Whole or NEW, adapted from Mishra and Koehler (2008).

Creativity deconstructed. Creativity is a complex construct, expressing itself in a variety of forms across disciplines and activities. Deconstruction of this construct assists researchers in defining and capturing the intricacies involved in “being creative.” Rhodes (1961) conceptualized creativity as the summation of the Four Ps - person, process, product, and press (the environment). Thus, an individual is labeled “creative,” or the chosen methodology is regarded “creative,” and/or the final product is determined “creative.” The “press” regulates social acceptance or rejection of the work as “creative.” Simonton (1990) extended the Four Ps to include persuasion. Simonton (1990) insisted the creative individual’s power of persuasion could sell an idea as “creative.” Runco (1992) added to the alliterative framework, suggesting creative “potential” as an area of study.

Creative “potentiality” is a significant addition to the creativity construct suggesting creativity is widely distributed, rather than ascribed to a few outliers. This idea dispels the myth that creative individuals are either gifted and talented or rebellious nonconformists. Runco (2013) proposes, “Creativity and the potential for self-actualization are not just for the eminent” (p. 319). Rather, creativity is for everyone.
“Creativity for everyone” can in fact, be deconstructed using the Four C Model of Creativity (Kaufman and Beghetto, 2009). The Four C model categorizes creativity into Big C, legendary creativity; Pro-C, professional creativity; Little-c, everyday creativity; and Mini-c, interpretive creativity. Kaufman and Beghetto (2009) propose this model for several reasons. First, it reiterates Runco’s (1992) position on creative potential where creative expression can be found at all distinguishable levels of ability. Secondly, the model assists creativity researchers by designating specific levels of creativity for areas of study. As such, for the purpose of this research in the K-12 classroom, Mini-c and Little-c creativity will be considered. The research will not expect students to express high levels of creative genius and professional output (Pro-C and Big-C) because of the limitations attributed to the research context (time, participant degree of practice and experience, participant age group).

Mini-c is defined “as the novel and personally meaningful interpretation of experiences, actions, and events” (Beghetto & Kaufman, 2007, p. 3). Essentially, Mini-c is the tinkering involved in creative thinking. Mini-c is appropriate for studying creativity in the classroom, where teachers can provide students with experiences to hone creativity skills through encouragement and opportunity for practice. Mini-c is manifested in the process. Little-c is defined as the everyday expression of creativity that can be observed across disciplines. Little-c can also be encouraged in the classroom by asking students to demonstrate and reflect on their learning using creative, novel ways (Beghetto & Kaufman, 2007). Little-c is demonstrated in the outcome.

The Four C Model additionally provides guidance for assessment of creativity. For the purpose of this research, assessment of Mini-c and Little-c creativity is necessary to understand how a classroom setting develops creativity in all learners, despite initial differences in self-
perceived creative ability. Beghetto and Kaufman (2009) suggest self-assessments are appropriate for examining the Mini-c level. The authors elaborate, self-assessments benefit students by asking students to focus and reflect on their creative capacity. Additionally, they help educators identify creative potential in students (Beghetto & Kaufman, 2009). Little-c in the classroom can be observed and evaluated by the use of creativity rubrics. The distinctions Beghetto and Kaufman (2009) present offer implications for focusing classroom practice into creative endeavor.

Using these evidence-based indications of creativity, this research study defines the “creative person” as a student with creative potential (Runco, 1992), who engages in the Little-C process of tinkering and manifests a Mini-C product of “every day” creativity (Beghetto & Kaufman, 2009). The research will refer to these distinctions while understanding how the young, adolescent individual engages in an experience to develop creativity. The confluence of these factors warrants a systems approach of thinking about creativity.

**Creativity reconstructed.** While aforementioned theories deconstruct creativity into units, several creativity theories use a systems framework. Csikszentmihalyi’s (1996) Systems Theory of Creativity suggests creativity “arises from the synergy of many sources and not only from the mind of a single person” (p. 1). In his five-year study of ninety-one exceptional individuals across disciplines (Nobel laureates, notable artists, successful change agents), participants consistently identified themselves not as “genius” but as a resulting confluence of passion, hard work, and a culture and climate enabling creativity. By analyzing data from this study, Csikzentmihalyi (1996) determined patterns and relationships illuminating characteristics of creative individuals, the creative process, and conditions encouraging or inhibiting idea generation (p.12). As a result of this longitudinal study, Csikzentmihalyi (1996) proposed
creativity as a consequence of interrelated parts: inclusive of 1. The Individual, 2. The Domain (culture), and 3. The Field (society/setting).

Sternberg and Lubart (1991) posited an Investment Theory of Creativity where six distinct, but interrelated, resources are necessary for creativity including: intellectual abilities, knowledge, styles of thinking, personality, motivation, and the environment. This systems perspective attributes creativity to a habit, where the creative individual has the drive to habitually engage in pursuing ideas that are unknown or out of favor (Sternberg, 2012). In essence, the creative person buys “low”- pursuing an idea that is unfavorable, and sells “high” developing that idea into a desirable concept or artifact. After the “sale,” the creative individual moves on to the next idea, developing a habit of creative endeavor. Sternberg (2012) insists, the most creative ideas are developed by individuals who have the “fortitude to persevere and go against the crowd” (p. 5).

Amabile’s (1996) comprehensive research on creativity confirmed a systems perspective. Amabile (1996) developed a Componential Theory of Creativity where creativity is the result of an integration of components. To be creative an individual must possess 1) Domain-relevant skills, 2) Creativity-relevant skills, 3) Task- motivation, and 4) The Social-environment must support creative endeavor. As noted in Chapter 1, Amabile’s (1996) Componential Theory of Creativity guides this study’s inquiry into a student’s creative experience in a non-traditional learning environment. Although the exploration of creativity systems theories offer interesting perspectives, they are less appropriate for this study. Csikszentmihalyi’s (1996) research appropriates the Systems Theory of Creativity to creative individuals with remarkable accomplishments, referred to as “Big C” creative, a level of creativity attributed to figures such as Leonardo da Vinci and Thomas Edison. This level of attainment is not probable in the K-12
educational setting. Meanwhile, Sternberg and Lubart’s (1991) \textit{creativity habit} unfortunately does not resonate with the K-12 classroom where creative thinking and learning is antithetical to school norms. Amabile’s (1996) Componential Theory of Creativity however is appropriate for the education setting, where domain skills (content knowledge), creativity relevant skills (thinking strategies), task motivation (accountability), and the social environment (interactions in the learning space) may all converge to develop the individual’s capacity for innovation.

\textbf{Componential Theory of Creativity}

Amabile’s (1996) Componential Theory of Creativity has been successfully applied across disciplines from psychological to organizational creativity research (Amabile, 2012). In education, the Componential Theory of Creativity is supported through empirical research regarding each component, Domain-relevant skills, Creativity-relevant skills, Task motivation, and the Social environment, as well as the confluence of these components. The following reviews each component specifically as it relates current evidence based investigations on creative learning and expression and creativity in the classroom.

\textbf{Domain relevant skills.} Domain-relevant skills refers to the knowledge about the domain where creative performance occurs; the technical skills required to perform; and often, but not necessary, a special domain-relevant talent. Amabile (1996) posits domain-relevant skills depend on innate cognitive abilities, innate perceptual and motor skills, and formal and informal education (p. 84). Csikszentmihalyi’s (1996) longitudinal study of eminent creative people found that participants expressed, “to be creative a person must first understand the domain” (p.340). Amabile’s (1996) creativity theory tends to suggest creativity is domain-specific, where the individual hones knowledge in one specific domain and uses that expert knowledge to express creatively. Hennessey and Amabile (1987) posit the larger the set of
knowledge within the domain, the more numerous the possibilities of developing creativity. Several studies have attempted to understand whether creativity is domain-specific or if creativity can be generalized across domains (Kaufman & Plucker, 2004; Kaufman & Baer, 2005; Plucker & Zabelina, 2009). In Plucker and Zabelina’s (2009) review on domain specific or inter-disciplinary creativity, overwhelming evidence suggests creativity is domain-specific. Research studies where participants engaged in creative tasks among different domains (for example a math problem and an artistic project) found creativity correlations to be low across domains, indicating a low probability for multi-potentiality (Baer, 1998). The domain-specific perspective was heavily informed by Gardner’s (1983) seminal theory of multiple intelligences. Gardner (1988) extended the theory to creativity where psychologists and educators ascribed an individual’s special creative inclination to a specific domain.

Yet, Plucker and Zabelina’s (2009) review also offers an opposing view. Plucker (1998) applied advanced statistical methods to peer-reviewed research studies on creativity domain-specificity or domain-generality research, and in his analysis found some evidence of domain-generality where results had previously indicated domain-specificity. Plucker (1998) noted methods, or creative tasks may not be similar across domains. Assessments tasks such as the Torrance Test of Creative Thinking showed domain specificity, while in contrast creativity check lists demonstrated domain generality (Plucker, 1998). These mixed-results can be attributed to creative personality traits that individuals employ across domains; for example, Kaufman & Baer (2005) explain, an individual might take risks or use divergent thinking patterns in a mathematical situation and might do the same during an artistic activity.

Domain-generality has implications for education programs seeking “to stimulate, enhance, and maintain” creative ability (Plucker, 1998). Plucker and Beghetto (2004) suggest a
hybrid position where creativity is domain-specific and domain-general at the same time. Using a developmental perspective, the model assumes Runco’s (1992) position that everyone has creative potential, and as an individual ages and experiences, creativity is developed moving from generality to specificity (Plucker & Beghetto, 2004). In fact, a recent study of creativity among adolescents found the youth exhibited creativity across domains by transferring or adapting knowledge and creativity approaches from one domain to another (Lassig, 2013).

Plucker and Zabelina (2009) suggest students should be exposed to a wide range of contexts in which to develop creativity. The developmental approach recognizes students will eventually discover a personal optimal condition of interest and creativity development. Until then, creative experiences in a variety of domains (whether it be math, literacy, science, or arts) foster flexibility of thinking and transfer of important creativity relevant skills (Plucker & Beghetto, 2004).

**Creativity relevant processes.** Through a review of empirical studies Amabile (1996) synthesized a cognitive style set characterizing skills creative individuals used in the “making” process. These skills include 1) Divergent thinking, 2) Breaking from cognitive set and starting fresh, 3) Understanding complexities, 4) Keeping response options open as long as possible, 5) Suspending judgment, 6) Using “wide” categories to note relationships across diverse information, 7) Remembering accurately, 8) Breaking from performance scripts, and 9) Perceiving creatively (p.88-89). Additionally, Openness to experience, describing “the breadth, depth, originality, and complexity of an individual’s mental and experiential life” is an evidence-based creativity relevant skill (Feist, 2010, p. 120). Tolerance of ambiguity is also related to creativity (Zenasni, Besancon, & Lubart, 2008). Zenasni et al. (2008) explain, “Tolerance of ambiguity allows individuals to continue to grapple with complex problems, to remain open, and
increase the probability of finding a novel solution” (p. 62). These cognitive processes, and slight variations on these dispositions, are generally accepted and confirmed through current research on the creative process (Csikzentmihalyi, 1996; Feist, 2010; Johnson & Hatch, 1990; Perrine & Broderson, 2005; Runco, 2007; Sternberg, 2003). These cognitive processes can also be viewed as habits creative individuals share. Habitually, creative individuals use a variety of lenses to look at problems, take risks, courageously defy groupthink, and persevere in the face of obstacles (Sternberg, 2012).

A recent study of creative adolescents investigated participants’ skills and strategies on approaches to creativity (Lassig, 2013). Because research on adolescent creativity is scant, Lassig (2013) used grounded theory methodology where results were co-constructed with participants’ perspectives and reflections on their individual creative experiences. The research discovered adolescents used “adaptation,” “transfer,” “synthesis,” and “genesis” most frequently to approach creative projects. These approaches reflect the evidence based creativity relevant skills of divergent thinking, understanding complexities, using wide categories, and remembering accurately to produce creative ideas and products. Genesis refers to a complete break from the cognitive set to create something new.

The study exemplifies Amabile’s (1996) confluence of domain relevant and creativity skills relevant components. Adaptation is an extension, variation, manipulation, or rearranging of an idea. These student participants used past experiences and domain-relevant knowledge to build upon to create a novel idea. Evidence of transfer was found when participants mentioned they had learned something in one domain and transferred this knowledge to another domain. For example, one student applied mathematical concepts to a Beatles album. Using synthesis as a method, participants combined two or more existing ideas. In another example a student used
domain knowledge of German expressionism and created an animation using a technique learned from her media class. Finally, genus was exemplified when student participants spoke of their most original ideas coming from an unidentifiable source. Although one student participant understood that, “you will never make something that’s 100% original…it’s impossible to create something that isn’t influenced by culture…your brain is never empty” (Lassig, 2013, p. 8).

Further, researchers noted an extra effect of the study. Participants claimed metacognitive awareness of preferred approaches to creativity was a valuable experience that could help them identify and practice creativity-relevant strategies. This self-awareness can contribute to intrinsic motivation that is highly valuable when performing for creative endeavor (Amabile, 1996).

**Task motivation.** The most important distinction between the componential framework of creativity and aforementioned systems theories of creativity is the prominence given to task motivation (Amabile, 1996, p. 107). Task motivation includes “attitude toward the task” and “perceptions of own motivation for undertaking the task” (Amabile, 1996, p. 84). Simply put, task motivation is the passion to engage in creative ventures. This passion depends on the level of intrinsic motivation toward the task, and the presence or absence of salient extrinsic constraints. The individual must have the capacity to minimize extrinsic constraints (Amabile, 1996). This position correlates to creativity-relevant skills reflecting risk-taking, thinking independently, and the ability to break from the cognitive set to pursue an unpopular idea (Amabile, 1996; Sternberg & Lubart, 1991). Research on creative individuals decidedly indicates motivation to pursuing solutions to problems is most often driven by passion rather than extrinsic reward (Amabile, 1996; Csikszentmihalyi, 1996). In fact, creative individuals
consistently recognize the drive is motivated more by the process or puzzle, rather than the final product or expectation of reward (Csikszentmihalyi, 1996).

To explore this notion of intrinsic versus extrinsic motivation, Amabile (1979/1982/1983) set up several experimental designs where consistently the control group, not expectant of intrinsic reward, produced a higher level of creative output. For example, from a sample of creative writers, Amabile (1983) asked participants to write two poems. The first poem participants were asked to write freely. Before participants received the second poem assignment, they were instructed to fill out a questionnaire. The control group filled out a questionnaire focused on intrinsically motivated reasons for writing; the experimental group filled out a questionnaire based on extrinsic motivation reasons. The study found that judges evaluated the first poem assignment without any significant differences in creative output between the first and second group. However, evaluation of the second set of poems found the experimental group’s poems less creative than the control group. Creativity researchers have consistently confirmed intrinsic motivation as a driving force of creativity, while extrinsic motivators are often detrimental (Collins & Amabile, 1999; Csikszentmihalyi, 1996).

Kaufman and Beghetto (2009) posit, “intrinsic motivation is more pressing at the mini-c and little-c level because an individual’s interest and commitment in the particular creative endeavor is still emerging” (p. 9). External rewards may put natural interests at risk when more salient rewards are involved. Beghetto (2005) explains a child may have a passion for the study of insects, but when a parent or teacher motivates the child with a reward to “win an insect trivia bowl” the child may trade their intrinsic interest for the extrinsic reward of winning.

Yet, current research shows appropriate extrinsic motivation may encourage creativity (Eisenberger, Armeli, & Pretz, 1998; Niu & Sternberg, 2003; O’Hara & Sternberg, 2001).
Amabile (2012) concedes to some extrinsic motivators such as explicit direction to “be creative,” constructive feedback, and appropriate recognition of creative work. Eisenberger et al. (1998) go further and demonstrate explicit reward increases creativity output. In their study, Eisenberger et al. (1998) gave fifth and sixth graders paper printed with circles and were asked to make a drawing using each circle as a major part of a picture. One group received instruction to “be creative” while the other group received no specific instruction. Each group was then divided in half, half of the instructed “be creative” group was promised monetary reward for good work, the other half was not; half of the second group with no instruction to be creative was promised the same monetary reward, and the other half was not. The promise of reward increased the creativity performance of the half that was instructed to “be creative” with reward expectation. This group was the most creative of all.

An investigation of creativity differences and motivation to be creative between American and Chinese university students by Niu and Sternberg (2003) is of interest. Each group of students was given instructions to make collages out of colorful stickers of different shapes and to arrange them in a depiction of an emotion: happy, sad, angry, or frightened. Americans consistently demonstrated a higher level of creativity in these depictions in all experiments. However using the instruction to “be creative,” as an extrinsic motivator, improved Chinese students’ creativity as demonstrated by the collage activity. Further, the Chinese students’ creativity increased more when given feedback on how to be creative.

Niu and Sternberg’s (2003) study is significant evidence suggesting the use of appropriate extrinsic motivators for a multi-cultural group of students. Amabile’s (1996) intrinsic motivation principal of creativity is suggested from a Western perspective, where creativity is a natural expectation of the culture. However, intrinsic and appropriate extrinsic
motivations might be useful for developing creativity in a multi-cultural group of students. Additionally, this study indicates how the social environment significantly influences the development of creativity.

**The social environment.** The social environment exists outside the individual, it can be described as the work environment, or in this research’s case, the classroom environment. This includes extrinsic motivators that influence the individual’s creativity, despite level of intrinsic motivation, creativity relevant skills, or domain knowledge. Amabile’s (1996) research in work settings revealed environmental factors that block creativity, such as “norms of harshly criticizing new ideas; political problems within the organization; an emphasis on the status quo; a conservative, low-risk attitude among top management; and excessive time pressure” (Amabile, 2012, p. 4). Moreover, specific environmental factors can encourage creativity. These factors include work that is engaging and challenging; collaborative, diversely skilled work teams; supervisors who encourage creativity through an innovative vision and appropriate feedback for creative work; and organizational systems and norms that promote development of new ideas (Amabile, 2012).

Affirming the social environment’s influence on creativity, Csikszentmihalyi’s (1996) research describes the “social environment” as “the field.” Csikszentmihalyi (1996) described “gate-keepers” in the field are the experts and critics who encourage, acknowledge, and diffuse creative expressions in the public sphere for acceptance. In Amabile’s work in organizations, the supervisor is the “gate-keeper;” for this research study in a K-12 setting, the school environment and more intimately the classroom, the teacher holds the key in encouraging creative thinking and expression. The classroom teacher establishes the social environment by choosing the
Acknowledging “the development of student creativity is crucial for economic, scientific, social, and artistic/cultural advancement,” Hennessey and Amabile (2010, p.585) urgently suggest the need to understand how the social school environment can positively affect the development of creativity. The literature review will explore the school environment with regards to creativity in depth in the following section. First, however, before discussing creative learning environments, it is important to define what creativity is as expressed in the social environment (Beghetto, 2010; Beghetto & Kaufman, 2014).

**Products of Creativity**

In the work or school setting, creative expression is often a tangible product that can be assessed. To define what is creative most researchers agree on two key elements, the creative work must represent something new or different and that it must be appropriate for the domain or context in which the creative work exists (Amabile, 1996; Csikszentmihalyi, 1996). Simonton (2012) simply equates creativity as Creativity= Originality X Appropriateness. Plucker, Beghetto, & Dow (2004) add the element of “context” (C=[O x A]context) to this equation. Plucker, Beghetto, and Dow (2004) analyzed ninety empirical research papers regarding creativity searching for a complete definition of “creativity.” In their analysis they found that only 38% of the papers explicitly defined creativity. Through this analysis, the research discovered recurring themes of “uniqueness” and “usefulness.” Thus, agreement among the research found “novelty” and “appropriateness” determined creativity. Plucker et al. (2004) derived the following definition from this investigation, “Creativity is the interaction among
aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within the social context” (p. 90).

Mishra and Koehler (2008) introduced a creativity definition with the use of an acronym “NEW” meaning Novel, Effective, and Whole. The work of Mishra and Koehler (2008) is an extension of Plucker et al.’s (2004) creativity definition, where novelty and appropriateness (effectiveness) are determining factors, and identifies the notion of context appropriateness as “Wholeness,” where creativity is context appropriate and is aesthetically remarkable. Henriksen, Mishra and Mehta (2015) explain, “Creativity defined as ‘novelty’ and ‘usefulness’ is insufficient because creative expression is sensitive to context, and must be valued within the domain in which they were created” (p. 463). Thus, contextual and aesthetic sensibility is necessary for acceptance as “creative.”

Inspired by the NEW definition of creativity, Henriksen et al. (2015) developed a creativity rubric based on Novelty, Effectiveness, and Wholeness. Henriksen et al. (2015) conducted a comprehensive review of creativity measures; of 220 measures the researchers found only 85 were actually related to measuring creativity. More important for this study, only a fifth of instruments targeted students in the K-12 age group, and only four measures addressed the creative product. Although the rubric is a nascent tool, Henriksen et al. (2015) provide descriptors and examples of how the rubric has been previously used. The rubric evaluates items or projects on the three key dimensions of the creativity definition, Novelty, Effectiveness, and Wholeness. This assessment tool will be described further in the methodology section.

The NEW creativity rubric has valuable implications for teacher and classroom use. As Beghetto and Kaufman (2009) explain Little-c creativity is the expression of creativity intended for an audience. As part of the learning process, K-12 students can be asked to demonstrate
Little-c creativity and creative expression can be measured using the Novel, Effective, Whole (NEW) rubric. Further, as Mishra, Henriksen, and the Deep Play group et al. (2013) succinctly iterate, “The process of creativity is often invisible to the outsider. What we have, at the end of the day, is what the creative process produces” (p. 11). Although the process is as important as the product, the end product is what educators have to assess. Additionally, creativity rubrics can enhance the social environment for creativity by providing the language, expectations, and vision for creative work. The NEW rubric becomes a tangible tool educators can use to encourage creativity in the classroom. For the classroom context, the definition of creativity as NEW and its subsequent creative product rubric, is most appropriate, and will be used within this research study.

**Creativity in the Classroom**

“WILD THING!”-Max’s adult supervisor, *Where the Wild Things Are*

The current education landscape has students preparing for “college and career readiness” focusing on Common Core standards that for example, emphasize “informational writing” over “personal narrative” (Rothman, 2012). Although these rigorous standards are presented as foundational “essential skills” from which to build a robust curriculum, often the priority skills become the entire instructional program, leaving little room for experimentation and innovation (Zhao, 2012). Certainly, Common Core standards and curriculum content is necessary, Amabile (1996) proves that creativity cannot exist without domain-relevant knowledge. However, “the problem is that schooling often stops short of encouraging creativity; teachers and testers are often content if students have the knowledge” (Sternberg, 2012, p. 4). Meanwhile, outside the classroom, the current 21st century economic, political, and social climate encourages, craves, and lauds creative expression (Wagner, 2012; Zhao, 2012).
Does school kill creativity? In a Newsweek article entitled “The Creativity Crisis” Bronson and Merryman (2010) presented data showing a steady decline in creativity in America since 1990. Reasons for this decline are inconclusive, yet the authors suggest the lack of creative development in our schools is of consequence. In fact, Torrance’s (1995) comprehensive, multi-year investigations of creativity and students found the more students attend school, the more cautious and less curious, less creative they become. Traditional methods of schooling do not help. Hennessey and Amabile (1987) writing for an NEA: What Research says to Teachers Report in a section entitled “How to Kill Creativity” suggested conventional teaching strategies such as extrinsic rewards, setting up competitive situations, having children focus on expected evaluation, limiting choice, and using plenty of surveillance smother creativity. Research shows these instructional strategies persist due to standardized testing accountability, outdated teacher education models, and entrenchment in conventional beliefs concerning instruction and learning (Sternberg, 2015; Robinson, 2006/2015; Zhao, 2012).

Mandates, measures, and much curriculum left behind. Berliner (2009) accuses the U.S. education system of being complicit in the “creaticide” of our students. It is widely researched that a high stakes testing environment encourages narrowing of the curriculum in what Berliner (2009) describes as “Much curriculum left behind.” This narrowing has resulted in the loss of special classes in the Arts, Social Sciences, and Foreign Languages that encourage creativity (Zastrow & Janc, 2004). Further, testing hinders creativity when teachers prioritize teaching students how to respond to test questions (Beghetto, 2010). Although the Every Student Succeeds Act (2015) alleviates federally mandated standardized testing pressures, performance tests are inherent in the American system (Zhao, 2012). In this culture of testing and reducing learning to indications of numbers and letter grades, creativity has little room to thrive.
Recently across the globe, education mandates espousing “developing creativity in the classroom” have demonstrated an increased awareness of creative teaching and learning (Hui & Lau, 2010). However, as Beghetto (2010) indicates, “a creativity mandate may only serve to exacerbate barriers to creativity…where teachers may feel overwhelmed and caught between seemingly contradictory demands” (p. 449). Beghetto (2010) believes creativity researchers can support teachers directly by helping teachers understand how to combine teaching for creativity while achieving standards of learning.

**Teacher beliefs and practice.** Creativity is not a prioritized concern of American teachers (Beghetto, 2010; Schacter, Thum, & Zifkin, 2006; Grigorenko & Sternberg, 1997) although in recent years, creativity has become a more accepted classroom value (Aljughaiman & Mowrer-Reynolds, 2005; de Souza Fleith, 2000; Hartley & Plucker, 2014). De Souza Fleith (2000) found school teachers believed a creative classroom environment should provide students with choices and focus on the whole child’s strengths, interests, and self-esteem. Perhaps this shift in values reflects international policies where “creativity development” has become (especially in East Asian nations) a government policy mandate (Hui & Lau, 2010), and domestically, in the U.S., a critical skill of the Framework for 21st Century. A recent study and comparison of American and Chinese teacher perceptions of creativity in the classroom demonstrated teachers of both nationalities could identify classroom practices that encouraged creativity (Hartley & Plucker, 2014). Surprisingly, the study showed Chinese teachers, working in a system that is notorious for rote learning, had a better understanding over American teachers. Yet, how is the shift in education policy and in changing teacher beliefs currently manifested in the classroom of the 21st century?
In an effort to understand a teacher’s perspective on creativity, Aljughaiman & Mowrer-Reynolds (2005) asked American elementary school teachers (n=36) about their attitudes, beliefs, and classroom practice regarding creativity. Generally teachers revealed positive attitudes and perceptions towards creativity and noted a desire for creative learning in the classroom. However, when asked whether it was the classroom teacher’s responsibility to integrate creativity in the curriculum, the teachers overwhelmingly responded negatively. The teachers explained the responsibility of creative instruction and expression was outside the realm of the traditional classroom (perhaps in a gifted classroom or for an after school activity). Thus, although teachers understood the superficial value of creative thinking and learning, they did not understand exactly how creativity might be integrated into the curriculum. Further, Aljughaiman and Mowrer-Reynolds (2005) posit, teachers are unable “to foster creativity when they do not know how to define creativity, recognize creativity, appreciate creative behaviors, or are overburdened with the demands of teaching content driven curricula toward high stakes testing” (p. 32).

A study by Schacter et al. (2006) measured creative elementary school teachers’ teaching behaviors and the impact of these behaviors on reading, language, and math achievement. Using a framework the authors developed to describe creative instructional strategies (explicitly teaching creative thinking strategies, providing opportunities for choice, encouraging intrinsic motivation, establishing a learning environment conducive to creativity, and providing opportunities for imagination and fantasy) the authors observed teachers over the course of a school year (p. 48). The study found the majority of the teachers did not implement any creativity fostering teaching strategies and classrooms with high portions of minority and low-performing students received significantly less creative instruction (Schacter et al., 2006, p. 61).
Finally and significantly, the students of the few teachers employing creativity fostering instruction showed substantial achievement gains.

Recent studies show teachers seem to be aware of the value of teaching for creativity and teaching creatively, yet teachers have yet to embrace this pedagogy in their daily practice. Teachers are observed teaching for creativity infrequently; for example teaching for creativity is most often observed only in exceptional or alternative programs (Craft et al., 2014). Sternberg (2015) reflects upon this dearth of creative teaching insisting that higher education programs must commit to changing traditional coursework and methods of preparing teachers. Sternberg (2015) understands, “Teaching for creativity is hard and contrary to traditional ways,” yet, until higher education teacher programs overcome this barrier “it is unlikely to see much spontaneous teaching for creativity in schools” (p.116).

**Creativity as distraction.** Torrance’s (1972) seminal study of 650 teachers revealed characteristics of creative students such as playfulness, emotional, open, and risk taking, were undesirable classroom behaviors. Since that time, not much has changed. Westby and Dawson (1995) found that even as teachers valued creativity in their students, they dismissed creative behaviors as distractions. Beghetto (2007) surveyed prospective teachers’ views on creative behavior in the classroom and participants overwhelmingly responded unfavorably. In Beghetto’s (2007) inquiry, creative responses from students were understood as distractions, rather than potential for interesting discussion.

Even creativity researchers and advocates Kaufman and Beghetto (2012) posit creative behavior should be encouraged in school, albeit appropriately. Certainly, creative students can be impulsive and uncontrollable, disrupting the regular classroom routine. Brandau et al. (2007) found students who were identified by teachers as hyperactive and disruptive scored higher on a
creative fluency test. Kaufman and Beghetto (2012) suggest teachers teach creative metacognition (CMC) techniques to creative students, to help students understand when to be and when not to be creative. This is a surprising position for creativity advocates, although Kaufman and Beghetto (2012) explain, “We are not advocating educational research should focus on the dark side of creativity, but should follow the lead of organizational researchers who recognize the complexity of the issue” (p. 160). Empirical research on this CMC method has yet to be investigated. However, as teachers plan for encouraging a creative classroom environment, this may be an interesting technique.

**Does school foster creativity?** Kaufman and Sternberg (2007) explain, “Although one cannot directly teach creativity, one can teach for creativity. This involves, first and foremost, encouraging students to be creative and rewarding creative behavior when it occurs” (p. 58). Hennessey and Amabile (1987) offer the story of Einstein, at the age of 15, who hoped to enroll in the Polytechnic Institute in Zurich. Unfortunately he failed the entrance examine and consequentially enrolled in a remedial, liberal Swiss school that stressed “searching for knowledge unencumbered” (p. 5). Hennessey and Amabile (1987) further explain, in his biography, Einstein remarked on the great impact this type of schooling had on his ability to experiment and grow. The school was based on the educational philosophy of Pestalozzi, who encouraged students to visualize concepts (Isaacson, 2015). Mindful of Amabile’s (1996) Componential Theory of Creativity, the social environment of the Swiss village school developed Einstein’s creativity-relevant skills, domain-relevant-skills, and intrinsic motivation. It was in this school Einstein devised his first *Gedankenexperiment*, a visualization of what it would be like traveling next to a light beam, a vision that would eventually lead to the theory of
relativity (Isaacson, 2015). It seems from this remarkable anecdote, that possibly, school can develop creativity.

**Creativity-relevant skills: teacher and student beliefs.** Recent research on creativity beliefs demonstrates how schools might develop creativity in the individual. Hong, Hartzell, and Green (2009) surveyed 178 elementary school teachers to understand the relationship between epistemological beliefs, intrinsic motivation, and goal orientation to their instructional practices fostering their students’ creative development. The study found that teachers with sophisticated beliefs about the nature of knowledge and those with intrinsic interest in creative work practiced creativity-fostering instruction (p. 205). Further, teachers who reported having a goal orientation of learning for mastery rather than for performance tests, used creativity-fostering instruction in their classroom. This study has important implications for schools wanting to break from entrenchment in traditional teacher practices. By offering professional development in current research in cognition, by creating a climate where a teacher’s personal creativity is encouraged and by focusing measures of accountability on a mastery orientation, a teacher may employ more creativity-fostering instruction.

Haigh (2007) conducted a four-year study of a senior year high school biology class in New Zealand. The biology curriculum was designed for students to engage in investigative, practical, or “hands-on” work. Haigh (2007) questioned whether this model of learning also fostered creativity. Haigh (2007) conducted this study at a time when New Zealand’s science curriculum was explicitly prescriptive. Haigh (2007) found students completed their prescriptive science work “unthinkingly,” unit after unit (p.126). However, when engaged in practical investigations the students engaged in creativity relevant processes: combining old ideas in new ways, exploration within the domain, and transformation –breaking from the rules of the domain
to form new concepts. Not surprisingly, hands-on and project based learning activities encouraged creativity.

A more interesting result from the study found that both student and teacher abilities and beliefs regarding learning and teaching limited their respective abilities to be creative (Haigh, 2007). Some students found it difficult to challenge traditional concepts of learning, while others felt comfortable. Teachers felt unsure and cautious of the investigative program. Haigh (2007) duly noted student and teacher beliefs on learning must accept creative endeavors, stating “roles previously understood…had to be renegotiated so that teachers and students had common expectations of learning in biology” (p. 140).

Regarding beliefs in creativity, two studies by Beghetto, Kaufman, and Baxter (2011) explored elementary student’s Creative Self-Efficacy (CSE) beliefs and teachers’ rating of students’ creativity. Both studies (the first in the science domain, the second in the science and math domain) noted that student CSE beliefs predicted teachers’ ratings of students’ creative expression. Significantly, teachers rated the students with high CSE as “highly creative”. Teachers also more readily identified students as creative while students underestimated their ability to be creative. The researchers posit, “While strong Creative Self-Efficacy alone cannot increase creative performance, weak efficacy beliefs will have a negative impact on creative performance” (Beghetto et al., 2011, p. 347). Thus, it is important for teachers to help their students recognize creative potential.

Explicitly encouraging creativity relevant skills by encouraging self-efficacy beliefs in “being creative” can help students and teachers build confidence to share and develop ideas (Beghetto, 2010). Providing a supportive environment, inclusive of the curriculum, where the teacher and student are allowed to take intellectual risks increases the chances of creative output.
Further, supportive feedback and robust self-beliefs on being creative supports a culture of innovative classroom activity.

**The social environment: the classroom.** A systemic literature review by, Jindal-Snape, Collier, Digby, Hay, and Howe (2013) surveying 210 research papers on creative learning spaces codified characteristics of learning environments that encourage creativity. Analysis of the review resulted in the following distinctions of a creative learning space. A creative learning environment shares these common features including “flexibility in the physical and pedagogical environment, learners having control of their learning and ownership of the activity, engaging in a varied physical environment at school and elsewhere such as museums, flexible use of time (including time beyond school and curriculum boundaries), and allowing pupils to work at their own pace without pressure” (p.88). Through the review, Davies et al. (2013) discovered relationship between teachers and learners, including high expectations, mutual respect, exchange of dialogue, and embracing flexible perspectives also encouraged creative output. Students also modeled behaviors of teachers who expressed creative attitudes. The literature determined creative environments encouraged opportunities for working collaboratively with peers, which included peer and self-assessment.

Thus far this research investigation has been concerned with developing creativity in a group of multi-cultural students as a 21st skill critical for success beyond schooling. However, Davies et al. (2013) reminds and brings attention to the significant benefits learning to be creative has on the individual in the school context. The authors noted “increased academic achievement, increased confidence and resilience, enhanced motivation and engagement, development of social, emotional and critical thinking skills, and improved school attendance” (Davies et al., 2013, p.88).
Evidence from the review has several implications for designing a learning environment that fosters creative development mindful of Amabile’s Componential Theory of Creativity. First, the review mentions the importance of the school culture in encouraging creativity by providing flexibility of the physical space, of the curriculum and of the lesson structure. Flexibility was also used to describe the teacher’s and the student’s behavior. This evidence mirrors Amabile’s (2012) suggestions for promoting a creative work environment in organizations. Second, flexibility reflects critical creativity relevant skills of openness and tolerance for ambiguity (Zenansni, Besancon, & Lubart, 2008). A focus on a teacher’s intrinsic task motivation is exemplified where the authors consistently found creative teachers as those who took on the role of “learner” to develop their own creativity, where teachers were open to “co-constructively” work with a coach or mentor, and where teachers behaved as reflective practitioners (Davies et al., 2013). The review did not find, however, any specific evidence of domain-relevant connections to creative learning environments. This is an unfortunate gap in the literature review because educators are primarily concerned with achievement in academic content knowledge (domain relevant). Also, it is of interest to understand whether domain-relevant, content knowledge is a pre-requisite for creativity, or whether content was learned concurrent with the creative process.

Davies et al. (2013) note additional critical shortcomings of the body of literature regarding creative learning environments. First, of the 210 research studies published between 2005 -2011 only 58 were empirically based studies. The authors note much of the literature was “philosophical” or “anecdotal” (p. 89). Second, the authors found little evidence of cross-curricular approaches in fostering creativity. Finally, there was relatively no discussion of the impact of creative environments across socio-economic, ethnic, or cultural groups.
Classroom “creaticide” or creative vibe? How does the social environment, in this case, the school, affect creativity? Do schools kill creativity? Or do schools foster creativity? Perhaps an either/or question is imperfect. A more reasonable question might be, how can schools achieve conventional standards-based objectives and teach for creativity? Beghetto (2010) insists, “Rather than view teaching as developing either academic knowledge or creative potential, teachers can develop both creative potential and students’ knowledge of academic subject matter” (p. 453). Perhaps a gradual shift in mindsets has begun. Education policy makers have made a concerted effort to add the language of “creativity” into national education agendas. Educator attitudes towards the benefits of creativity in the classroom have been observed, although entrenchment in traditional school routines maintains traditional models. Sternberg (2015) notes, “When people are used to doing things in a certain way, they often do not change how they do things unless they have to. And if there is no reward in teaching for creativity, few teachers are likely to venture into that endeavor. So nothing changes because nothing has to” (p. 116). Yet, research shows evidence of creative learning environments and possibilities for exemplar school models for the 21st century (Davies et. al, 2013; Craft et. al, 2014). Perhaps these models can demonstrate, not whether creativity is developed or not, but how creativity is developed in concert with the intended learning objectives.

The Makerspace

“...and made mischief of one kind and another”-Max, in wolf suit

It has been widely noted that the traditional classroom environment often stifles creativity while alternative pedagogies (such as Montessori or Waldorf) promote creativity (Besancon and Lubart, 2008). This research will investigate the experience of a multi-cultural group of students in a non-traditional learning environment, a Makerspace. The Makerspace concept is just
beginning its manifestation in schools, as an extension of the Maker Movement. The “Maker Movement” has gained popularity since the first Maker Faire in 2006 and refers to people who are engaged in creative production in their daily lives and share their products with the general public (Halverson & Sheridan, 2014; Fallows, 2016).

The Makerspace is a current and innovative setting where the act of “making” takes place. The physical space is intentionally designed to bring tools and technology to the average person (the Maker community regards all people as makers), and depending on funding and resources, the physical space can be outfitted with the latest technological hardware and software, such as a laser cutter and 3D printer, or very simply, with Legos, cardboard, hammers and nails. Dougherty (2012), the founder of Maker Media and often credited with popularizing the Maker Movement, claims the growing availability of low cost computational and fabrication tools makes the opportunity where anyone can innovate possible.

The Makerspace concept can be grouped into three categories: making as entrepreneurship and/or community creativity (e.g. an after work, hobbyist, community space); making as STEM pipeline and workforce development (e.g. Fablab@School at Stanford University); and making as inquiry-based educative practice (e.g. an after school activity, a hands-on museum space) (Vossoughi & Bevan, 2015). For this specific research study, the Makerspace will be regarded as an inquiry-based educative practice. The Makerspace for this context is a pilot program intended for students K-12. In this space classroom teachers can collaborate with the Makerspace teacher to create and execute, interdisciplinary lessons integrating science, technology, engineering, art, math, (STEAM) as well as humanities and language arts.
The Makerspace environment shares many of the characteristics of a “creative learning environment” as illustrated by the Davies et al.’s (2013) review on settings fostering creative development. Makerspaces are flexible, open spaces, where students are independent to choose activities to explore and projects to create using available tools and materials. Makerspaces in education settings also have facilitators who assist students through constructive feedback, posing open-ended questions, and modeling (Voussoughi & Bevan, 2015).

“Making” (also known as “tinkering”) in the Makerspace implies progressive education ideals advocated by John Dewey (1938), Maria Montessori (1912), and Loris Malaguzzi (1998) where building, exploration, experience, and play construct knowledge while developing critical thinking, problem solving, and especially relevant for this study, creative thinking and expression skills (Bevan, Gutwill, Petrich, & Wilkinson, 2014). “Making” can be any set of activities designed with a variety of learning goals (Halverson & Sheridan, 2014). These activities are limitless, from building a robot, focusing on principles of engineering, science, and design or to constructing simple moveable puppets, integrating principles of social studies, art, and engineering. Despite grounding in interdisciplinary progressive pedagogical practices, empirical research on Makerspace settings for educational practice is scant. Zhao (2012) encourages bringing the Maker Movement to schools as an alternative method of learning. Zhao (2012) notes “making” is product oriented, creative, and active; “making” is the antithesis of what schooling has been for students as “passive consumers and recipients of whatever adults give them: books, facilities, knowledge, tests, and disciplines” (Zhao, 2012, p. 209).

Despite Zhao’s (2012) outcry, educators question how making activities can relate to curricular requirements and standards based understandings (Voussoughi & Bevan, 2015). Bevan et al. (2015) remark, “the informal science field has been challenged to articulate the learning
that is possible or that has been realized through tinkering [making] programs” (p. 100).

Educators want to know, “What is learned here?” and “How does this learning translate to the disciplines and domains that we care about in K-12 education?” (Halverson & Sheridan, 2014, p. 501). In response to these questions and the dearth in research, Bevan et al. (2015) documented the learning outcomes of a museum-based “tinkering” program and subsequently created theoretically grounded tools that could support the work of Makerspace educators.

In a case study Bevan et al. (2015) documented the activity of youth participants framed by the Tinkering Learning Dimensions Framework, a tool that was previously developed by the lead author of the study. The Tinkering Learning Dimensions Framework (TLDF) was refined concurrently with the case study (Bevan et al., 2015). The Framework is organized around four learning dimensions: 1) Engagement; 2) Initiative and intentionality; 3) Social scaffolding; and 4) Development of understanding. Serendipitously, the TLDF aligns well with the Componential Theory of Creativity (Amabile, 1996). The learning indicated in each dimension can be described as a component referring to Amabile’s (1996) model: engagement refers to creativity relevant processes; initiative and intentionality regards the learner’s intrinsic task motivation; social scaffolding relates to the social environment; and development of understanding refers to domain relevant skills. Although the TLDF was developed to describe learning in the Makerspace, rather than creativity development, making the connection is valuable to the study of creative development and experience in a Makerspace setting.

During the investigation Bevan et al. (2015) found participants manifested the four learning dimensions. For evidence of engagement, learners spent time tinkering in activities, played, explored, and tried things over and over. The learners also remained after they finished one activity to start something new (Bevan et al., 2015, p.104). These engagement dispositions
reflect creativity-relevant skills, such as openness to experience, tolerance for ambiguity, risk
taking, and enjoying the process more than the completion of a product (Amabile, 1996).
Participants showed initiative and intentionality by persisting in the face of frustration and
showing confidence when disagreeing with each other, thus demonstrating moments of intrinsic
task motivation (Bevan et al., 2015, p. 104). Additionally, participants sought feedback from
facilitators and the environment, and when stuck, attempted to model innovative approaches as
demonstrated by facilitators. In this way, participants responded to appropriate extrinsic
motivation. The participants used the social environment to ask for help, for inspiration for new
ideas, to connect and collaborate with other workers, and to use tools that were readily available
(Bevan et al., 2015, p. 105). The Makerspace provided a safe environment for risk taking and
failure. This unthreatening climate mirrors Amabile’s (1996) suggestions for organizations or
classroom settings that want to foster creativity. Finally, the participants showed their
understanding of content or attainment of domain-relevant skills. The learners showed this
through their explanations, connecting to prior knowledge as well as indicating new knowledge.
They strove to understand through questioning, and expressed excitement when completing a
project and/or coming to realization (Bevan et al., 2015, p. 105). The confluence of the learning
dimensions shows that the Makerspace is capable of developing a student’s creativity.

Another case study by Voussoughi (2015) investigated the activities of students in an
after school Tinkering program serving minority youth. The program is designed to engage
students in designing and building a variety of projects through a workshop model curriculum.
Projects are STEM related and have an added artistic dimension. In the research, Voussoughi
(2015) presents a few anecdotal interactions of students engaging in the practice of “making.”
Voussoughi’s (2015) observations recorded student participants practiced learning dispositions
highlighted in the TLDF that included: “orientations towards iteration, drafts, and mistakes; increasing curiosity about the process through which artifacts and machines are made; the appropriation of tinkering practices across activities/settings; growing confidence in problem solving, tool-use and scientific language; and new forms of collaboration” (p. 46). These thought processes and actions display characteristics closely related to creativity relevant skills. Although the mission of this program was not focused on developing creativity, participants practiced critical thinking routines that encourage creativity.

**Makerspace precautions.** Although the Makerspace experience is exciting and compelling, offering unique innovative opportunities for students, Voussoughi and Bevan (2015) present some precautions and recommendations. First, the authors caution focusing too narrowly on STEM objectives, and recommend opening the Makerspace to artistic pursuits, not just as hidden STEM projects, but arts for art’s sake. Second, it is important to create a balance between sophisticated and everyday tools. This will ensure engagement of participants with different levels of knowledge and comfort using tools. Blikstein (2013) argues that sophisticated fabrication (for example with 3D printers) allows learners to focus on the aesthetics and refinement of their product versus struggling with raw materials (for example cardboard and tape). Voussoughi and Bevan (2015) take the opposing view and believe using low-tech materials aids in deepening student understanding of resources and sets up the chance to grapple and practice creating several iterations of the product.

Further, Voussoughi and Bevan (2015) note a suggestive trend to separate the Makerspace from the education field. Promoting the entrepreneurial, creative spirit, Makerspace advocates are concerned by the education sector’s encroachment, a system that often constricts, requiring evaluations of success or failures (Halverson & Sheridan, 2014). Additionally,
Makerspace advocates insist on calling educators of the Makerspace “facilitators.” This is an indication that the adult is a guide, co-constructing with the learner. Voussoughi and Bevan (2015) understand this inclination, but are cautious of Makerspaces devaluing education words such as “teacher” and “pedagogy,” this may “shortchange the many generative aspects of pedagogical talk and interaction and forego opportunities to share valuable knowledge with other educators” (p. 37).

Finally, the authors discuss problems and tensions with equity. The “maker” or “hacker” stereotype is a white, middle class, male and the Making world is shaped by “white male nerd dominance” (Halverson and Sheridan, 2014, p. 497). Voussoughi and Bevan (2015) point out “phrases like ‘self-directed’ and ‘independent’ learning, or ‘celebrating failure’ are common in the literature on making …we worry that they are out of touch with the realities of schooling for students of color and can easily lend themselves to deficit frames” (p. 497). This is a powerful statement reminding this research, a study of multi-cultural students experiencing a Makerspace for the first time, to address connections between learning dispositions and identity complexities.

**Makerspace for learning in schools.** The Makerspace learning environment shows the promise of an exemplar model for fostering creativity in students. Makerspaces engage children in a process where content knowledge is learned in concert with the development of creativity-relevant skills. Through experimentation and tinkering, students build confidence and intrinsic motivation. The social environment promotes a safe environment where new ideas and risk taking is welcomed. In this way, the Makerspace addresses Amabile’s (1996) Componential Theory of Creativity, a framework for developing creativity. While advocates of the trending Makerspace enthusiastically celebrate these innovative practices, Voussoughi and Bevan (2014) offer cautionary advice. Voussoughi and Bevan (2014) suggest researchers should address
questions of concerned educators asking, what exactly is learned here? Further, Makerspaces must insist on offering an equitable opportunity for making for all children. Consideration of the individual’s identity, background, and experience can compel a more meaningful experience.

**Creativity and Identity**

“...all around from far away across the world” – Max wants to be where someone loves him

Culture has a remarkable influence on individual creativity and research shows creative expression is distinct among societies (Lubart & Sternberg, 1998; Niu & Sternberg, 2001, 2003; Rudowicz, 2003). As creativity conceptual frameworks overwhelmingly invoke the affect of the social environment (Amabile, 1996, 2012; Csikzentmihalyi, 1996), investigation of creativity related to cultural identity is certainly warranted. The notion is especially significant for this research setting that is uniquely situated in an international school (SYIS) in China where the population consists of 45% Korean students, 25% U.S. American students, 11% Chinese students, and the remaining 19% from countries around the world. Creativity research concerning this specific diverse population justifies, in fact begs, investigation of the relationship of cultural identity and creativity. As Rudowicz (2003) posits, cross-cultural investigations on creativity allow for “more meaningful interpretations of creativity, as it helps to unravel the effects of tradition, values, and the philosophy on creative expression” (p. 286). Establishing this understanding will help inform existing creativity beliefs and experiences of student participants.

**East-West conceptualizations of creativity.** Globalization has blurred once distinguishable lines between Eastern and Western culture, thus the comparison of creativity among these societies must be qualified with a sense of generalization and caution. Mindful of this caveat, the West is generally perceived as the culture of Europe and the nations with heavy European influence including the United States, Canada, Australia, New Zealand and countries
of South America (Weiner, 2000). The East pertains to nations of the Asian continent that were once tributaries of Imperial China and that also share the tradition of Confucian philosophy, inclusive of Japan, Korea, Singapore, all of Mainland China, Taiwan, and Hong Kong.

For this research, the West distinction will primarily speak of the American (United States) culture. Americans, as well as citizens of other countries, frequently maintain that American society is more open to innovation and creativity than others (Weiner, 2000). Historically, American values of newness, innovation, change, and a future oriented perspective have been widely recognized and celebrated. This perspective began in seventeenth-century Europe when America constituted the “New World,” a place of “infinite” opportunities (Weiner, 2000, p. 125). The perception continues to this date, even as education policy makers and academics worry about creative stagnation seizing the nation (Zhao, 2012).

In contrast, the East, specifically Asian societies have different notions of creativity. Grounded in Confucian ideals of authority and respect for traditions, creativity is welcomed within the scope of “goodness” and in the spirit of “collectiveness” (Rudowicz, 2003). Creative individuals in a traditional Eastern society must adhere to the social-cultural system rather than break from it to come up with a “new” idea, thus creativity does not contradict “conformity” (Rudowicz, 2003, p. 276). Eastern creativity takes the form of “adaptation” in contrast to Western creativity that is defined by “novelty.”

Where the West, specifically American, society is defined as an “independent” society, and the East as “collectivist” society, creativity-relevant processes are also distinct. Creative-relevant processes such as divergent thinking, tolerance of ambiguity, risk-taking, independence, and openness to new experiences adhere closely to American values (Weiner, 2000; Kim, 2005). In contrast, Confucian ideals –particularly obedience, conformity, and a “work-play” dichotomy-
actually work to suppress creativity-relevant processes (Kim, 2005). Kim (2005) explains further, “Asian parents socialize their children to be psychologically dependent on the in-group and to avoid conflict, where Western parents socialize their children to be independent and to have a positive outlook on conflict” (Kim, 2005, p. 341). These conceptions reflect empirical studies on cross-cultural ideas and expressions on creativity (e.g. Niu & Sternberg, 2001; Wang & Greenwood, 2013; Lim & Plucker, 2001).

A study by Wang and Greenwood (2013) applied the Four C Model of Creativity to determine how Chinese students’ perception of their own creativity compared to their perceptions of Western students’ creativity. The authors surveyed 100 Chinese students and interviewed 10 students with open-ended questions based on the Four C distinctions of the creative person. The Four C distinctions were categorized by questions that spanned the little-C category (e.g. “the ability of a Chinese student or Western student to come up with novel answers”) to the pro-C category (e.g. “the ability to come up with a small invention or write a minor thesis”). The results showed consistently that Chinese students rated their Western counterparts as “more creative” than they perceived themselves. In the open-ended portion of the study, Chinese students perceived their own lack of creativity was largely the consequence of the Chinese educational system (Wang & Greenwood, 2013, p. 638).

In an empirical study by Niu and Stenberg (2001), the researchers designed an experiment to compare the creativity performance between American and Chinese college students. The rationale behind this comprehensive study of cultural influences on creativity raised several questions. Niu and Stenberg (2001) reasoned studying creativity in the social context is important: first, cross cultural studies enrich the knowledge about the nature of creativity, especially in the social context; second, cultural values can influence creativity; and
finally studies examining cultural effects on people’s creative potential have been inconsistent in their results, thus encouraging further investigation in this area (p. 230). These motivations led the researchers to conduct several variations of the experiment.

Chinese college students and American college students were asked to participate in two artistic activities. The participants were asked to make a collage using colorful stickers in a variety of shapes. The instruction was to arrange the stickers to depict an emotion of choice: happy, sad, angry, and frightened. The second task involved drawing an extraterrestrial alien. Nine American judges and nine Chinese judges scored the artworks. Overall, judges consistently rated American participants’ creativity and aesthetics as more pleasing and more creative than their Chinese counterparts, even as judged by both American and Chinese judges. Niu and Sternberg (2001) found a significant effect of instruction and feedback on Chinese creativity. Chinese students’ creativity improved when the instructors asked participants to “be creative” and the creativity improvement increased when instructors modeled creative behaviors, such as ripping the sticker to create a different shape. Niu and Sternberg (2003) revisited this experimental design and investigated Chinese high school students’ creativity to understand the effects of instruction and modeling. The students performed better under specific instruction to “be creative” and even better when they were told how to be creative.

Drawing from these studies, Niu and Sternberg (2001/2003) offer complex responses to complicated questions. Why did Chinese students display lower levels of creativity? The authors suggest three possible explanations. First, Americans can be expected to be more creative because Americans derive from an independent culture, based on individual freedoms and expressions of individuality, while Chinese culture encourages conformity (p. 111). Chinese participants tended to respond better (improve creativity) to constraints, such as instruction and
by receiving modeled expectations. Second, the lack of creativity in Chinese students may be due to Chinese pedagogical practices- a school system that “predominantly emphasizes the learning of basic knowledge and analytical skills” where the American school system values self-orientation and self-expression (p. 111). Third, educational testing systems impact both cultures priorities in learning, yet in China, the national test performance plays a more vital role in dictating which students succeed. The importance of studying and passing national exams in China leaves little room for cultivating creativity. Thus, the value of “being creative” is not as robust as the American drive for creative endeavor.

Understanding exactly how creativity is valued in East Asian societies merits investigation. Woong and Plucker (2001) surveyed Korean adults perceptions of creativity in the individual. The researchers claim studying implicit theories, or personal constructions, can reflect cultural values; in this case how the Korean culture perceives creativity. The study compared results to previous research on implicit theories on creativity with regards to American and Chinese respondents finding comparable results (Chan & Chang, 1999; Rudowicz & Yue, 2000; Runco, 1993, as cited in Woong & Plucker, 2001). Koreans believed cognitive factors of “industrious and resourcefulness” resonated with American implicit theories on the creative ability. Yet, Koreans assigned negative social behaviors, such as independence and deviance, to the creative individual. This factor aligned with Chinese cultural contexts and implicit beliefs on creativity. Woong and Plucker (2001) found Koreans perceived creative people as “nonconformists” indicating a negative viewpoint in a culture that values social responsibility and conformity. The researchers (Woong & Plucker, 2001) suggest this result is a “potential (and serious) barrier to creativity in this culture” (p.127).
Eastern and Western conceptualizations of creativity. An exploration of Eastern and Western traditions of cultural perceptions of creativity is important for a study engaging a multicultural group of participants. The review understood the perception of creativity in an individualist (Western) society is remarkably different from a collectivist (Eastern) society. Further, these two societies may engage in different thinking processes while pursuing creative endeavors. Finally, the environment can either foster or stifle the creativity of individuals, thus providing an environment to encourage creativity must be cognizant of individual identity.

With the merging of education interests between the East and West, the value of creativity in education is currently changing globally among societies. Education systems have reformed policy agendas to include creative development as a significant curricular activity. Yet, there is a considerable bridge to cross from mandates to implicit theories. Thus, an understanding of cross-cultural creativity in the classroom is of significant value for policy makers to classroom teachers.

Summary

At the end of Where the Wild Things Are (Sendak, 1963) Max, decidedly returns to his room and settles in for supper and sleep. Max leaves his imaginative adventure because he craves his place, to be where “someone loved him best of all,” perhaps because as Weiner (2000) suggests, “cultural identity and social stability require continuity” (p. 12). Yet, Max’s mischief shows that, at the same time “curiosity, imagination, and enthusiasm drive us to invent, explore, and express ourselves in ever new ways” (Weiner, 2000, p. 12).

This tension between creativity and tradition has been explored in the literature review supporting an investigation of multi-cultural students experiencing a Makerspace classroom intended to foster creativity. Traditional models of schooling and alternative learning
environments conflict over the question of pedagogy and curriculum. Traditional, collectivist societies and future-oriented, individualist societies conflict over perspectives on the creative individual. Weiner (2000) explains, “Tradition and creativity are in perpetual conflict- one represents a commitment to the past; the other a push towards the future” (p. 12). Yet, this tension does not argue the value of creativity. Creativity and innovation is good for society. In fact, now more than ever, creativity is perceived as one of the most important resources for the 21st century (Florida, 2004).

The mystery of creativity has persistently captured the human imagination. In ancient times the ability to innovate, be it of artistic sentiment or scientific invention, was a gift from the gods; later creativity was related to extraordinary talent or genius. Today, creativity inspires the same kind of mystical allure, even as experts across disciplines try to deconstruct the origins of the creative process, in hopes of a more complete understanding. The literature review has presented investigations adding to the body of research regarding creativity. The evidence indicates various nuances the creativity construct inspires, and can point to what creativity is for the classroom context.

In the classroom, creativity can be developed in a student at the mini-C and Little-C classroom level (Beghetto, 2010). The classroom creative product can be understood as novel, effective, and whole (NEW) (Henriksen et al., 2014; Mishra & Koehler, 2008) and students can engage in the process of making and constructing to hone creativity skills (Davies et al., 2013). The spirit of creativity in these young individuals can be more concretely considered as The Componential Theory of Creativity (Amabile, 1996), a synergy of domain relevant knowledge, creativity relevant processes, and intrinsic motivation working within an influential social environment. In fact, the social environment can have a profound effect, beyond the present,
physical space. It has been shown that cross-cultural creativity notions, regarding perspectives and values grounded in tradition, impact processes involved in creative expression. These distinct understandings of creativity can assist educators in capturing and developing creativity within every student, a critical skill for the 21st century learner.
Chapter III: Methodology

This research study investigated the development of creativity in a diverse, multi-cultural group of students attending a Makerspace classroom in an international school in China. Mindful of creativity as a complex phenomenon, a qualitative research exploratory case study was the most appropriate methodology for this investigation. The specific case study was defined as a multi-cultural group of adolescent students participating in 6-week in-school Makerspace class, at an international school in China. The study employed a qualitative exploratory case study design to “build a complex, holistic picture” while collecting and analyzing “words, reports, and detailed views of the informants in the natural setting” (Creswell, 2013, p. 21). The exploratory case study also explored how traditional academic objectives were achieved during this Makerspace course.

This research study embraced the constructivist paradigm where the researcher assumes that reality is an interpretation of what is observed. As the researcher remained as objective as possible, the researcher’s background and perspective could not be separated from the data collection, analysis, and reporting (Creswell, 2003). As Patton (2002) artfully writes, “[Constructivists] offer perspective and encourage dialogue among perspectives rather than aiming at singular truth and linear prediction” (p. 267). Keeping the constructivist perspective in mind, the researcher objectively and intellectually collected a variety of data from several sources to allow triangulation of data and a pattern of meanings to emerge (Creswell, 2003).

Research Questions

1. How does a Makerspace curriculum, activities, and classroom environment foster creativity in a class of culturally diverse adolescent students?
2. How does a Makerspace curriculum, activities, and classroom environment support student learning of targeted academic subject matter objectives in a class of culturally diverse adolescent students?

The research inquiry was guided by three objectives. First, in this population of multi-cultural students, it was important to understand student perceptions of creativity, including self-reflection on creative ability and students past experiences with creativity. Student participants were individually interviewed before partaking in the Makerspace class. Interview questions were informed by the literature review regarding creativity in the classroom context, cross-cultural creativity, and the Componential Theory of Creativity (Amabile, 1996). Students were informally interviewed during the Makerspace program and participated in at least one formal individual interview during the course of the 6 weeks. Students participated in a final individual interview at the end of the Makerspace program.

The second objective was to examine how creativity can be fostered in a group of multi-cultural students through an in-school Makerspace classroom setting. This examination was informed by multiple sources of evidence including individual student interviews, anecdotal notes, observation notes guided by the Tinkering Learning Dimensions Framework (Bevan et al., 2015), collection of student artifacts and final products using the NEW creativity rubric (Henriksen et al., 2015). The Makerspace teacher was interviewed regarding teaching for creativity in the classroom and curriculum, lesson plans, and activities were collected for analysis.

Third, the study determined how student traditional classroom performance objectives were achieved while participating in the non-traditional Makerspace classroom. Traditional quizzes, student written responses, and grades were collected to determine student standards
achievement. The research inquiry also reviewed Makerspace curriculum, lesson plans, activities, and assessments.

**Rationale for Qualitative Case Study Research Design**

The rationale for a qualitative case study was informed by the research questions, theoretical framework, and literature review. Specifically, the research employed an exploratory case study approach. Exploratory case study was used to describe the real-life happenings of the Makerspace class that were too complex for survey or experimental strategies (Yin, 2014). This investigation explored the creative development in the individual and how the Makerspace environment and experience may have contributed to students’ creative development. Cognizant of these complex variables, the case study method facilitated investigation of a complicated phenomenon using a variety of data sources (Yin, 2014). While investigating the case of the Makerspace class, ten students were highlighted for closer examination on the experience. Data collected from these highlighted students added to the evidence, spotlighting personal experiences and outcomes. Baxter and Jack (2008) explain multiple sets of data “ensures that the issue is not explored through one lens, but rather a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood” (p. 544). Another advantage of this approach was the collaboration between the researcher and the participant, where the researcher engaged the participant in telling his or her “story” (Baxter & Jack, 2008). As Hocevar (1981) suggests, “A useful way to measure creativity is to simply ask the subject. This is not a profound position, but yet the procedure is rarely used” (p. 459).

The exploratory case study was bound by time, place, and activity (Creswell, 2003; Yin, 2014). The research was conducted during a 6-week period where the 5th grade students at SYIS participated in the Makerspace classroom. The students explored three interdisciplinary units.
(Unit 1: Social Studies- Maps and European Geography; Unit 2: Science- Forces and Motion; Unit 3: Science: Simple Machines-Independent Makers project) using the Makerspace as a classroom. Students were expected to meet classroom objectives as measured by traditional unit assessments while participating in project-based experiences that were intended to develop student creativity.

**Case study propositions.** The study addressed three propositions developed from the literature review and shaped by the Componential Model of Creativity (Amabile, 1996). Creativity self-efficacy beliefs, creativity values, creativity-relevant processes, task-motivation and the influence of the social environment are necessary components for creative development. This study proposed that students would express different levels of creativity as evidenced in their individual interviews, activity, and products. From the literature, it was assumed that Western educated (North American, European, and/or Latin American) students would display more creativity (in self-efficacy beliefs, task motivation and creativity relevant processes) than their East Asian educated (Korean or Chinese) counterparts (Kim, 2005; Lim & Plucker, 2001; Niu & Sternberg, 2001, 2003).

The second proposition hypothesized all students would increase their creativity by participating in the Makerspace class. In the Componential Theory of Creativity, the Makerspace can be viewed as the fourth component, the “social environment.” Amabile (2012) posits the social environment as an additional influence on creativity. Further, non-traditional learning spaces and learning environments that teach for creativity have been shown to develop creativity (Davies et al., 2013; Amabile, 1996). In this study, the environmental context included the physical classroom space, the curriculum, the teacher’s instruction, and the collaboration among peers.
Finally, the case study proposed students in the Makerspace would also achieve classroom expectations as measured by traditional quiz and test scores. According to Amabile (1996) students need to be versed in content knowledge to have the capacity to express creatively within that specific domain. Schacter et al. (2006) found students of teachers who taught with creativity objectives also raised academic achievement scores. Davies et al. (2013) found similar results. Yet, Voussoughi and Bevan (2015) did not find concrete evidence that creative learning spaces, specifically Makerspaces, could increase student achievement scores.

To reiterate, the following propositions focused the case study and guided the direction of the data collection and discussion (Yin, 2014):

1. Students will evidence different levels of creativity, with students of Western education experiences and backgrounds evidencing greater creativity in comparison to students of Eastern education experiences and backgrounds.
2. Students of the Makerspace classroom will increase student creativity self-efficacy and creative ability.
3. Students of the Makerspace class will achieve traditional grade level standards and performance outcomes expectations by way of their creative activity.

Research Context and Participants

Shenyang International School of China (SYIS) is an international school located in Northeastern China. SYIS is the larger of two established international schools in Shenyang, China, a second tier Chinese city of 8 million people. SYIS’s mission statement is as follows, “SYIS exists to provide a United States college preparatory education, which includes educational learning opportunities integrating faith and learning, for students in Foundations (3 year-old) to grade 12 who are foreign passport holders living in this city.” SYIS provides an
American curriculum based on Common Core standards and is accredited by the Western Association of Schools and Colleges (WASC). The total student population as of October 15th, 2015 was 241 students. At that time, the overall population was 45% Korean, 25% American (U.S.A.), 10% ethnically Chinese with foreign passport, and 20% from other countries worldwide. The school had 48 full time teaching faculty, mainly from the United States.

The SYIS academic program followed a traditional curriculum that was informed by Common Core standards for Language Arts and Math, Next Generation Science Standards (NGSS) for science, and by textbook resources from American publishing companies. The school day was arranged by fifty-minute periods, where each block of time was dedicated to one specific core subject. Administrators and staff were concerned with this conventional model and understood the need to revise and expand the program to meet 21st century learning objectives. It was within this context administrators opened up the opportunity to create and pilot a Makerspace K-12 program. This research study took place during the Makerspace’s pilot semester, over 6 weeks from April 2016- June 2016.

**Makerspace teachers.** During the course of the study, Mr. Stewart was a first-year middle school science teacher, and the lead developer of the Makerspace classroom. It was Mr. Stewart’s first year in China, having recently graduated with a Master’s of Science in Career and Technical Education at a Midwest state university in the United States. Mr. Stewart was 27 years old at the time and described himself as a “big-idea,” “open to risk taking” individual. During the school year in which the research study took place, Mr. Stewart created an elective “Problem Solving” class where students tackled real-world problems, trying to find solutions through project based learning activities. In all his classes, Mr. Stewart used his talents as a highly competent maker in woodworking, robotics, and electronics. Mr. Stewart enjoyed
teaching these skills to his students. Although Mr. Stewart was enthusiastic about his teaching, he was concerned with the structure and management of his class and mentioned he would have liked to improve his pedagogical practice.

During the investigation, the researcher of this study was a special education consultant at SYIS. As a research-participant, the researcher developed the Makerspace program with Mr. Stewart. Mr. Stewart and the researcher worked together to arrange the physical space; find materials, resources, and equipment appropriate for making and learning; and to develop a pilot curriculum for a 6-week program. Mr. Stewart and the researcher, while collecting data, co-taught the pilot program.

**Student participants.** The 5th grade class consisted of 18 students (7 Korean, 4 Chinese, 4 American, 2 Latin American, and 1 German). Ten student participants were purposefully selected for individual interviews and spotlighted observations. Students were purposefully selected to represent the multi-cultural diversity of the school population. Previous educative experiences were specifically considered, from students who had attended East Asian models of schooling to students solely taught in American schools to students who had attended non-traditional education models such as Waldorf and Homeschooling.

**Recruitment.** Participation in the study was voluntary. Dr. Young, the director of SYIS indicated enthusiastic support for the Makerspace program and regarded the research as a pilot study that could inform staff members at SYIS. Dr. Young offered to assist in recruitment of participants by allowing the researcher to participate in an informal, voluntary parent meeting to discuss the Makerspace, the research study, and implications. Further, letters specifying details regarding participation in the research study were sent home in three languages, English,
Chinese, and Korean. The researcher offered an incentive (an ice-cream Sunday party) to the classes for returning signed consent or dissent letters regarding participation in the study.

**Data Collection and Procedures**

According to Yin (2014) a case study should be considered when the research question asks “how” and “why” questions. The first research question sought to understand “how” creativity develops in the individual in a non-traditional Makerspace classroom environment. The second research question asked “how” accountability measures (standards and performance outcomes) were achieved within this learning environment. Yin (2014) posits a case study is necessary when the environment or contextual conditions play a significant role in influencing the phenomenon in question. In this study, the non-traditional classroom environment was a serious consideration for the development of creativity within the participants. Further, it was unknown whether such an environment would encourage or inhibit achievement of traditional grade-level standards (Voussoughi & Bevan, 2014).

At the end of April 2016, the 5th grade class participated in a 6-week Makerspace pilot program. The researcher engaged in the role of research-participant, acting as a co-teacher with Mr. Stewart, the lead Makerspace teacher. The Makerspace class occurred daily (Monday-Friday) for a 90-minute period. The researcher conducted individual student and teacher interviews, made observations and recorded field notes, collected teacher artifacts, and catalogued student artifacts. To develop an in-depth understanding of the phenomenon, how creativity is developed over time, multiple sources of data collection were needed (Yin, 2014). The data collected was as follows:
**Table 1**

*List of Data Collected for Analysis*

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Data Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>Interviews</td>
<td>Transcribed Pre-Interview, Middle point Interview, Final Interview</td>
</tr>
<tr>
<td>Artifacts</td>
<td></td>
<td>Design Journal, Work plans, sketches</td>
</tr>
<tr>
<td>Regular classroom work/</td>
<td></td>
<td>Quizzes, Reflection paragraphs</td>
</tr>
<tr>
<td>Makerspace Classwork</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Product (s)- Group project,</td>
<td></td>
<td>Pictures, Graded on NEW rubric</td>
</tr>
<tr>
<td>Partner project, Independent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photographs</td>
<td></td>
<td>Pictures of students working</td>
</tr>
<tr>
<td>Teacher</td>
<td>Interview</td>
<td>Pre –interview, post interview</td>
</tr>
<tr>
<td>Peer reviewers</td>
<td>Observations</td>
<td>Support of Creativity in a Learning Environment tool</td>
</tr>
<tr>
<td>Teacher Lesson Plans</td>
<td>Understanding by Design unit</td>
<td>UbD template</td>
</tr>
<tr>
<td></td>
<td>plan</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Daily lessons</td>
<td>Journal, worksheets, pictures of white board, classroom</td>
</tr>
<tr>
<td></td>
<td>Assessments</td>
<td>Quizzes</td>
</tr>
<tr>
<td>Researcher</td>
<td>Field Notes/observations</td>
<td>Researcher journal, field notes and jottings, Tinkering Learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dimension Framework observation tool</td>
</tr>
<tr>
<td></td>
<td>Reflections</td>
<td>Analytic Memo</td>
</tr>
</tbody>
</table>

*Classroom observations.* As a participant-observer, the researcher used direct observation to collect data with the guidance of the Tinkering Learning Dimensions Framework (Bevan et al., 2015). The TLDF observation tool (see Appendix A) was used to account for student behaviors in the Makerspace classroom. Specifically, the observation tool looked for behaviors of *Student Engagement, Student Initiative and Intentionality, Developing Understanding, and Use of the Social Environment.* The instrument will be described further in the next session. After each session, using a checklist per student, the researcher marked an X for
evidence of the behavior, an 0 for lack of evidence for the behavior, an A if the student was removed from the room, and an n/a for an absence (see Appendix B for example).

In addition, field notes were written to collect observation data. According to Emerson, Fretz, and Shaw (1995), field notes are, “Accounts describing experiences and observations the researcher has made while participating in an intense and involved manner” (p. 3). The researcher jotted notes on a post-it note pad as reminders and evidence of what was observed (Emerson, Fretz, & Shaw, 1995). The post-it notes were then organized into the researcher’s field journal. Photographs and audio recordings of Makerspace participants and activities were also collected and catalogued. The photographs were uploaded into the researcher’s laptop and organized by date. Combining visual images with complementary qualitative methodology helps researchers give a richer description of the study context, and in turn gain a deeper understanding of the phenomena (Kingsley, 2009). Audio recordings were uploaded into the researcher’s laptop and organized by date. These audio recordings were later transcribed into Word documents. The researcher transcribed these short interviews (approximately 7 minutes to 20 minutes).

**Artifacts.** To understand the Makerspace curriculum and activities, teacher documents such as lesson plans, class work sheets, and rubrics were collected. Hard copies of the lessons were put in a folder and soft copies were uploaded into the researcher’s laptop. Photographs of the teacher giving a lesson and working alongside students were taken. Further, the classroom instructional space, such as the Whiteboard was photographed. These multiple sources of data were collected to understand the Makerspace curriculum holistically. Further, student classwork, quizzes and unit tests were collected as documents showing student achievement of targeted objectives (see Appendix C-E for example). Each student’s design journal and final projects
were collected and evaluated. The researcher took pictures of student entries and final projects and uploaded the images into her laptop, cataloguing them by date. Final projects were evaluated with the NEW rubric (see Appendix F for example). Multiple sources of data collected from the environment assisted in developing the narrative in the analysis (Yin, 2014).

**Interviews.** In-depth interviews provided a better understanding of observed behavior. Seidman (2013) states, “At the root of in-depth interviewing is an interest in understanding the lived experience of other people and the meaning they make of that experience” (p. 9). Thus, on arranged dates and times, in-depth interviews were conducted with each of the spotlighted students (n=10). Each targeted student received the same individual interview protocol during the 6-week research period (see Appendix G). The students were asked to participate in a preliminary interview, a mid-program interview, and a post interview. To account for the developmental age of the sample population and to respect the student’s class schedule, short 10-20 minute interviews were scheduled. Each interview began with pleasantries to establish rapport with the student. After the greeting, the researcher used a semi-structured interview method guided by the interview protocol. Semi-structured questions are focused while allowing for open-ended responses.

Multiple sittings for interviews were necessary to uncover development in creativity over the bounded time period in the Makerspace class. The researcher conducted a preliminary interview with individual students (spotlighted students n=10), before the Makerspace experience. This interview session’s aim was to establish a student’s current beliefs on creativity and self-perceptions as a creative individual. Subsequently, a mid-program interview with the same individual students was conducted to monitor progress in creativity development, take note of any student concerns, as well as address achievement of traditional academic objectives. The
researcher recorded these students’ comments during the Makerspace activity as well. At the end of the 6-week period, the researcher conducted a final comprehensive individual interview. In this way, interviews allowed observed behavior to be put in context providing access to understanding each individual’s action (Seidman, 2013, p. 10). The researcher audio recorded the student interviews, using an I-phone, at the permission of the participant. Audio recordings were uploaded into the researcher’s laptop and were catalogued by student and data. Audio recordings were subsequently transcribed into a Word document by the researcher. Data from these interviews collected and the analysis were performed at two-levels: within each individual and across individuals (Yin, 2014). The individual interview protocol and questions will be described in more detail below.

**Instruments**

A case study requires in-depth data collection from multiple sources of information within the bounded system (Yin, 2014). Documents, archival records, interviews, direct observations, participant-observation, and physical artifacts are diverse data types that can be used collectively to triangulate evidence (Yin, 2014). Several instruments were used to collect data:

1. The individual interview protocol (Appendix G; Appendix H)
2. The Tinkering Learning Dimensions Framework (Bevan et al., 2014) (Appendix A)
3. Support of Creativity in a Learning Environment (Richardson, 2016) (Appendix I)
4. The NEW Rubric (Novel, Effective, Whole) Creativity evaluation tool (Henriksen et al., 2015) (Appendix F)

**Interview protocol.** The interview protocol (Appendix G) was developed for this specific research study as a guide for the interview process. The interview questions were written to
elaborate on the theoretical framework guiding this study, the Componential Theory of Creativity and to address the research questions and propositions. The interview questions covered issues related to creativity and background education experiences, self-reflections on creative ability and preferred personal creative processes, learning and creative development in the Makerspace environment, and learning and creativity in the traditional classroom context. Understanding creativity as a system of creativity relevant processes (creativity), domain relevant skills (knowledge and expertise), intrinsic motivation, and the social environment (identity, school experiences, culture), questions were directed towards these four factors. For example, the question: “Do you think you are a creative person?” was asked to understand whether the student has confidence in one’s own creative ability, a creativity relevant thought process; while Do you get good grades? Asked whether or not the student had expertise or was knowledgeable about many things, showing domain relevant skills. Three sets of interview questions were developed for this prolonged case study interview, extending over a period of time, covering multiple sittings (Yin, 2003).

To improve the quality of the interview questions and to clarify personal biases and unwarranted prompting, Creswell (2003) suggests the interviewer should answer the question as if responding as an interview participant; consider the questions from multiple viewpoints; and to have the questions reviewed by outside sources. To this end, the interviewer/researcher responded to the questions, asked for feedback from colleagues on wording of questions, and revised the questions as needed.

**Tinkering Learning Dimensions Framework.** Since a case study takes place in a real-world setting, the opportunity for direct observations exist (Yin, 2014). Considerable interest in the environment’s influence on creative development was reflected in the research question: How
does a Makerspace provide an opportunity for students to explore and pursue creative activity? Further, the proposition Students of the Makerspace class will increase creativity self-efficacy and creative ability demanded observation of the Makerspace classroom experience and student activity. The Tinkering Learning Dimensions Framework (Bevan et al., 2015) guided observations of participants’ activity in the Makerspace classroom. The framework describes key attributes of learning attributed to the Makerspace setting (Bevan et al., 2015). The current framework is a refinement of earlier drafts developed by Petrich, Wilkonson, and Bevan (2013) in collaboration with 28 after school STEM expert-practitioners. The earlier drafts were developed over a two-year period, informed by investigation of 14 after school Makerspace programs. The current version is not empirically validated for reliability, yet educators seeking to understand and articulate behaviors in the Makerspace context use the framework to observe, check, and evaluate (Bevan et al., 2015). Since the framework also contributes to emerging theories related to learning through making (Bevan et al., 2015), the instrument was useful for this research study.

The Tinkering Learning Dimensions Framework (TLDF) establishes four learning dimensions to observe for students working in the Makerspace. For this research, the Tinkering Learning Dimensions Framework was cross-referenced with the Amabile’s (1996) Componential Theory of Creativity:

1. Engagement/ Creativity Relevant Processes
2. Initiative and Intentionality/Intrinsic Motivation
3. Social Scaffolding/ Social Environment
4. Development of Understanding/ Domain Relevant Skills
The researcher used the framework as a guide during Makerspace classroom observations, checking for indications of each learning dimension/each component of creativity. Indicators evidenced each learning dimension/component of creativity (see Appendix B), for example:

1. Engagement/ Creativity Relevant Processes: i.e. “Spends time tinkering”
2. Initiative and Intentionality/Intrinsic Motivation: i.e. “Set’s one’s own goals”
3. Social Scaffolding/ Social Environment: i.e. “Inspiring new ideas through environment”

The researcher made a TLDF checklist for each student participant (see Appendix B for sample). During observations and/or immediately after each Makerspace classroom session, the researcher marked the TLDF checklist for evidence (marked X) or lack of evidence (marked 0). Each student participant received a rating daily. When a student was absent the check box was marked with an “n/a;” if the student was removed from the class for misbehaviors, the box was marked with an “A.” This TLDF log served as a record of student behaviors over the course of the program. The log assisted in triangulating data of anecdotal observations and field notes composed by the researcher.

**Support of Creativity in a Learning Environment (SCALE).** The SCALE (Richardson, 2016) is a classroom observation tool that is used to assess the ways in which a learning environment supports student creativity through three facets: Learner Engagement; the Physical Environment; and the Learning Climate (see Appendix I). The observation tool is short and informal and is non-evaluative in nature. The SCALE primarily serves as a reflective tool and point of discussion for teachers seeking to establish a creative learning environment.
The tool was used while observing video footage of a Makerspace class period from Unit 3. Four observers were asked to complete the observation tool separately. The researcher, Mr. Stewart, the 5th grade classroom teacher, and Dr. Young, the head director, all completed the survey independently. These raters were chosen because of their intimate experience with the Makerspace program and the students at SYIS. The survey results were then uploaded into the researcher’s laptop for analysis. Discussion of the results also helped participating observers reflect on the Makerspace program.

**NEW rubric.** The NEW Rubric (Henrickson et al., 2015) was adapted by the researcher for student work, establishes guidelines on assessing creative products (see Appendix F). The rubric was developed through an extensive literature review and search on creativity measures with the purposes of giving practitioners a useful tool to measure creativity in the classroom. Although the rubric is nascent, it has valuable implications for classroom use. A creative product is defined as NEW because it demonstrates novelty (e.g. surprising), effectiveness (e.g. appropriateness), and wholeness (e.g. aesthetically pleasing). The rubric gives qualitative definitions at each score point giving the scorer some anchors and exemplars to arrive at an estimated range of creativity value of a final product. The researcher, at the permission of Dr. Mishra, adapted the NEW rubric and its indications for scoring of a student product. The NEW rubric was used with student participants as a self-critique reflective scoring tool. The researcher and the student scored the final product on the NEW rubric together, not as an evaluative tool but as a reflection on creative successes and needs for improvement. The rubric was used as a teaching tool as well, to teach students a descriptive common language for creative expression.
Data Analysis

The propositions for this case study, the Componential Theory of Creativity framework, and information gleaned from the literature review served as the reflective backdrop of this the qualitative data analysis. Yin (2014) explains, “Data analysis consists of examining, categorizing, tabulating, or otherwise recombining the evidence to address the initial propositions of a study.” Yin (2014) describes five techniques for analysis: pattern matching, linking data to propositions, explanation building, time-series analysis, logic models, and cross-case synthesis. Explanation building and pattern matching were used to analyze data. Further, a constant comparison analysis was used to compare interview data to observed data to artifacts. A collection of artifacts, including design journals and final products were analyzed alongside over four hundred photographs of activity in the Makerspace. The Constant Comparison Analysis method is an iterative process, where “incidents or data are compared to other incidents or data” (Fram, 2013). The method is most often used in grounded theory, but has been used outside grounded theory as a technique to compare data (Anfara & Brown, 2001; Fram, 2013).

Explanation-building. Explanation-building is an iterative process where the proposition is revisited and refined through pattern matching (Tellis, 1997). Explanation-building attempts “to explain a phenomenon by stipulating a presumed set of causal links.” In this case data collected was linked to considered propositions (Yin, 2014). This was a significant process because the practice led to a focused analysis. Additionally, the process allowed for exploration of rival propositions in an attempt to provide alternate explanations. Further, “when engaging in this iterative process the confidence in the findings is increased as the number of propositions and rival propositions are addressed and accepted or rejected” (Baxter & Jack, 2008, p. 555). Observation data, documents, and physical artifacts were organized according to
the components of creativity as recognized in Amabile’s (1996) Componential Theory of Creativity and patterns were related to these factors.

For example, in preliminary interviews some students iterated their lack of creativity confidence. Some students were observed hesitant in starting their projects during Unit 1. Students of East Asian schooling were observed to be the most hesitant. Matching the observed behavior, with interview responses, and linking this to the proposition based on the literature review, helped confirm a finding. A rival theory, for example, ‘hesitation due to a misunderstanding of the instruction’ was explored. This rival theory was rejected after checking student’s design journal for indication of understanding of the objectives.

**Coding.** Individual interviews with participants were audio recorded and transcribed. The researcher transcribed each interview into a readable Word document. The language of the interviews was coded to decipher any emerging patterns, as coding affords the “meticulous attention to language and deep reflection on the emergent patterns and meanings of human experience” (Saldaña, 2009, p. 10). Saldaña (2009) outlines coding methods into First Cycle and Second Cycle. The first cycle of coding captured ideas based on the interview question and language of the participant. Structural coding identified a content-based or conceptual phrase representing the topic of inquiry (Saldaña, 2009, p. 66). The interview protocol was categorized into topics of inquiry. Using structural coding, interview responses were coded within the topic of the question. For example, all students were asked to describe their background education history. This topic was labeled as “the previous social environment,” and responses were coded representing that topic of inquiry (i.e. South east Asian school, American curriculum, Waldorf).

Another iteration of the first cycle of coding analyzed interview responses using In Vivo coding. In Vivo coding uses the language of the participant. This method was particularly
useful when analyzing the voices of a diverse group of youth, as it “deepens the understanding of their cultures and worldview” (Saldaña, 2009, p. 74). Pattern coding further reduced codes into a smaller set of units. This set was used to identify themes among the codes to begin the Second Cycle of coding. The Second Cycle of coding analyzes how “everything fits together” (Saldaña, 2009, p. 150). Pattern coding identified or rejected major themes from the data and was related to propositions. For example, many students reiterated the “fun” they had working in the Makerspace. In vivo terms such as “enjoy,” “feel great,” “super fun,” were coded under the theme of engagement.

**Constant comparative analysis.** A constant comparison analysis was used to relate coded data among participants to documents and artifacts. Using constant comparison analysis, the data was compared within categories and between categories (Anfara & Brown, 2001). This technique was used to compare language within an interview, across interviews with students in the same group (i.e. high, average, low creativity), and across interviews with students in different groups. Coded interviews were then compared to data from document analysis. For example, students with low creativity self-efficacy responses were coded with “I don’t have any ideas” or students with high creativity self-efficacy were coded “I have many ideas;” the students’ design journals depicting ideation were compared to these responses. Further, observed behavior was compared to artifacts and coded interviews. Findings were confirmed using constant comparison analysis of data.

**Artifacts and document analysis.** Collected artifacts and documents were analyzed to gain a deeper understanding of the Makerspace experience. Bowen (2009) posits document analysis can support research by 1) Providing data on the context of the case study; 2) Eliciting new questions to consider; 3) Providing supplementary research data; 4) Providing a means of
tracking change over time; and 5) Verifying findings and corroborate evidence. Teacher documents, such as unit plans and lesson activities provided data on the context of the case study. These documents were analyzed and compared to emerging themes. For example, students began to speak of creativity processes in their interviews such as “try and try again,” this was compared to the unit plan’s creativity objective “perseverance.” Student artifacts, such as their final products were related to observation data and provided a means of tracking change over time.

**Visual ethnography.** Over four hundred classroom photographs of students and teachers working in the Makerspace were taken, catalogued, and analyzed. Kingsley (2009) argues combining visual methodology with other qualitative research methods enhances a study by giving the reader a sense of time and space and by reminding the researcher “aspects of the study that might otherwise slip away” (p. 535). The photographs were organized in several permutations; for example, photographs of highlighted students were organized by time and photographs of students working on emerging themes, such as ideation/brainstorming. The organized photographs were then compared to all other forms of collected data. Kingsley (2009) explains, “Combining visual methodology with complementary qualitative research methods enables researchers to gain a deeper understanding of complex phenomena” (p. 545).

**Validity and Credibility**

Reliability and validity imply the trustworthiness and credibility of a research study. Creswell (2012) describes eight different verification techniques for qualitative research and suggests that any researcher should engage at least two of these techniques: 1) prolonged engagement or persistent observation 2) triangulation 3) peer-review or debriefing 4) negative case analysis 5) clarification of researcher bias 6) member checks 7) rich thick description and 8)
external audits. Yin (2014) adds using multiple sources of evidence to ensure construct validity. For this research study, prolonged engagement and persistent observation, triangulation of multiple sources of data, peer-review and debriefing, member checks, and rich thick description supported validity and credibility.

The researcher participant engaged in a “prolonged engagement and persistent observation” of the Makerspace experience and students participants. The research study began before the intervention of the Makerspace with individual interviews of the participants. Observations and collection of classroom data (i.e. photographs, recorded student conversations) occurred on a daily basis. Informal in-situ interviews informed daily activities and formal individual interviews were scheduled at a midpoint of the six-week period. The research study ended with a completion of a full 6-week program and a final formal individual interview. This daily involvement in the research study added to an in-depth understanding of the process.
Prolonged engagement in the full course program is a more valuable and reliable distinction of observation versus snapshot documentation of activities and lessons.

“Triangulation” of multiple data sources assisted in establishing credibility of results and findings. This investigation collected data in multiple formats, and the data was analyzed using a constant comparative technique. Triangulation of data assisted in confirming emerging patterns and themes identified (Creswell, 2003).

“Peer review and debriefing” adds an auditor to the research study, who assists the researcher through validation procedures, constructive criticism, and feedback. In this study, Dr. Chris Unger, the researcher’s graduate advisor, who has a specific interest in progressive, innovative pedagogy, was an invaluable asset since the inception of this research inquiry. With a critical eye, Dr. Unger focused this research study to a more credible line of inquiry. Mr.
Stewart, the Makerspace co-teacher and a research study participant, added a practitioner perspective to the theoretical underpinnings of this research study. Further, Dr. Young, SYIS’ head director, and the 5th grade regular classroom teacher, participated in an informal observation using the SCALE instrument.

Mr. Stewart was asked to review the findings and discussion section of the research study. Mr. Stewart’s feedback, as Makerspace co-teacher and research participant, provided a check on Makerspace happenings and events. Mr. Stewart confirmed the report was an authentic description of the 6-week Makerspace program.

The research study incorporated “rich, thick, description” to provide a comprehensive understanding of the phenomena observed (Yin, 2014). Rich, thick description was informed by the collection of multiple sources of data, collected using a variety of methods. The research study was designed to include a broad description of the phenomenon of creativity among the 5th grade class while presenting an in-depth look at highlighted individual students.

**Protection of Human Subjects**

The researcher completed an IRB application for the Human Subjects Review Board at Northeastern University seeking permission for this research project. The IRB application included a brief description of the research objectives, the nature of the participants, the research methodology, the researcher’s qualifications to do research, the risks and benefits involved in the research, and the methods of informed consent collection from potential participants.

Several issues arise when conducting a study within a K-12 education setting. The student participants were viewed as a “vulnerable” population. Due to their age they may not have been fully aware of the implications of participating in a study (Fraenkel, Wallen, & Hyun, 2012). Thus, informed consent from parents was necessary for participation in a study.
(Fraenkel, Wallen, & Hyun, 2012). To ensure confidentiality, the names of the student participants and teacher participant were changed to an appropriate alias.

**Summary**

The investigation of creativity in a Makerspace among a multi-cultural, diverse group of presented a myriad of complications. First, creativity is an elusive construct, making it difficult to observe or quantify. Second, cross-cultural studies are uniquely sensitive and subjective. Third, the Makerspace classroom is an organic, new space, pushing the limits of the traditional classroom. Yet, this complexity was mitigated by a rigorous methodology procedure, guided by an established theoretical framework and informed by the literature review, where multiple sources of data informed the phenomenon to be studied.
Chapter IV: Presentation of Findings

By way of a qualitative research methodology, the findings of this case study are informed by the collection of data gathered during the 6-week Makerspace program. The research questions guiding the data collection and analysis were as follows:

1. How does a Makerspace curriculum, activities, and classroom environment foster creativity in a class of culturally diverse adolescent students?

2. How does a Makerspace curriculum, activities, and classroom environment support student learning of targeted academic subject matter objectives in a class of culturally diverse adolescent students?“

Several different forms of data were collected and analyzed to answer these two questions. The data was collected from the Makerspace students, teacher, and the researcher’s observations including: 1) Individual interviews with participants; 2) Student artifacts (including traditional worksheets, design journals, sketches); 3) Student assessments (traditional quizzes, tests, essays, and final product); 4) Audio recordings and photographs of students working in the Makerspace; 5. Teacher artifacts (including unit plans, lesson plans, notes); and 6) Researcher’s observations, peer rated observations, and field notes.

The students’ individual voices recorded through interviews, observations, photographs, and their work tell a genuine story of the Makerspace learning experience. Throughout the reporting of the data, direct quoting is used to give readers the opportunity to make their own judgments and interpretations regarding this study’s findings. Further, photographs of the Makerspace environment, student participants, and student artifacts give the reader a sense of the place and time.
This results section is divided into four sections. The first section revisits the study context and introduces the teachers and student participants. The second section presents the findings in relationship to the first research question on the Makerspace experience and the development of creativity in individual students. The third section presents findings in relationship to the second research question on the Makerspace experience and student achievement of academic objectives. Finally, a summary will provide a synthesis of the data from across all data points.

It is important to note, that I, as researcher participant used an objective lens challenging beliefs and biases by referring to the case study protocol and by offering rival theories to the case study propositions (Yin, 2014). The case study propositions are stated as such and are referred to in the reporting of the data:

1. Students will evidence different levels of creativity, with students of Western education experiences and backgrounds evidencing greater creativity in comparison to students of Eastern education experiences and backgrounds.
2. Students of the Makerspace class will increase their creativity self-efficacy and creative ability.
3. Students of the Makerspace class will achieve traditional grade level standards and performance outcomes expectations by way of their creative activity in the Makerspace curriculum and space.

**Study Context**

Shenyang International School (SYIS) follows a traditional model of K-12 American schooling. The lead classroom teachers are all American and teach using a U.S. Common Core standards based curriculum. The classrooms are organized by grade level, and the structure of
the day is arranged by blocks of time dedicated to core subjects. SYIS’s 5th grade class was chosen to participate in the Makerspace pilot program, the context of this study. This selection was based on 100% parental consent to participate and because the 5th grade class (see Figure 2) is representative of the school wide demographics with 39% Korean students, 22% Chinese students, 28% American students, and 11% from other nations (5th grade students n=18; 7 Korean students, 4 Chinese students, 4 American students, 2 Latin American students, and 1 German student). There are 8 females and 10 males.

![Figure 2](image.png)

*Figure 2. The 5th grade class. From traditional classroom to Makerspace classroom.*

The student participants engaged in a 6-week K-12 Makerspace pilot program. The program was designed to foster creativity while meeting traditional academic standards. To do this an interdisciplinary Makerspace curriculum, inclusive of creativity objectives, was
developed (see Table 2). The curriculum was informed by SYIS content knowledge objectives, Next Generation Science Standards, and Common Core standards. The Makerspace physical space and curriculum was designed, developed, and implemented by two Makerspace teachers, one being the researcher.

Table 2

*Makerspace Units of Study*

<table>
<thead>
<tr>
<th>Unit</th>
<th># of days</th>
<th>Topic of Study</th>
<th>Creativity Objectives</th>
<th>Assessment/Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Me as a Maker</td>
<td>1 day</td>
<td>Makerspace</td>
<td>Maker identity</td>
<td>Self-portrait as Maker</td>
</tr>
<tr>
<td>Information Maps: Europe</td>
<td>8 days</td>
<td>SYIS World Geography; Electrical Circuits</td>
<td>Design thinking routines; Ideation techniques; Perseverance, Novel, Effective Whole (NEW)</td>
<td>Map of geographic region; Europe test</td>
</tr>
<tr>
<td>(Group project)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Great Mousetrap Car</td>
<td>10 days</td>
<td>Forces and Motion; Themes in literature (Survival)</td>
<td>Tolerance of ambiguity; Risk taking; Ideation techniques; Novel, Effective, Whole</td>
<td>Mousetrap car; Newton’s Laws of Motion science lab work; Forces and Motion test</td>
</tr>
<tr>
<td>escape (Partner project)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Express yourself:</td>
<td>6 days</td>
<td>Automata and DIY</td>
<td>Divergent thinking; Transfer of ideas; Persuasion</td>
<td>Independent project; Persuasive Essay</td>
</tr>
<tr>
<td>(Independent Project)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Makerspace teachers. Mr. Stewart described himself as a “Maker” and a “Tinkerer.” He grew up making things with his father, a professional carpenter. As a first year middle school science teacher, Mr. Stewart recently graduated with a Masters in Career and Technical Education, a degree often used for teaching shop at the high school level. Mr. Stewart has a background in woodworking, electronics, robotics, and construction. He also has experience working in a university level Makerspace located in the school of engineering at Pittsburgh State University in Pittsburgh, Kansas. Mr. Stewart explained this space is a cross-
disciplinary space where students from the education department interact with students from the engineering department. The university level Makerspace is intended to teach engineer students and teachers of the sciences how to use fabrication tools. This experience gave Mr. Stewart the inspiration to create a K-12 Makerspace at SYIS.

In discussion of the Makerspace at SYIS, Mr. Stewart envisioned a space where teachers could plan for STEAM (Science, Technology, Engineering, Art, and Math) activities to enrich the current curriculum. Further, he saw the Makerspace as a space where students could practice 21st century skills: creativity, collaboration, critical thinking, and communication. Mr. Stewart noted uncertainty on the program’s structure for the K-12 level, but as creative people demonstrate, he was tolerant of this ambiguity. Mr. Stewart demonstrated several characteristics of a creative individual; he was open to taking risks and described himself as a big idea person. “I have a lot of ideas, sometimes it overwhelms people. I’m always full ideas…it’s about being able to be sensitive to [classroom] teachers who have never done this before” he explained in response to challenges he might face in recruiting teachers to participate in the program. “I enjoy that kind of tinkering for getting things to work, and I don’t enjoy the step by step lesson planning, and that’s the difference with me and a lot of teachers,” Mr. Stewart explained he enjoys the openness and the experimental nature of activities the Makerspace allows for learning and instruction.

The researcher participant, myself, known to students as “Mrs. MaryAnn,” also identified herself as a “creative” teacher. A Special Education teacher with 18 years experience teaching and leading schools, I have always taught using arts-integrated, project-based interdisciplinary lessons. I have knowledge and practice with progressive education philosophies and pedagogy. With a research interest in creativity and learning, the Makerspace pilot program was a perfect
context for study. Unpacking my biases for the research study, I planned objectively with Mr. Stewart to develop and implement the program while collecting data for the case study.

Data collected from the Makerspace teacher interviews and conversations indicates both teachers identify as creative individuals. Patterns regarding tolerance of ambiguity and “chaos” in the classroom; pushing limits to defy traditional teaching methods; taking risks; demonstrating perseverance and reflection; and appreciating the importance of teaching for creativity and critical thinking, were common themes in our discussions.

**Student participants.** The 5th grade class consisted of 18 students. Of these 18 students, all agreed to participate in the research study and were given parental consent to participate as well. While all students participating in the Makerspace class were included in classroom observations, the collection of anecdotal evidence, and collection of class artifacts, only ten students (see Table 3) were identified for individual in-depth interviews. These ten students were purposefully selected to be representative of the general make-up of the international school population, a group of students from diverse cultural backgrounds with vast differences in their schooling experiences until enrollment at SYIS.
Table 3

Students Participating in In-depth Individual Interviews

<table>
<thead>
<tr>
<th>Name/Gender</th>
<th>Age</th>
<th>Grade</th>
<th>Nationality</th>
<th>Years in international school with American Curriculum</th>
<th>Years in alternative schooling</th>
<th>Years in East Asian schooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie (F)</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chris (M)</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Chaoxiang (M)</td>
<td>10</td>
<td>5th</td>
<td>China</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Ellen (F)</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Jason (M)</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Jin-Hai (M)</td>
<td>11</td>
<td>5th</td>
<td>China</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Myunghee (F)</td>
<td>11</td>
<td>5th</td>
<td>S. Korea</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Nathan (M)</td>
<td>10</td>
<td>5th</td>
<td>Germany</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Sang-Ook (M)</td>
<td>11</td>
<td>5th</td>
<td>S. Korea</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Song-Yun (F)</td>
<td>11</td>
<td>5th</td>
<td>S. Korea</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

The literature demonstrates the social environment greatly influences creative development (Amabile, 1996; Davies et al., 2013) thus grouping students by their diverse education experiences provided an organizational structure for the case study narrative (see Table 4 for groupings). Further, coding of initial student interviews demonstrated these units of social organization shared similar ideas regarding beliefs and values of creativity. Saldaña (2009) informs the coding of units of social organization with “similar cognitive aspects” to determine topics for study is a legitimate strategy. Yet Saldaña reminds the researcher “the understanding of human experience is a matter of chronologies, more than of causes and effects” (Stake, 1995 as cited in Saldaña, 2009, p.15). Accordingly, as these students (see Figure 3) chronicled their stories and reflections of the Makerspace experience their paths began to diverge and cross into diverse units of social organization. Student participant descriptions and their comments are written in present tense to give the reader a concise representation.
Table 4

Student Participant Groupings: Schooling Experiences and Creativity Self-efficacy

<table>
<thead>
<tr>
<th>Name</th>
<th>Majority of Schooling Experience</th>
<th>Preliminary Interview on Creativity Self-efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chris</td>
<td>Homeschooling in the U.S.A</td>
<td>High</td>
</tr>
<tr>
<td>Nathan</td>
<td>Waldorf schooling in Germany</td>
<td>High</td>
</tr>
<tr>
<td>Annie</td>
<td>SYIS</td>
<td>Average</td>
</tr>
<tr>
<td>Ellen</td>
<td>SYIS</td>
<td>Average</td>
</tr>
<tr>
<td>Jason</td>
<td>SYIS</td>
<td>Average</td>
</tr>
<tr>
<td>Song-Yun</td>
<td>South Korean</td>
<td>Low</td>
</tr>
<tr>
<td>Myunghee</td>
<td>South Korean</td>
<td>Low</td>
</tr>
<tr>
<td>Sang-Ook</td>
<td>SYIS</td>
<td>Low</td>
</tr>
<tr>
<td>Chaoxiang</td>
<td>Chinese International School (English section)</td>
<td>Low</td>
</tr>
<tr>
<td>Jin Hai</td>
<td>Chinese</td>
<td>Low</td>
</tr>
</tbody>
</table>

Figure 3. The highlighted students participating in individual interviews

Students with traditional American schooling experience. The traditional American school education is similar to the SYIS model, where students follow United States standards and learning is focused on core content areas. Recent literature reviews this type of learning as a
creativity- stifling environment with a focus on standardized assessments (Robinson, 2015; Hennessey & Amabile, 2010; Berliner, 2009).

Ellen. Ellen is 11 years old. She is a U.S. citizen and identifies as Korean American. She has attended SYIS her whole life. Ellen enjoys school and gets good grades. She is a voracious reader and in her spare time, including recess, she is seen reading an above grade level novel. In her preliminary interview Ellen does not perceive herself as a “creative person.” When asked, “Do you think you are a creative person?” Ellen hesitates, “Well…well sometimes I’m creative.” Ellen pauses thoughtfully, “If I had enough time I might be creative, but it takes me a long time to think of ideas and then [by the time I have an idea] we just move on to the next activity.” Ellen can point to a time she was creative, where she had a lot of time to write a fantasy story. Interestingly, Ellen, without a prompt or question on gender differences interjected “I think boys [are creative], they just get it and they start.”

Jason. Jason is 11 years old. He is Mexican–American and has been at SYIS for two years. He is diagnosed with ADHD (Attention Deficit Hyperactivity Disorder) and receives Special Education services. He has a difficult time paying attention in class, is easily frustrated and aggressive. He has trouble completing his classwork and needs to be constantly redirected. In Jason’s preliminary interview, Jason said he feels creative but didn’t feel like he could be creative in class. He said he feels most creative when he is playing Minecraft, “Like I want to build this and I want to build that…it’s a game that is meant to expand creativity, in Minecraft the limit is your imagination.”

Annie. Annie is 11 years old and is Romanian-American. She has been at SYIS her entire school career and has always received good grades in all subjects except for math. She believes she can be creative when she is composing her own stories. She usually writes on her
own, outside of class assignments. Annie explains, “I do think I’m creative, but only in like specific things, like writing and stuff, but painting and drawing, I’m as creative as a lot of dirt.” Annie is an avid reader and she says she gets her ideas from the stories she reads, “I read quite a lot, so I’m like, ‘Hey this looks like a good idea! I could use this in one of my stories’.” Annie discusses getting inspiration from her readings and adapting ideas to make new, creative stories.

When coding this group’s ideas on creativity, all shared the thought that creativity meant inventing new ideas or expanding on existing ideas. They also thought being creative was important. However, they discussed expressing creativity outside the realm of school. Jason feels creative when he is playing Minecraft, Annie is creative when she writes her stories during her own personal time, and Ellen thinks she could be creative but school doesn’t give her enough time to think of her own ideas. For the purpose of this study, this group is rated of “average” creativity self-efficacy.

Students with alternative schooling experience. Alternative, or non-traditional schools espouse an education philosophy where the curriculum is student centered, students engage in their own choice learning experiences, and learn at their own pace. Evidence in the literature suggests these types of learning environments foster creativity (Davies et al., 2013).

Nathan. Nathan is 11 years old. He is from Germany, yet speaks English fluently. He has lived in Shenyang for two years. Nathan is boisterous and his teachers indicate he is disruptive in class. Nathan has poor handwriting “because they didn’t teach me in Waldorf” and has below average grades in all subjects except P.E. Nathan attended a Waldorf school before moving to Shenyang. Waldorf schooling is recognized as an alternative learning environment, where the focus is on the creative development of the individual and play is emphasized. Nathan
explains, “So, I first was in Waldorf School in Germany, where you can be creative, and you do a lot of stuff.” He goes on to tell about one project,

At my old school in Waldorf, we had to make a robot that is the size of our size, so that we can actually go in like a suit and we could use everything [different materials]. I made it so I could shoot paintball guns out of my arms, it looked [silly] but it was kind of my way, so I liked it.

When asked if he sees himself as creative, Nathan enthusiastically claims, “Yes, I am [creative], and I am a very active person.” With confidence he reiterates later on in the interview, “I think I’m very creative and everyone in my old school thought so too, and my parents told me I should stay creative.” He doesn’t feel he can be creative in school now so after school he goes on the Internet and watches YouTube for instruction on how to make things. About his education at SYIS, Noah says,

Some teachers think if you do a lot of paper worksheets, then you get smarter, but I think if you let the kid gets a little bit of freedom, like make more projects, then I think they can learn better and have more fun learning.

Chris. Chris is 11 years old. He is from the United States and has been at SYIS for two years. Chris is an average student with difficulty in math and spelling. Before coming to SYIS, Chris was homeschooled. Chris likes being homeschooled because “you can finish before lunch and then after lunch you can just play.” Chris often played games and went outside in the afternoon after completing his lessons. He likes homeschool for that reason, but likes being at the international school because he has friends. Chris thinks he is creative when he is in a “good mood.” He likes to make things like “little swords and stuff for my brothers…in America [after lunch] I used to make them out of wood.”
Both students from alternative schooling methods mention creativity as the ability to “make” their own inventions. Unlike the other students interviewed, Noah and Chris discuss experiences during their school day when they had opportunity to be creative through projects or play. For the purpose of this study, this group is rated with “high” creativity self-efficacy.

**Students with East Asian schooling experience.** Students in this group have received instruction in South Korean or Chinese school systems. These school systems are known as the Education Giants for their consistently rated top scores on the PISA assessments (Stewart, 2012; Zhao, 2012). The literature reports these types of school encourage rote learning and practice of skills, while stifling creativity (Niu & Sternberg, 2001, 2003).

**Song-Yun.** Song-Yun is 11 years old and is a highly motivated, exemplar student. This is her 2nd year at SYIS, previously she attended school in South Korea. She speaks English fluently. She consistently receives the highest marks in every school subject. Her after school tutoring schedule is rigorous, two to three hours each evening and Saturdays with subjects ranging from Chinese to Korean traditional instrument to English Writing. She explains the time commitment is extensive because she receives homework from each of the tutoring sessions. Song-Yun is humble regarding her achievements and schedule and quietly smiles.

During the interview, Song-Yun paints a picture of South Korean schooling, the differences between school in South Korea and SYIS, and her impressions. She explains that in South Korea the students sit two by two in rows, and face front. The teacher stands in the front and teaches.

First teacher tells you how to solve this problem, tells you the basic, but only a little bit like quick summary about the basic, even though we didn’t learn it, and then later she will just give hard problems, and then we would have to solve it… so you’ll have to study
a lot in your house, you have to go through a lot and then you come back, if you’re like 4th or 5th grade, you usually come back at 12 o’clock at night, from the tutor.

She calls the American school experience “fascinating”, “Because the [American] teachers go around [the classroom]. In Korean school, when I was there, the teachers and the students have really huge distance which was kind of far. But in America, teachers are like a friend!” Song-Yun giggles at the differences between the two schooling experiences. Although American teachers are “nice” and “friendly,” Song-Yun says the Korean teachers challenge students more, and the problems are harder “so you learn more, like deep into it.” In the American school the learning is “basic, basic, basic.” When asked if she could be creative in her Korean school, Song-Yun said, “No.” Being in an American school she was surprised, she thought, everybody was creative, but I don’t know anything that I can think of because I was in Korean school. Korean school is like, the teacher just gave you a topic and then the teacher say, do something like this, and then OK, then we’ll copy a little bit and then copy other partners, something like that. So everyone is the same.

After being in American school, Song-Yun believes she can be a “little bit creative.”

**Myunghee.** Myunghee has attended SYIS one year and was at an international school in Tianjin, China last year. Myunghee excels in 5th grade and receives straight A’s on her report card. Before that she attended Korean school and her description is similar to Song-Yun. Myunghee’s first remark is how the Korean school teacher stays in the front, “The teacher just stay in front and not walk around [like they do in American International school] in the classroom.” Students copy what the teacher writes on the board and students sit in rows by height order, the shortest in the front and the tallest in the back. Myunghee explains that is so everyone can see the board. When asked if she thinks she is creative, Myunghee responds, “Not
really.” Asked to elaborate, Myunghee explains, “I don’t have any ideas.” She explains further, if she receives a “creative” assignment, her strategy is to, “First, look at the other people’s example, and then take their ideas, and make it a little bit different, and then put it my project.”

**Jin Hai.** This is Jin Hai’s first year in international school. Previously he attended a private Chinese school. He has limited English and is designated as an ESL student at SYIS. Jin Hai does very well in math but has difficulty in his other coursework, his lessons are modified and his grades are designated at an ESL level. He chooses to be interviewed without a translator. When asked about his Chinese school, he laughs at the major difference between Chinese school and the international school, “Each 4th grade class has 40 students in it, and there are seven 4th grade classes.” The students sit in pairs and face the front where the teacher lectures.

A discussion on creativity is difficult because the concept is abstract. Jin Hai says “I don’t know if I am creative.” The word creative is translated to Chinese, “chuàngzuò de,” he understands the term, but still responds he doesn’t know if he is creative. The interview delves deeper into the concept; perhaps Jin Hai doesn’t fully understand what creative is. We look at two different sharpeners, one is a basic sharpener, and the other is a little bear with a hole in the mouth where the pencil goes in. To secure the pencil, the little bears ears need to be squeezed. The bear’s tail is the crank used to sharpen the pencil. Jin Hai decides the bear pencil sharpener is more creative because it “is different” and “cute.” Despite the elaborate discussion on creativity, what it is and what it is not, Jin Hai still responds he doesn’t know if he is creative.

**Chaoxiang.** Chaoxiang is Chinese and he is 10 years old. This is his third year at SYIS. Chaoxiang likes SYIS much better than the Chinese school because, “Here we have library and computer lab …” He also likes that there are less students in this school. When asked if he thinks of himself as a creative individual, Chaoxiang hesitates and says, “So-so.” I probe further
asking if he can remember a time when he was creative or did a creative project, but he can’t remember. He says sometimes he is not creative because, “I just sit here and I don’t know what to do.”

_Sang-Ook._ Sang-Ook has been at SYIS for three years and in Korean schools for two years. Sang-Ook likes the international school because he thinks it’s easy, “next year though, my mom is taking me back to Korea to go to Korea school because she doesn’t think we learn enough here.” When asked about his creativity, Sang-Ook is not confident in his creative ability and cannot say whether he is creative or not, “I don’t know if I’m creative.” When pointing out his language arts poster project he recently completed with comic book characters and humorous bubbles, Sang-Ook doesn’t think that is creative, “I just did what the teacher told me I had to do for the project.” Sang-Ook likes to “finish assignments quickly so then I can play.”

Students with East Asian schooling experience demonstrated the least confidence in their creativity. When asked if they were creative, these students responded, “a little bit” or “I don’t know,” or “not really.” When asked if they could remember a time when they had been creative, they were unable to give any examples. The students in this group reported the most difficult part of being creative was coming up with ideas. For the purpose of this study, this group is rated students with “low” creativity self-efficacy.

At the end of the preliminary interview, students were notified that they would spend some class time in the Makerspace. No students had heard of the Makerspace before, except for Nathan, who exclaimed, “That’s what my school [Waldorf] in Germany was.” All students reported excitement to try the new class.

**Summary of Study Context.** The Makerspace teachers and student participants voices and beliefs established a preliminary perspective of participants before entering the Makerspace.
Makerspace teachers demonstrated enthusiasm for an alternative learning environment that promotes creative thinking and learning. Student interviews evidenced that each individual participant held different beliefs on creativity self-efficacy. Students who had alternative schooling experiences believed affirmatively they were creative and gave examples of when they were creative in school. Students from an American schooling tradition thought they were creative at times, and pointed out they were creative outside normal school activities. Students from East Asian schooling traditions didn’t know if they were creative or didn’t think they were creative, lacking in ideas. Data collected from the preliminary interview is significant to indicate baseline ideas on creativity. The data also confirmed the first proposition, that students from Western education backgrounds would evidence greater creativity than students from East Asian backgrounds.

**Research Question 1: How does a Makerspace classroom environment, curriculum, and activities foster creativity in a class of culturally diverse adolescent students?**

The findings of this study show the Makerspace classroom curriculum, activities, and environment foster creativity in a class of culturally diverse adolescents students. As noted above, students initially identified with different levels of creative self-efficacy; students either demonstrated high confidence in creativity, average confidence in creativity, or low confidence in creativity. The findings show there was growth of creativity in all students by the end of participation in the Makerspace class. Findings related to classroom curriculum and activities, and environment is discussed as follows. Data collected from multiple sources, using multiple methods encouraged reliability and validity of findings. Further, reliability was assured using a constant comparison analysis while coding the data over several cycles (Saldaña, 2009; Anfara & Brown, 2001). Finally the study findings report was sent to Mr. Stewart for review and for
validation through member checking (Creswell, 2013). The findings for this research question will be discussed in two parts. Part 1 will report on the Makerspace curriculum and activities and Part 2 will report on the Makerspace environment. Student voices on aspects of curriculum, activities, and the environment will be interwoven throughout the reporting.

**Part 1: How does the Makerspace curriculum and activities foster creativity?** The Makerspace pilot curriculum was designed to be inter-disciplinary, student centered, with hands-on project based learning activities. The Makerspace units were written into the Understanding by Design (Wiggins and McTighe, 1998) template, following SYIS’s lesson planning guide (see Appendix J, K, L). However, the Makerspace curriculum incorporated two differences, the addition of intentional creativity objectives and the addition of cross-disciplinary standards. Three interdisciplinary units were planned using 5th grade SYIS curriculum and standards guide: Unit 1: World Geography: Europe; Unit 2: Forces and Motion: The Mousetrap Car; Unit 3: Express Yourself: Independent project.

As evidenced by the Tinkering Learning Dimension observation checklist, classroom observations, student voices, and student final products, findings suggest the curriculum and activities fostered creativity through

1. A “design thinking” lesson approach
2. Explicitly naming creativity behaviors

**Design thinking routines.** Each Makerspace unit was presented through a “Design Thinking” focus. Students were introduced to the concept of “Design Thinking” on the first day of the Makerspace program. Students understood, in the Makerspace, the expectation was to
approach a lesson differently. Mr. Stewart explained, “The grade is not that important; what is
important is if your design works.”

Over three units, students engaged in design thinking principles: 1. Define the problem;
design thinking process, each unit lesson opened with a “wicked problem” or a real-world
problem students had to solve by presenting a tangible, made product. Students were given the
task, a deadline, and the resources of the Makerspace to come up with a solution.

Ideation techniques. In the preliminary interviews, students reflecting on their creativity
said they had difficulty coming up with ideas, thus they did not view themselves as creative
individuals. The curriculum provided for ways to “come up with ideas” beyond the typical
brainstorming sessions. As evidenced by a constant comparison analysis of student voices,
classroom observations, the Tinkering Learning Dimensions Framework observation checklist,
and student artifacts, by the end of the three units, students were able to use strategies for
“coming up with ideas.”

The Tinkering Learning Dimension “Social Scaffolding” indicates how students may
generate ideas in the Makerspace: by requesting or offering help, through using the environment
or materials to inspire new ideas, and to physically connect to the work. Each period, students
received a check when observed engaging in the learning dimension or a 0 when not evidenced.
The data shows that over time students used these processes for generating an idea (see Table 5).
Table 5

*Percentage Of Time Student Indicated Social Scaffolding Learning Dimension Per Unit*

<table>
<thead>
<tr>
<th>Name</th>
<th>Pre-Interview</th>
<th>Social Scaffolding/Use of Social Environment (Indication: requests/offers help to problem solve; inspiring new ideas or approaches; physically connecting to the work)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creativity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 1</td>
</tr>
<tr>
<td>Chris</td>
<td>High</td>
<td>100%</td>
</tr>
<tr>
<td>Nathan</td>
<td>High</td>
<td>96%</td>
</tr>
<tr>
<td>Annie</td>
<td>Average</td>
<td>81%</td>
</tr>
<tr>
<td>Ellen</td>
<td>Average</td>
<td>81%</td>
</tr>
<tr>
<td>Jason</td>
<td>Average</td>
<td>44%</td>
</tr>
<tr>
<td>Song-Yun</td>
<td>Low</td>
<td>81%</td>
</tr>
<tr>
<td>Myunghee</td>
<td>Low</td>
<td>81%</td>
</tr>
<tr>
<td>Sang-Ook</td>
<td>Low</td>
<td>40%</td>
</tr>
<tr>
<td>Chaoxiang</td>
<td>Low</td>
<td>44%</td>
</tr>
<tr>
<td>Jin Hai</td>
<td>Low</td>
<td>28%</td>
</tr>
</tbody>
</table>

These processes were specifically taught to students through the Makerspace curriculum. The curriculum focused on the following techniques:

- C-sketching (Collaborative-sketching, a quiet brainstorming activity where students share ideas with each other and give feedback)
- A Looking Closely technique to explore complexity and find opportunity
- Through a cycle of tinkering and research (using the environment for inspiration)

For Unit 1, the curriculum performance task was to create an interactive map of Europe that gives an overview of the geography, culture, economy, history, and politics of Europe. To generate ideas, students engaged in a “Looking Closely” routine, where they looked at a variety of maps, from geographic to information maps, to pop up maps. The students explored the complexity of these maps, and found opportunity to think of a different way to create an information map. After looking and connecting with various maps, students engaged in C-
sketching to brainstorm ideas for their own information map (see Figure 4). C-sketching allowed students to request or offer help as indicated in the Tinkering Learning Dimensions Framework.

Figure 4. Students engaged in C-sketching

C-sketching encouraged the development of ideas in a safe environment. “When we C-sketch, we don’t have to worry if someone will laugh at the idea, because you don’t have to put your name on it,” Annie mentions. “It’s cool because you get to see what your friends are thinking about, and you can say, good idea! Or I was thinking the same thing!” Myunghee tells about the process. She adds, “I like that it is quiet too so everyone gets a chance [to express their idea].” Ellen was appreciative of the quiet time as well, and liked that she didn’t feel rushed to think of an idea. In her preliminary interview, Ellen had said she didn’t feel creative in class because she never had enough time to think of ideas.
Despite practice with the new ideation technique, student artifacts show that, during Unit 1 C-sketching there was a wide range of idea generation, some students had zero, one, or two ideas while several students had many ideas (see Figure 5). In student interviews, Chaoxiang (low creativity self-efficacy) and Chris (high creativity self-efficacy) mentioned they did not get ideas through brainstorming techniques, but they liked to think of ideas as Chris said, “Just getting right into the project and figuring it out.”

Figure 5. Variation in ideation during Unit 1

Spending time tinkering in the Makerspace classroom environment and with classroom materials increased ideation (see Figure 6, next page, for student preference to tinker for ideation). In student interviews just seeing the materials inspired ideas, “Here you see all the tools, you can use whatever you want and build what you think,” reported Nathan. Annie said, “Because I saw this thing and I was like ‘Armor!’ Yes! I’ll make that!” Jin Hai who didn’t know if he was creative and showed difficulty starting or coming up with ideas in Unit 1, in his final interview spoke of the availability of a wide variety of materials, “I think with the things I have, I just can make something new and I see what I can make.”
The activity of “Looking closely” also generated ideas. For Unit 2, students had to build a Mousetrap car. Students “looked closely” at examples of Mousetrap cars built by the Makerspace teacher and researched Mousetrap cars on the internet. They were asked to draw the cars they investigated in their journals, as they looked closely at the details and explored the complexity of the mechanics. Then they were asked to find opportunity in their drawings, and add new details to improve the car with fresh, creative ideas. Looking closely gave students a starting point to generate an idea. Sang-Ook was notorious in the classroom for saying, “I don’t have any ideas.” Using the Looking Closely routine, Sang-Ook said, “If I look at something, then it will give me an idea of what I can do.”
By Unit 3, all students were able to generate ideas for their independent projects. Students from Unit 1 who had trouble generating ideas were able to come up with several ideas for their final project. It was observed some students used brainstorming techniques, while others used looking closely and finding opportunity, still others tinkered. The Makerspace gave students flexibility to think of ideas using their own preferred strategy at their own pace. Learning how to generate ideas was an essential activity in the Makerspace curriculum that helped foster creativity. As evidenced below (Figure 7, 8), the partners used “looking closely” and “c-sketching” to brainstorm ideas for their Unit 2 final product, a mousetrap car.

*Figure 7. Looking closely to understand complexity and find opportunity*
In Design Thinking, the “wicked problem” is a real problem where the answer is unknown. The Makerspace curriculum introduced students to real problems and students were tasked to solve them. The “wicked problem” was proposed as a hook, challenging and motivating students to engage in the design process to solve the problem. It also forced students to “tolerate ambiguity,” a creativity skill, because as Mr. Stewart explained, “The answer is unknown, it hasn’t been invented yet.”

Data collected through the Tinkering Learning Dimensions Framework observed students increasing their engagement in solving the “wicked problem” over time. Students were observed daily for evidence of engagement that was indicated by 1) time spent tinkering and 2) for showing affect, emotion, and behaviors such as expressions of joy or disappointment. The data (see Table 6) shows students, mostly those who started with a “low-creativity” indication, had trouble engaging with the “wicked problem” during Unit 1.
### Table 6

<table>
<thead>
<tr>
<th>Name</th>
<th>Pre-Interview</th>
<th>Engagement/Creativity Relevant Skills (Indication: Spends time in Tinkering activities; Displays Motivation through Affect or Behaviors)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creativity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chris</td>
<td>High</td>
<td>Unit 1 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 83%</td>
</tr>
<tr>
<td>Nathan</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annie</td>
<td>Average</td>
<td>Unit 1 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
<tr>
<td>Ellen</td>
<td>Average</td>
<td>Unit 1 95%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 95%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
<tr>
<td>Jason</td>
<td>Average</td>
<td>Unit 1 39%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
<tr>
<td>Song-Yun</td>
<td>Low</td>
<td>Unit 1 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
<tr>
<td>Myunghee</td>
<td>Low</td>
<td>Unit 1 44%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
<tr>
<td>Sang-Ook</td>
<td>Low</td>
<td>Unit 1 67%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
<tr>
<td>Chaoxiang</td>
<td>Low</td>
<td>Unit 1 50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
<tr>
<td>Jin Hai</td>
<td>Low</td>
<td>Unit 1 44%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 2 65%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit 3 100%</td>
</tr>
</tbody>
</table>

Anecdotal observations confirm low engagement during Unit 1 from these same students. Chaoxiang and Jin Hai surfed the internet aimlessly, and when asked “What are you doing? Do you guys have a plan?” They replied, “We don’t know what to do.” Myunghee understood she needed to research facts on her geographic area of Europe, and conceded all making and tinkering tasks to her group members. She did not feel comfortable “tinkering.” The Makerspace teacher noted some students could not “tolerate ambiguity,” and thus redirected these students giving them extra support through revisiting the “wicked problem” and modeling possible solutions.

During Unit 2, most students were observed engaged in solving the Mousetrap car problem. I asked students why they felt engaged and motivated to keep going despite frustrations and students responded, “I want to solve the ‘wicked problem’”; “Because I think [my project] is going to look awesome;” “I want to make it work.” Students showed intrinsic motivation for engagement, no student mentioned extrinsic rewards for completing the project. I
probed even further, “Why is it that for example, in math, you quit very quickly if you don’t understand the problem, but in the Makerspace you don’t quit?” Annie responded, comparing a “wicked problem” to a classwork math problem,

It’s because I really like making things and getting my hands on like, I like to be able to use my hands and my brain, and just like, be able to make something to solve a problem while in Math we just write and we don’t make a lot of things to help with our learning, so I either lose attention or I just quit.

Comparing data from the Tinkering Learning Dimensions Framework with coding of student interviews and observations note a pattern of intrinsic motivation to solve the wicked problem. On several occasions, I was asked as I passed students in the hallway, “Can we go up to the Makerspace during recess? I need to finish my project.”

*Researching, prototyping, and testing.* Design thinking compels students to go through a process of research, ideating, prototyping, testing, choosing, implementing, and presenting. This process increased student creativity skills by giving students multiple opportunities to test and improve their product. During Unit 1, Sang-Ook attempted to make a model Ferrari to show that part of Italy’s economy is based on luxury goods. During one observation, Sang-Ook looks at his Ferrari and laughs because “It’s not good! I failed! It looks like a van!” The Makerspace teacher asked Sang-Ook, could he improve on it? Make it look better? Sang-Ook replied he doesn’t want to because “I just wasted 10 minutes building this thing.” The Makerspace teacher encouraged Sang-Ook to improve his prototype, to go through the process again. Sang-Ook hesitated but did as the Makerspace teacher suggested.

In a reflective interview on that moment, Sang-Ook talked about his Ferrari and how he failed. He realized he made it better because, not only did he make the car look more like a
Ferrari, he expanded on the original idea, and decided to cut a race track into the map, and have the Ferrari move. He says, “Yes” when asked if the final product was better. When asked if he learned anything during this unit about being creative, Sang-Ook responds, “I have made a new habit for try and try.” The research, prototype, and test process encouraged students to endure failure, to persevere, and to keep response options open, with the understanding that perhaps a better idea will come.

Data from the Tinkering Learning Dimensions Framework indicates students during the first unit had difficulty persisting (see Table 7). As students practiced the design thinking routine during the program, students were observed to show more initiative with each following unit. Initiative and persistence are both necessary for creative pursuits (Amabile, 1996)

Table 7

<table>
<thead>
<tr>
<th>Name</th>
<th>Pre-Interview Creativity Self-efficacy</th>
<th>Initiative and Intentionality/Intrinsic Motivation (Indication: Persisting, Taking risks, Goal setting, Responding to Feedback)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unit 1</td>
</tr>
<tr>
<td>Chris</td>
<td>High</td>
<td>97%</td>
</tr>
<tr>
<td>Nathan</td>
<td>High</td>
<td>97%</td>
</tr>
<tr>
<td>Annie</td>
<td>Average</td>
<td>100%</td>
</tr>
<tr>
<td>Ellen</td>
<td>Average</td>
<td>86%</td>
</tr>
<tr>
<td>Jason</td>
<td>Average</td>
<td>36%</td>
</tr>
<tr>
<td>Song-Yun</td>
<td>Low</td>
<td>89%</td>
</tr>
<tr>
<td>Myunghee</td>
<td>Low</td>
<td>75%</td>
</tr>
<tr>
<td>Sang-Ook</td>
<td>Low</td>
<td>39%</td>
</tr>
<tr>
<td>Chaoxiang</td>
<td>Low</td>
<td>44%</td>
</tr>
<tr>
<td>Jin Hai</td>
<td>Low</td>
<td>28%</td>
</tr>
</tbody>
</table>
Naming creativity skills. Unit lesson plans show evidence of creativity objectives were added to the curriculum to foster creativity skills. Students were introduced to a set of creativity skills at the start of a unit, and they completed activities to reiterate the objectives (see Figure 9). The Makerspace teachers were observed saying “Don’t be afraid to take risks;” “Try again, improve it;” “It’s ok if you’re not sure how it will come out, just try it.” The Makerspace teachers also modeled creativity skills while learning alongside students. Coding of student interviews showed students most often referred to three sets of creativity skills: Making something NEW; risk taking; and perseverance.

Figure 9. An introductory lesson activity showing creativity objectives.

Making something NEW. The NEW rubric evaluates products for creativity (see Appendix F). The “N” stands for novelty and uniqueness, the “E” stands for effectiveness and usefulness, and “W” stands for whole, where the final product is aesthetically pleasing, and
accepted by an audience. Students reflected on this rubric as they decided whether their final product met creativity objectives. They rated their products for critique, not for a grade. As students practiced with the NEW rubric, they indicated where their projects succeeded in being creative and where there was need for improvement. The feedback from the NEW rubric helped students improve their design’s novelty, usefulness, and attractiveness (see Figure 10).

![Mousetrap car](image)

**Figure 10.** Mousetrap cars rated on the NEW rubric

The NEW rubric scores were recorded as data points for consideration. Students looked for evidence of novelty and surprise on their product, effectiveness in the mechanics, and for aesthetic sensibility. It is noted students scored their products higher than their own creativity self-efficacy beliefs. Further, an average of students’ scores shows students, in general, created “average” to “high” creative final products (see Table 8). The scores also challenge the proposition that “Students will evidence different levels of creativity, with students of Western education experiences and backgrounds evidencing greater creativity in comparison to students
of Eastern education experiences and backgrounds.” By the end of the third unit, stark contrasts in creativity between groups were indistinguishable.

Table 8

*Student Final Product Creativity Scores on the NEW Rubric*

<table>
<thead>
<tr>
<th>Name/Gender</th>
<th>PRE-Self-report on Creativity beliefs</th>
<th>Unit 1 NEW rubric score on Map</th>
<th>Unit 2 NEW rubric score on Mousetrap Car</th>
<th>Unit 3 NEW rubric score on DIY project</th>
<th>Average of NEW rubric scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie (F)</td>
<td>Average</td>
<td>15</td>
<td>11</td>
<td>15</td>
<td>14 (High)</td>
</tr>
<tr>
<td>Chris (M)</td>
<td>High</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>12 (High)</td>
</tr>
<tr>
<td>Chaoxiang (M)</td>
<td>Low</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>11 (Average)</td>
</tr>
<tr>
<td>Ellen (F)</td>
<td>Average</td>
<td>15</td>
<td>9</td>
<td>13</td>
<td>12 (High)</td>
</tr>
<tr>
<td>Jason (M)</td>
<td>Average</td>
<td>6</td>
<td>14</td>
<td>15</td>
<td>12 (High)</td>
</tr>
<tr>
<td>Jin-Hai (M)</td>
<td>Low</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>7 (Average)</td>
</tr>
<tr>
<td>Myunghee (F)</td>
<td>Low</td>
<td>15</td>
<td>13</td>
<td>10</td>
<td>13 (High)</td>
</tr>
<tr>
<td>Nathan (M)</td>
<td>High</td>
<td>13</td>
<td>10</td>
<td>15</td>
<td>13 (High)</td>
</tr>
<tr>
<td>Sang-Ook (M)</td>
<td>Low</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>14 (High)</td>
</tr>
<tr>
<td>Song-Yun (F)</td>
<td>Low</td>
<td>15</td>
<td>9</td>
<td>15</td>
<td>13 (High)</td>
</tr>
</tbody>
</table>

*NEW rubric score 15-11 high creativity; 10-6 average creativity; 5-1 low creativity

*Risk taking.* Students had to engage in the practice of risk taking to reach curricular objectives. The presentation of the “wicked problem” task left students with a responsibility to figure out their own design and solution. Not knowing exactly which direction to go in forced students to experience risk and take chances in their process. The Makerspace teachers explicitly told the students, “You must take risks because you don’t know what is going to work and what is not going to work.”

Song-Yun discusses the element of risk taking in a most compelling way. I asked, “Of the creative strategies you’ve learned in the Makerspace, do you think you’ll use it in another classroom?” She responded, “Yeah, especially risk taking.” She explained further,
In other classes, there’s like 50 out of 50 chances to get 100. You can use one of the chances to like, “OK, I do this way and I don’t care” like this [like risk taking]. Then you might feel more confident than staying in a safe place because you did something different. The Makerspace is a place you’ll succeed and fail, when you succeed you feel great, and when you fail you are going to endure more, so no worries.

Ellen, who displayed lack of confidence in the preliminary interview, decidedly said she felt she could take risks in the Makerspace. “Now I think I can just do what I want, like I don’t need to be scared of anything and just try everything,” Ellen explained. Risk taking was not just a requirement for idea generation, but for physical act of making. Students needed to use power tools to create a final product that worked. Ellen, cautious at first, by the end of the Makerspace program was observed enjoying the use of powertools, “I love the drill! I am going to ask for one for Christmas!” She also said, “I didn’t know girls could use these tools. I thought boys only used them.” Ellen’s comments below are indicative of how her confidence in her creativity and willingness to take risks changed over the 6-week Makerspace program (see Table 9).
Ellen’s Development of Creativity Processes During the Makerspace Program

<table>
<thead>
<tr>
<th>Creativity Processes (Amabile, 1996)</th>
<th>Risk Taking</th>
<th>Persistence/ Trying again</th>
<th>Tolerance of Ambiguity</th>
<th>Confidence in one’s own creativity</th>
<th>Divergent thinking (Understand complexities and break from cognitive set)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellen’s comments from Preliminary Interview (1), to Mid-program interview (2) to Final interview (3)</td>
<td>1. None</td>
<td>1. “I don’t have enough time to be creative”</td>
<td>1. None</td>
<td>1. “I guess sometimes I feel creative, but other times I have no clue”</td>
<td>1. None</td>
</tr>
<tr>
<td></td>
<td>2. “The boys they get it and don’t care about being perfect, but the girls, they have to get it perfect or they get frustrated”</td>
<td>2. “I get frustrated”</td>
<td>2. “I think the boys could do more mechanical stuff, like engineering thing, because they think more than the girls”</td>
<td>2. “I agreed with the boy’s when nobody liked my idea”</td>
<td>2. “Other projects they look more different than ours”</td>
</tr>
<tr>
<td></td>
<td>3. “The most important thing for me was to take more risks, because before I was just trying to do everything well”</td>
<td>3. “I learned to try again and just try to think what’s new and try to make your own thing”</td>
<td>3. “I can just try everything”</td>
<td>3. “I think I can just do what I want, like I don’t need to be scared of anything”</td>
<td>3. “I think it’s just like being creative, be yourself and just be free”</td>
</tr>
</tbody>
</table>

**Perseverance.** During independent interviews, “Try and try again” was a common response to the question, “What do creative people do?” Nathan said, “They try and try, they redo, they solve the wicked problem, and they never give up.” Chris responded similarly, “They [creative people] try again when they failed and they research and they make things.” Chaoxiang explained a creative person, “Thinks, and try and try again...Also, [a creative person] could fail and try again.”

The Tinkering Learning Dimensions Framework shows evidence of “students persisting to achieve goals in the problem space” during the Makerspace program. Students’ initiative and intrinsic motivation was considerably low in Unit 1, by Unit 3 students were persisting through the problem (see Table 7, above). As interviews demonstrate, students could indicate the
importance of perseverance to solve the problem. By Unit 3, students were motivated to try and try again.

Jason, the student with ADHD had an interesting perspective on persistence however. During Unit 2’s Mousetrap car construction, Jason explained, “Only one try.” I inquired further, “Only one try? What happens if you don’t get it after the first try?” Jason responded, “Then it’s over.” Jason experienced a high level of frustration with Unit 1 and Unit 2 and trying to get his product to work. He often quit in frustration of not getting his product to work after the first try. Although creative process lauds perseverance, the Makerspace teachers modified the curriculum for Jason, so that he could feel more successful and less frustration. This was achieved by limiting materials and one-on-one assistance. By Unit 3, on an independent project of his own design, Jason was observed persevering and improving his product.

Product orientation. The Makerspace curriculum incorporated a performance assessment that was product oriented. Students had to produce a final, tangible product for assessment and acceptance by their teacher and peers. Students received critique and feedback on their work, and in rebuttal could persuade their audience to accept their product. In an interview with Mr. Stewart, I asked, “How do you know they’re learning?” and Mr. Stewart simply responded, “Well, if the end of the unit product or project works, then I know they learned the information and the process.”

The design must work. Students were assessed by the presentation of the final product within the constraints of the due date. By the due date, students felt pressed to complete their projects with confidence. Confidence was necessary because during the presentation, the group, partners, or individual would have to defend their product while accepting critique and feedback.
A “design must work” attitude was observed in students engaged in tinkering up to the last minute.

In one observation, during presentation of the Unit 1 map, Myunghee and Kyung realized their light bulb would not turn on. They discovered their battery had run dry, and scurried to find another 9-volt battery. All they could find was 1.5 volt batteries and discovered a 1.5 volt would only provide a dim light. Without assistance from the teacher, they collected 4 1.5 volt batteries and proceeded to pile them up on each other to create 6 volts. This did not work. Finally they figured out to line the batteries up, tape them with electrical tape, quickly connect the long battery to their circuit, and finally light up their map facts. They were observed high fiving and jumping for joy as they got their design to work, at the very last minute.

On the day the mousetrap car was due, Song-Yun, after days of testing and failures came to class with excitement.

I dreamt about the problem, Mrs. MaryAnn! In my dream I fixed the Mousetrap car and it worked! My problem was that my wheels were too wobbly so in my dream I put rubber bands around axel and stabilized the wheels in between rubber bands. I am going to try it now, I can’t believe it!

Song-Yun tried the idea she had dreamt about, and the solution worked. Her wheels stabilized and her mousetrap car was able to go the distance. Having a product orientation encouraged students to think deeply about their problem, and to think of multiple ways to solve it.
**Audience acceptance.** The Makerspace curriculum required students to present their products to a greater audience, beyond their classmates and teachers. The Unit 1 map was intended for whole school use, Unit 2 mousetrap cars would be put on display for kids to tinker and play with, and Unit 3 an independent project, a toy of your design, would be showcased at graduation. Knowing this, students were compelled to create a product that was significant enough to be displayed to the public (see Figure 11, 12).

*Figure 11.* The process. Creating a notable final product from idea to presentation.
Figure 12. The map of Europe. The final product presented to a school wide audience.

The power to persuade. Students practiced persuasion skills throughout the design process and during the presentation of the final product. Students had to persuade their group members to embrace their ideas and the Makerspace teachers to accept their designs. The Makerspace teachers were observed asking probing questions, “What does that do? What is this for? Can you explain to me what your thoughts are on your project?”

For Unit 3, the students were asked to make an invention of their own choosing. The project was called “Express Yourself” and students were happy to design their own project without constraints. A lesson on cams and rods for “Automata” was introduced, as a suggestion for a project (Appendix L). Student ideas for this project ranged from a puppet theater to a desk top school supplies holder, to Automata of different designs. At the end of this 6 period unit, students were asked to present their products (see Figure 13). In observation notes, students
demonstrated confidence and pride in their work and creativity. Annie explains, “I guess I did get a little more creative because I made something no one else thought of before, and that was kind of cool!”

**Figure 13.** Student presentations. Persuading an audience to accept the final product.

**Summary.** Preliminary interview responses were compared to post-interview responses on creativity self-efficacy (see Table 10). The table shows all students felt creative by the end of the Makerspace experience and could indicate why they felt creative. Student ratings on creativity during preliminary and post interviews were based confidence of response on being creative and whether or not they could give an example of their creativity.

Evidence from multiple sources presented above confirms the research study’s proposition: Students of the Makerspace class will increase their creativity self-efficacy and creative ability. The Makerspace curriculum was found to support this increase in creativity.
# On Creativity Self-Efficacy Pre-Interview and Post-Interview Comments

<table>
<thead>
<tr>
<th>Name/Gender</th>
<th>Pre-Interview Creativity Rating</th>
<th>Post Interview Creativity Rating</th>
<th>Pre-Interview Confidence in one’s own creativity “Do you think you are a creative person?”</th>
<th>Post-Interview Confidence in one’s own creativity “After the Makerspace program, do you think you are a creative person?”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie (F)</td>
<td>Average</td>
<td>High</td>
<td>“I think I am creative, but only in specific things, like writing and stuff, but painting and drawing I’m as creative as a lot of dirt”</td>
<td>“So I guess I did get a little more creative because I made something that no one else thought of before, and that was kind of cool!”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“I get ideas for my writing because I read a lot, so I’m like ‘Hey this looks like a good idea! I could use this in one my stories’”</td>
<td>“Now I make little things at home”</td>
</tr>
<tr>
<td>Chris (M)</td>
<td>High</td>
<td>High</td>
<td>“I like to do creative stuff like make swords for my little brothers”</td>
<td>“I think I learned to be a little more creative because I tried and failed and then I researched and made something”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“I make comic books”</td>
<td>“I feel most creative when I’m working on something”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“I am creative when I am in a good mood”</td>
<td></td>
</tr>
<tr>
<td>Chaoxiang (M)</td>
<td>Low</td>
<td>Average</td>
<td>“So-so”</td>
<td>“My project is the Flash, the hat could stick, use magnet stick to its body, it’s really fun! I thought of a project in a different way.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Researcher: “Can you explain?” “Sometimes I just sit here and don’t know what to do”</td>
<td>Researcher: “So do you feel more creative than when you started?” “I did the magnet and my flash, the arms could move, and yeah!”</td>
</tr>
<tr>
<td>Ellen (F)</td>
<td>Average</td>
<td>High</td>
<td>“I guess sometimes I feel more creative, but other times I have no clue what I should do”</td>
<td>“I felt free and it’s fun because you can just make whatever you want.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Well, I think If I had more time, I could have more ideas, like when we had time to write our fantasy story, I like that.”</td>
<td>“What the whole Makerspace is about is just being creative and be yourself”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>“I thought the most important thing for me was to take risks”</td>
</tr>
<tr>
<td>Jason (M)</td>
<td>Average</td>
<td>High</td>
<td>“I feel like I am a creative kid when I play Minecraft”</td>
<td>“I felt free. I felt my creative juices are going down the pipe”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“I think I am creative in paper works and comics”</td>
<td>Researcher: “What does that mean?”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>“I felt all the energy and creative juice went straight to the brain”</td>
</tr>
</tbody>
</table>
Research Question 1 Part 2: How does the Makerspace classroom environment foster creativity?

According to a constant comparison analysis of the SCALE (Support of Creativity in a Learning Environment) observation tool (Richardson, 2016), student and teacher interviews, and

<table>
<thead>
<tr>
<th>Name</th>
<th>Gender</th>
<th>Average</th>
<th>High</th>
<th>Response</th>
<th>Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jin-Hai</td>
<td>M</td>
<td>Low</td>
<td>Average</td>
<td>“I don’t know”</td>
<td>“Hmm-mm. Yeah.” Researcher prompt: “How do you know you are more creative?” “Hmm-mm. I just like to make things with the things [materials] that I have [in the Makerspace]”</td>
</tr>
<tr>
<td>Myunghee</td>
<td>F</td>
<td>Low</td>
<td>Average</td>
<td>“Not really”</td>
<td>“I learned more how to get a little more creative and make stuff”</td>
</tr>
<tr>
<td>Nathan</td>
<td>M</td>
<td>High</td>
<td>High</td>
<td>“Yes I am, and I am very active person.”</td>
<td>“Yeah, I think already am the creative-est person in my family and from my friends”</td>
</tr>
<tr>
<td>Song Yun</td>
<td>Low</td>
<td>High</td>
<td></td>
<td>“In Korea I think I couldn’t be creative”</td>
<td>“Yes, I know how to be creative”</td>
</tr>
<tr>
<td>Sang-Ook</td>
<td>M</td>
<td>Low</td>
<td>High</td>
<td>“I don’t think I’m creative”</td>
<td>“Yes” Researcher: “How are you more creative”</td>
</tr>
</tbody>
</table>

“Being creative, you have to think different from others so you can make something more useful and different. Also creative people have to keep trying and don’t give up.”

“In the Makerspace you learn about what the creative person do...you will get new ideas and learn how to be original”

“[I] can invent something that you cannot do in your house or in your class”

“Just did that because my teacher told me to”
observation documentation, the Makerspace physical and social environment fostered moderate to high evidence of a creativity fostering environment. Findings show:

- The physical space indicated “high” evidence of fostering creativity
- The social environment encouraged a “moderate to high” creative culture and climate.

**The physical space.** The space contained various “stations.” Although the space is the size of a regular classroom, the corners were designed to house woodworking and powertools; electronics and robotics materials; art supplies; and recycled materials. All materials were accessible and labeled. Mindful of the educative purposes of this Makerspace, traditional elements of a classroom remained. The presentation area, an open space with projector and screen, was critical for instruction and for reflection and critique of student work. Students had access to research materials from a small, class library and also made use of a laptop cart and when needed, brought lap tops to their work area.

**Creativity inspiring.** “It should have wheels,” Mr. Stewart was adamant that tables, desks, cabinets, should have wheels. Mr. Stewart explained, “It’s so that teachers and students can create their own space according to their needs and the needs of the project.” As we looked at Makerspace practices and our curriculum objectives, ideas for the practical and decorative details materialized with excitement. To focus the design process, we brought research based practices from the literature review on creative learning and spaces and the Makerspace Playbook published by MakerEd. These research based practices, our own instructional experiences and the limitations of our resources informed and shaped the physical space (see Figure 14).
Using constant comparison analysis of our planning notes and coding of interviews, the data suggests the Makerspace physical space prioritized flexibility, choice, space to allow movement and collaborative work, space to pull apart for independent work, space for ideation, and materials organization. The teachers also expressed the need for elements of surprise, a list itemizing ideation spaces reads “not just Whiteboards…chalkboards, corkboards, mirrors, post its hung by clothespins.” The physical space was intentionally designed to be “creativity inspiring” with access to spaces, tools, and materials to rouse tinkering and experimentation.

Creswell (1998) suggests, when engaging in qualitative studies, representation of multiple perspectives enhances the validity of the data. The physical space was thus rated for creativity using the SCALE (Support of Creativity in a Learning Environment) observation tool (Richardson, 2016). The SCALE (Appendix I) observes for ways an environment supports creativity, using research based claims. It is a non-evaluative, short and informal tool, and used for reflection of the classroom environment (Richardson, 2016). The Makerspace teachers, the 5th grade regular ed classroom teacher, and Dr. Young, the head director of SYIS, completed the observation checklist independently (see Figure 15).
Physical Environment

<table>
<thead>
<tr>
<th>Physical Environment</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A variety of resources are available and accessible to students.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples of student work appear in the space.</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A variety of work stations or areas are available to students.</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>The furniture allows for multiple arrangements and configurations.</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Figure 15. Dr. Young’s ratings on the SCALE factor physical environment

All observers agreed that a variety of work stations were available to students and that the furniture allowed for flexibility. All observers agreed that more student work needed to appear in the space. Mr. Stewart added “Because this Makerspace was still being developed there were not dedicated spaces in the room to display work.” There was disagreement over the amount of resources, where the makerspace teachers reported a high rating, the 5th grade teacher responded the need for more tools. He added, “It would benefit the students for a greater quantity of tools, but this allowed for the students to plan when to use the tools.” Peer ratings by the 5th grade classroom teacher and Dr. Young added to the reliability of the data collection.

Coding of student comments and comparison of observations data demonstrates students saw the physical space as a place to “make.” A majority of students demonstrated excitement when introduced to the space. They were heard saying, “This is awesome!” “So cool!” “I can’t wait to make something.” These students were eager to use the different stations to make something of their own invention. It was observed that this zeal provoked behavior issues on the first day of the Makerspace. Some students were upset that they didn’t get to dive into the physical space and do whatever they wanted. On reflection of this moment, Chris said, “I was annoyed because I wanted to make something. Here was all this stuff and we had to listen to the
teachers talk.” At the same time, some students were cautious of the physical space. This will be discussed in the next section.

**Students’ relationship with the space.** While a majority of students demonstrated excitement for the space, some students expressed caution during the first unit. It was observed, some students were unsure how to move about the room, there were no assigned seats, and tables that could be wheeled around to make new classroom configurations went untouched.

In an introductory lesson exploring the Makerspace room, students used a design thinking routine to investigate the space. The students had to 1. Look Closely, 2. Explore Complexity, and 3. Find Opportunity in the room. Their responses were collected and evaluated (see Figure 16).

---

**Figure 16.** Makerspace environment activity. What is the purpose of this space?
A difference was noted between students of Eastern and Western traditions of schooling (see Table 11). The Makerspace teachers recorded this distinction on diverse student perspectives of the physical space. Accommodations were made to the lessons to model use of the space and materials.

Table 11

*Makerspace Physical Space, What is the purpose of this space?*

<table>
<thead>
<tr>
<th>Pre-Interview</th>
<th>Pre-Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Average Creativity Students</td>
<td>Low Creativity Students</td>
</tr>
<tr>
<td>Magical, Cool, to build stuff,</td>
<td>Left response blank, this is the</td>
</tr>
<tr>
<td>invent projects, where you do</td>
<td>material or storage box…it is</td>
</tr>
<tr>
<td>your invention work, where you</td>
<td>organized with boxes and</td>
</tr>
<tr>
<td>make your science work</td>
<td>name tags, this is where you get</td>
</tr>
<tr>
<td></td>
<td>stuff you need</td>
</tr>
</tbody>
</table>

Accommodation of the classroom environment was necessary for Jason, the student with ADHD. In reviewing observation notes, Jason was off-task on average 1/3 of the classroom time. During the first unit (9 class periods), Jason had to be removed from the room five class periods for using materials inappropriately, for not having regard for safety, and destroying other student’s projects. For the second unit, Jason was given a box to keep his materials and to help him focus. He was also given an independent space to tinker when he needed a break. This alleviated the feeling of being, in Jason’s words, “too excited” and “I can’t decide what to do.” With these accommodations, Jason was able to attend all classes until the end of the semester. An avid cartooner, Jason was asked to draw his experience in the Makerspace and reflect on his behavior (see Figure 17).
Figure 17. Jason’s response to “What is your behavior like in the Makerspace?”

**Spending time tinkering.** The Tinkering Learning Dimensions Framework (refer to Table 6, above) shows students became more adept to tinker and experiment through the course of the program. In reflection, Chaoxiang reported, “I was not used to moving around the room, I didn’t know I could just get up and get materials. I wanted to ask the teacher. I didn’t know what to do.” During Unit 1 Chaoxiang and his group, that included Jin-Hai and Dewei, needed a high level of support. The Makerspace teacher worked alongside them to help design their map. The Makerspace teacher suggested ideas, materials, and tools and modeled tinkering. By unit 2, these students were ready to tinker on their own to build their Mousetrap car. By unit 3, the Tinkering Learning Dimensions Framework shows this group was independently tinkering, making, and used materials with confidence (see Figure 18).
During the third unit, I asked Chaoxiang, “At the end [the last unit], you were able to start your idea quickly, right? Why do you think that is?” He responded, “Because I became more smarter!” I asked for clarification, and he said, “I know how to use the materials and the classroom.” Spending time tinkering had helped Chaoxiang come up with ideas quicker.

At the start of unit 3, Mr. Stewart and I commented on the vast differences of student behaviors in the physical space as compared to the first unit. After three units of making, all students, from diverse backgrounds and special needs, were confident in the use of the physical space and use of materials with safety precautions. Comparison of the data from aggregated scores on the SCALE physical space observation check list, data from the Engagement Learning Dimension Table, and analysis of student voices and observations shows the physical space fostered creativity.

*Figure 18. Chaoxiang’s increase in tinkering over time*
The social environment. The social environment is designated as the Makerspace teachers, the student participants, and their relationships with each other. It was observed that the social environment fostered moderate evidence of supporting creativity.

Makerspace teachers. “Well that’s the great thing about this space, there are no right or wrong answers,” Mr. Stewart is heard supporting a student who is struggling. Observations and records of direct quotes show teachers empowered student creativity through their language. Teachers encouraged students to tolerate ambiguity, “OK, let’s try it! See what happens!” and “Don’t worry, if it doesn’t work. We have time to try again.” Teachers encouraged students to keep their response options open, and to look at their work in a different way, “What if you used this wheel instead?” “How about you try using [a different material]?” Teachers asked students to reflect on their ideas “Can you explain to me your project?” and gave immediate, constructive feedback “I think your object is too heavy and the rod won’t support it.”

Teachers took time to conference with students in a non-threatening way. In one example, several students wanted to build a weapon, an activity against school rules. Traditional classrooms often quickly dismiss and reprimand student ideas that are inappropriate (Beghetto & Kaufman, 2009). Although against school rules, “weapon building” was not dismissed, it led to a discussion of using creativity for ethical purposes and it brought up topics regarding creative inventions that have led to destruction (see Figure 19). Students understood the consequences of creative endeavor and the caution “makers” must employ in their invention process. Yet, these students, demonstrating confidence, then argued to use the mechanics of weaponry to build something positive. The teacher responded very simply, “Ok show me your idea.”
Observations recorded teacher language that demonstrated excitement and enthusiasm for student ideas, the process, and the final product. They also challenged students with suggestions to improve their ideas. The teachers gave students immediate feedback when students sought out help. The teachers worked alongside students, as co-learners. Mrs. MaryAnn did not have experience with power tools and learned with the students how to use the power tools and drill press. The teachers shared genuine joy with student successes as well as genuine disappointment alongside student failures. In one example noted in an analytic memo, Mrs. MaryAnn writes,

Although “celebrating failure” is an indicator of encouraging a creative learning environment, as a teacher co-learner, it was difficult to not feel the same level of frustration and disappointment when a mouse trap car didn’t work after several rounds of improvements and trials.

Despite setbacks, teachers encouraged and modeled perseverance. Student voices tell a story of the several roles the Makerspace teacher employed.

Figure 19. Unintended consequences. Weapon making and teachable moments.
Figure 20. The role of the teacher in the Makerspace

Table 12

*Makerspace Teacher Roles*

<table>
<thead>
<tr>
<th>Role</th>
<th>Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher as instructor/expert</td>
<td>“Sometimes the teacher just did it and I followed what he did” – Chris</td>
</tr>
<tr>
<td></td>
<td>“The teacher showed me how to do it and then I did it” – Chaoxiang</td>
</tr>
<tr>
<td>Teacher as guide</td>
<td>“The first time the teachers helped me and the next time I did it independently” – Sang Ook</td>
</tr>
<tr>
<td></td>
<td>“[The teacher] just guided me, like showed me how to cut off the sleeves and what do with the glue and the tape…and yeah, that’s nice. The was nice of the teacher” – Annie</td>
</tr>
<tr>
<td>Teacher as co-learner</td>
<td>“It’s like you can have free time…you can talk with your teachers and invent something that you cannot do in your house or in your [traditional] class” – Song Yun</td>
</tr>
<tr>
<td></td>
<td>“The teachers are fun! They don’t make us write and sit and all that stuff” – Myunghee</td>
</tr>
</tbody>
</table>

**Student relationships in the Makerspace.** The units were designed for students to work in groups, in partners, and independently. A constant comparative analysis of data gleaned from
observation notes and photographs shows how students created a culture of cultivating creativity. Visual ethnography uses digital media to learn more about people and their world (Kingsley, 2009). In pictures, students are observed collaborating, sharing and being respectful of ideas, assisting and encouraging each other (see Figure 21). In fact, in observations, students celebrated each others’ ideas through expressions of joy in instances of success (i.e. high fives, hugs, jumping, clapping, cheering) and students supported each other when they failed, giggling, and saying “Fail!” and then trying again. Annie was recorded saying to her partner, “Oh no! There’s no quitting in the Makerspace!”

![Photographs show students working together in close proximity, gesturing, overlapping hands, sharing ideas, and making.](image)

*Figure 21. Students fostering a creativity encouraging culture and climate*

Yet, there were times when collaboration and working together challenged students. Data results from the SCALE observation finds raters gave the learning climate high evidence for supporting creativity, with the caveat, a consensus in concern for students caring and
respectfulness. The 5th grade teacher added to the comments section “Disagreements happened and sometimes required outside intervention to find a solution” (see Figure 22).

<table>
<thead>
<tr>
<th>Learning Climate</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students are involved in discussions among themselves, with or without the teacher that deepen their understanding.</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>The students are caring, respectful, and value differences.</td>
<td></td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>The teacher is a facilitator, co-learner, explorer, or inquirer with students.</td>
<td></td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Mistakes, risk-taking, and novel ideas are valued or encouraged.</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

*Figure 22. The 5th grade teacher’s rating on the SCALE factor learning climate*

To narrate one example, Darren and Stephen (not individual interview participants) were in disagreement for six of the ten periods of working together on the Mousetrap car. Darren wanted to change teams, and threatened to quit, explaining Stephen is “selfish.” Stephen rebutted, “I gave up one of my ideas so now he needs to give up one of his ideas.” The teacher observers, although concerned, regarded these difficult moments were opportunities for practicing collaboration skills. Even as students disagreed all teams and partnerships stayed together to complete the projects throughout the course of the program.

**A “fun” environment.** “Well, I feel more creative when I’m in a good mood,” mentions Chris, of high creativity self-efficacy, in his preliminary interview. In accordance, individual interviews with students regard “Fun!” to describe engagement in the Makerspace. The theme of “fun in the Makerspace” emerged in every individual interview. When asked about the Makerspace experience all students expressed how much they liked being in the Makerspace, that it was “fun,” “great,” “more fun to learn this way” “I loved it!”
The SCALE observation findings demonstrate high evidence of the environment supporting learner engagement. While the Makerspace teachers rated high evidence of “Learner engagement,” the 5th grade teacher and Dr. Young concurred on all points, and were both concerned with some off-task behavior (see Figure 23). In defense of this point, Mr. Stewart noted that he felt that these students did in fact demonstrate enthusiasm beyond being “on task.” He added, “I am amazed at how the students transfer their new found making skills into projects at home. I started hearing from parents how [the students] now want to buy tools and not video games.”

<table>
<thead>
<tr>
<th>Learner Engagement</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Students are involved in tasks that are open-ended and/or involve choice.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Students are involved in activities that may include inquiry, project based learning, or interdisciplinary tasks.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Students use multiple perspectives/viewpoints/ways of knowing or various modes of investigation/problem solving.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Students demonstrate interest in or enthusiasm for the activity beyond being “on task.”</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

*Figure 23. The 5th grade teacher’s ratings on the SCALE factor learner engagement*

In the final interview, students were asked, “If a new student comes to SYIS, what would you tell them about the Makerspace?” After coding this response, several themes emerged, fun and enjoyment, alongside creativity most often was uttered by students. Coding of these student responses demonstrate students thought the environment was “fun,” a natural catalyst for engagement (see Table 13).
<table>
<thead>
<tr>
<th>Student</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie</td>
<td>“I would say it’s a place that is super fun! Where we can make things and we can be creative and take risks, and no one can tell us we are wrong because we just like, make it, and then we realize: Ah I shouldn’t have done that, so you either just start over again or go back a step. I’ll just tell them it’s a place where you can be unique and do your work without having to just sit and write and read all the time”</td>
<td>Fun, Creative, Take risks, Unique, No sitting</td>
</tr>
<tr>
<td>Chris(M)</td>
<td>“I would say it’s really fun and that we get to make stuff, and it’s like making stuff but learning at the same time” “I would tell him to think and try your best and to make sure to research ”</td>
<td>Fun, making, Try, Research</td>
</tr>
<tr>
<td>Chaoxiang (M)</td>
<td>“You have to think, and try and try again, and if you don’t know you can ask the teachers, and you could be a creative! There you can have fun with your friends and your friends can help you [too]”</td>
<td>Try, Creative, Fun Friends</td>
</tr>
<tr>
<td>Ellen (F)</td>
<td>“I would say, I feel the same because I have never done this before. I would say do what you think and what seems right for you”</td>
<td>Do what you think is right for you</td>
</tr>
<tr>
<td>Jason (M)</td>
<td>“It’s fine not to fit in! You will enjoy it because you get to do your own projects!”</td>
<td>You don’t need to fit in Enjoy</td>
</tr>
<tr>
<td>Jin-Hai (M)*</td>
<td>“It’s a fun place to make things, make plans, and make ideas, and learn and be creative!”</td>
<td>Fun Make Ideas Learn Creative</td>
</tr>
<tr>
<td>Myunghee (F)</td>
<td>“I think it’s better in here because you don’t have to just sit down, open a book and just solve it like that. If I keep sit down I feel like my head is going to blow up. But if I walk around then it gives me more, how to say, it feels a bit better!” “I would tell them don’t give up and try, and later you will succeed in making something creative!”</td>
<td>No sitting Try Succeed Creative</td>
</tr>
<tr>
<td>Nathan (M)</td>
<td>“You are going to learn about what the creative person do, you’re going to learn about some creative person, you will get new ideas and you will learn how to be original”</td>
<td>Creative person New ideas Original</td>
</tr>
<tr>
<td></td>
<td>“I would say that Makerspace is a place you'll succeed and fail, so you don't have to be that nervous. And then when you succeed, you are going to feel great, and when you failed, you are going to endure more. So, no worries”</td>
<td>Succeed Fail Endure Feel Great</td>
</tr>
</tbody>
</table>
Summary. Multiple sources of evidence indicate the Makerspace environment supported moderate to high creativity through the physical arrangement, access to materials, and an engaging, creative culture established by teachers and practiced by the students, during most times (see Figure 24).

Research Question 2: How does a Makerspace curriculum, activities, and classroom environment support student learning of targeted academic subject matter objectives in a class of culturally diverse adolescent students?

But, what are the students learning here? On the SCALE observation tool, Dr. Young’s score on the gives a moderate score for evidence of students understanding for “deeper learning.” He explained, “This seems like an enrichment activity,” although enthusiastic about the program, he was uncertain whether or not students were engaged in “deeper learning” to meet traditional objectives. To respond to the concerns of a traditional K-12 educational setting,
the need for standardized measurement indicating achievement, the second research question asks, how does the Makerspace curriculum, activities and environment supports traditional objectives?

The findings of this study show the Makerspace classroom curriculum and activities, and environment supports the achievement of traditional objectives, except for expository writing. The findings show the majority of students scored average to above average on traditional classroom assessments connected to each unit of study, except for expository writing where good writers were able to maintain their writing levels, while below average writers did not improve their writing skills (see Table 14).

Table 14

<p>| Students’ Scores on Traditional Assessments Based on Makerspace Lessons |
|-----------------------------|---|---|---|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Name/Gender</th>
<th>Age</th>
<th>Grade</th>
<th>Nationality</th>
<th>Unit 1 Social Studies</th>
<th>European Geography Test</th>
<th>Unit 2 Science Force and Motion Test</th>
<th>Unit 3 Persuasive Essay</th>
<th>Pre Self-report on grades in school</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annie (F)</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>80</td>
<td>95</td>
<td>100</td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>Chris(M)</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>86</td>
<td>90</td>
<td>60</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Chaoxiang (M)</td>
<td>10</td>
<td>5th</td>
<td>China</td>
<td>60</td>
<td>80</td>
<td>60</td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>Ellen (F)</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>97</td>
<td>93</td>
<td>100</td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>Jason (M)**</td>
<td>11</td>
<td>5th</td>
<td>USA</td>
<td>79</td>
<td>95</td>
<td>70</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Jin-Hai (M)*</td>
<td>11</td>
<td>5th</td>
<td>China</td>
<td>60*</td>
<td>80*</td>
<td>60*</td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>Myunghee (F)</td>
<td>11</td>
<td>5th</td>
<td>S. Korea</td>
<td>96</td>
<td>95</td>
<td>100</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Nathan (M)</td>
<td>10</td>
<td>5th</td>
<td>Germany</td>
<td>80</td>
<td>95</td>
<td>60</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Sang-Ook (M)</td>
<td>11</td>
<td>5th</td>
<td>S. Korea</td>
<td>97</td>
<td>90</td>
<td>80</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Song-Yun (F)</td>
<td>11</td>
<td>5th</td>
<td>S. Korea</td>
<td>95</td>
<td>100</td>
<td>100</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

*ESL student accommodations/translation when needed **SPED student extended time accommodation

Findings suggest the Makerspace curriculum, activities, and environment supported most traditional classroom objectives (see Table 15). As evidenced by student test scores, analysis of student interviews, and observation data, the Makerspace curriculum supported for traditional
student achievement through 1) Using the Understanding by Design framework; 2) Incorporating traditional assessments; 3) Creating multiple opportunities to master content. The environment supported traditional standards through 1) technology integration; 2) access to teachers as experts and guides; and 3) by supporting a self-directed learning culture.

### Table 15

**Traditional Academic Standards from the SYIS Curriculum**

<table>
<thead>
<tr>
<th>Standards</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Social Studies</td>
<td>Science</td>
<td>Persuasive</td>
</tr>
<tr>
<td></td>
<td>European Geography</td>
<td>Force and Motion</td>
<td>Essay</td>
</tr>
<tr>
<td>1. Understand how to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.</td>
<td>1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.</td>
<td>Write opinion pieces on topics or texts, supporting a point of view with reasons and information.</td>
<td></td>
</tr>
<tr>
<td>2. Understand the physical and human characteristics of places.</td>
<td>2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.</td>
<td>Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.</td>
<td></td>
</tr>
<tr>
<td>3. Understand that people create regions to interpret Earth's complexity.</td>
<td>3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</td>
<td>Provide logically ordered reasons that are supported by facts and details.</td>
<td></td>
</tr>
<tr>
<td>4. Understand how culture and experience influence people's perceptions of places and regions.</td>
<td>4. Apply Newton’s Third Law to design a solution to put an object in motion</td>
<td>Link opinion and reasons using words, phrases, and clauses</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Provide a concluding statement or section related to the opinion presented</td>
</tr>
</tbody>
</table>

#### Cross disciplinary standards

| CCSS ELA: Determine a theme of a story, drama, or poem from details in the text; summarize the text. | NGSS- Electrical Circuits | NGSS- Simple Machines |

| Assessment type | Label Map and Open ended questions test | Multiple choice test | Persuasive writing rubric |
The Makerspace curriculum and activities supports student learning of traditional academic goals. The Makerspace curriculum used traditional standards and objectives gleaned from the SYIS curriculum to guide the lessons and activities.

Lesson plan. The unit lesson plans were designed to reflect the standard lesson plan template at SYIS. Using the Understanding by Design framework, the Makerspace teachers were intentional about curricular goals and desired results. The Makerspace teachers incorporated “essential questions” as part of the design thinking tradition of the “wicked problem” (see Table 16). For example, in Unit 1 the “wicked problem” was building an information map of Europe to inform an audience about Europe’s geography, culture, economy, politics, and history. In addition, the essential question for this unit was, “What can a map tell us? How are maps useful?” In this way, traditional concepts of the “essential question” or the “big idea” worked in conjunction with design thinking’s “wicked problem.”

Table 16

<table>
<thead>
<tr>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Studies</td>
<td>Science</td>
<td>Persuasive</td>
</tr>
<tr>
<td>European Geography</td>
<td>Force and Motion</td>
<td>Essay</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UbD Essential Question</th>
<th>Wicked Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>What can a map tell us? How are maps useful?</td>
<td>Build an interactive map to teach an audience about Europe</td>
</tr>
<tr>
<td>How does Newton’s laws of motion affect the design and function of an automobile?</td>
<td>Build a Mousetrap car out of the resources you have to escape and survive!</td>
</tr>
<tr>
<td>How can I persuade an audience to think my product is creative?</td>
<td>Be innovative! Build an interesting toy or object that is creative and NEW</td>
</tr>
</tbody>
</table>

The lesson plan also followed a typical model of instruction. The Makerspace teacher started the lesson with a “hook”- typically the “wicked problem,” followed by an introduction of objectives, followed by modeled expectations, and guided practice (see Figure 24). Students were expected to respond to questions, offer background knowledge, and ask for clarification. In
this way the lesson plan followed a traditional classroom structure, with the teacher up front, leading the instruction and students listening and receiving information. Students’ learning was scaffolded, where teacher instruction was front loaded with the introduction of new material. As students showed understanding, the teacher released students to self-direct their learning. The teachers continued to check for understanding throughout the entire unit (see Figure 25).

*Figure 25. Traditional instruction in the Makerspace*
Traditional assessments. To ensure students were learning content objectives, students were expected to take traditional assessments. Students were not required to study for the “test” though, and did not receive advanced notice. The Makerspace teachers wanted to see if students had learned the material through the Makerspace experience versus memorizing facts. Although students complained, “This is so unfair! You didn’t tell us about the test!” students were surprised with their test results. For Unit 1 and Unit 2 (Appendix C, D), most students scored above 80%. Students who were rated as above average students maintained their status. Average students and below average students showed an increase in their grades when compared to similar tests in the same content areas during traditional classroom learning. Yet, some students did score below average grades. Students did not show improvement in their writing skills however. The Unit 3 Persuasive Essay assignment demonstrated above average writers
maintained their strong writing status, and those who struggled with writing did not improve (see Appendix E).

Jason’s (the student with ADHD) scores are of particular interest. For the first unit, Jason had to be taken out of the Makerspace several times for his misbehavior. Yet when the geographic sections of Europe were complete, Jason was asked to help put the map together. He enjoyed this process and was excited about the map of Europe coming together. He was asked to paint the background and put on the final touches. He also tested the lights and mechanics of the interactive map. Afterwards, Jason took the European geography test and received a high score of “79” on the test (see Figure 27). Another surprising observation is that Jason did not need any accommodations to complete this test.

![Figure 27. Jason’s scores on the European geography unit test](image-url)
Multiple opportunities for mastery. Jason’s test scores, along with the test scores of his peers, shows that students were able to master the concepts as stated in the Makerspace curriculum and lesson plan. Without receiving notice, students were able to take a Social Studies map test with open-ended questions and Science test with multiple-choice questions. These tests tested for lower order thinking skills of identification, comprehension, and application. Still, students showed competency for those levels of understanding. Each Makerspace unit allowed for multiple methods of constructing the learning, through direct instruction from the teacher, through reading and researching in books and on the internet, through note taking in their design journals, and when building and making. While building and making, students communicated and talked about their problems, objectives, and outcomes.

Teachers were observed constantly moving around the room to give help to groups or to conference one-on-one with individuals. As Jason mentioned, “The teachers go around from builder to builders to talk, if someone needs anything, like ‘how’s it going’ or ‘what’s up’?” Teachers gave immediate feedback and instruction when needed. Teachers took the time to accommodate and modify instruction for students with special needs. Jin Hai, the Chinese ESL student, often received one-on-one attention regarding unit vocabulary (see Figure 28).
Jin Hai’s Makerspace learning trajectory is an example of how multiple opportunities allowed for mastery of traditional objectives. Jin Hai was heard talking more with his peers than during his traditional class time. He was also observed asking “How do you say…?” often to his Chinese-speaking peers. His Chinese-speaking peers helped introduce him to the names of different materials and activities like “drilling.” Indicated by his 5th grade classroom teacher who often observed the Makerspace class, said Jin Hai sought out the teacher’s help more often in the Makerspace than in his traditional classroom. He asked for materials, and would ask “How do you say [pipe cleaner] or [Styrofoam]?"

During his Unit 1 project, Jin Hai did not know where to start. He would say, “I don’t know what to do.” However, by the deadline, he was able to complete his task of building the country of Poland with facts about the country. I asked him, “Jin Hai, how did you figure out what to do?” He said, “I looked at what my friends were doing. I looked in the book about Poland. I looked on the Internet. I asked you, my teacher.” Jin Hai comments on several ways
he learned the content. His response on an open-ended question about the economy of Europe reads, “Yes, I think the economy of Europe is strong. Poland is a ship building country and ships are very expensive. There is farming in Poland too. Belgium has chocolates and a little box of chocolates from Belgium is expensive.” The response is not very deep, but for Jin Hai’s ESL level, he remembers some facts about the economy and can respond in English.

The Makerspace environment supports student learning of traditional academic goals.

Access to teacher and a guide. As noted above, in observations of the Makerspace teacher, it is evident that the traditional role of the teacher did not necessarily change. Even as students self-directed their learning, the teacher was still needed by students for expertise, for clarification, and for guided support and for feedback. The teacher also provided accommodations and modifications for students with special needs. The teacher was needed to set up the activities, give instruction, collect student work, and record student data.

Technology integration. Students had access to a lap top cart right outside the Makerspace doors. The availability of laptops was integral to student directed learning. For each unit of study, students researched on the Internet for facts about their topic. They watched short YouTube videos for information and for step-by-step how to make a product. Teachers used the Internet to support instruction. In the 5th grade traditional classroom, students had access to 2 desktops for 18 students. In the Makerspace, students had one to one access with the laptops. Students were allowed to imbed their laptops right into the workspace, as teachers trusted the students to take care of the equipment (see Figure 29).
Student directed learning. The Makerspace environment gave students the flexibility and choice on how to direct their learning. After receiving instruction, students were able to move about the room, choose their seating and work area, and to work at their own pace. They were able to learn content from a variety of sources, from the teachers, from the small resource library in the Makerspace, from each other, and from the Internet. Students received a deadline and they created their own pacing charts, graphic organizers provided by the teachers, although completion of the pacing chart was not required. Makerspace teachers only required students to finish the product within the due date. In the Makerspace, students were responsible for their own learning of traditional academic expectations with the added competency of creativity.
Students were pressed to meet objectives beyond solely completing the task, students needed to demonstrate understanding with a final tangible product for an audience.

On the first day of the Makerspace program students were introduced to the concept of being a Maker. The lesson introduced “makers” from antiquity to the present day. Students noticed they were all self-directed learners. Mr. Stewart mentioned, “Galileo didn’t have Google to look up the answer. He had to figure it out all by himself.” The activity that followed the lesson asked students to draw themselves as a Maker. This was a 15 minute timed assignment. On the final day of the Makerspace program, students went through the same lesson as day one and were asked to do the same activity, in the same amount of time. The pictures are telling of student growth, as self-directed learners and as students with the skills necessary for creativity. Nouns in the first drawings are replaced by action words in their second drawings (see Figure 30, 31).
Figure 29. Kyrie’s before and after illustration of a Maker. An interesting change in drawings is the subtle frown to subtle smile. From observations and anecdotal conversations she began the program with expression of low creativity self confidence.

Figure 30. Ellen’s before and after illustration of a Maker.
Summary of Findings

To respond to the research questions, “How does a Makerspace curriculum, activities, and classroom environment foster creativity in a class of culturally diverse adolescent students?” and “How does a Makerspace curriculum, activities, and classroom environment support student learning of targeted academic subject matter objectives in a class of culturally diverse adolescent students?” the research study collected a wide category of data over a period of six weeks. Individual student interviews before the Makerspace program, during the program, and at the end of the program imparted a student perspective of the experience. Recorded conversations between the Makerspace teachers demonstrated teacher intentions and reflections. The use of creativity observation tools assisted in focusing the data collection. Student artifacts were also collected, from classwork and traditional assessments, to sketches and final products, these artifacts evidenced student learning. Finally, photographs of students working in the Makerspace informed the data by giving visual imagery of the time and place.

Through a constant comparison analysis across the data, several themes emerged. The Makerspace curriculum increased creativity by:

- Engaging students in a design thinking process
- Specifically naming creativity behaviors as objectives
- Establishing a product oriented goal as the authentic assessment

The Makerspace environment increased creativity through:

- A stimulating physical space
- A social space with an encouraging, and at times conflicting, culture and climate
- Second, the Makerspace curriculum, activities, and environment supported the achievement of traditional objectives with the exception of the ELA Common Core
writing objectives. Students mastered grade level Science and Social Studies performance indicators. The Makerspace curriculum did this by aligning the Design Thinking routine to the Understanding by Design lesson plan framework and instruction

- Offering multiple opportunities for mastery of objectives in a variety of modalities
- Progress monitoring and assessing student understanding through traditional and non-traditional checks for understanding.

The Makerspace environment supported the achievement of traditional goals by:

- Integrating technology with one to one laptops
- Combining the traditional role of teacher as expert, instructor, with the progressive role of a Makerspace teacher co-learner and guide
- Promoting self-directed learning, while accommodating for diverse needs

Within this regard, students thus confirmed the following propositions guiding the case study.

1. Students of the Makerspace class will increase their creativity self-efficacy and creative ability.

2. Students of the Makerspace class will achieve traditional grade level standards and performance outcomes expectations by way of their creative activity.

The third proposition stated

3. Students will evidence different levels of creativity, with students of Western education experiences and backgrounds evidencing greater creativity in comparison to students of East Asian education experiences and backgrounds.

Students during the preliminary interviews and pre-Makerspace did in fact evidence different creativity self-beliefs, in accordance with their education experiences. East Asian educated
students felt less creative than their Western educated counterparts. However, by the end of the Makerspace program, all students self-reflected and identified, albeit to varying degrees, as creative individuals.
Chapter V: Discussion of the Findings

Revisiting the Problem of Practice

Creativity is an essential skill for the 21st century (National Research Council, 2004; Partnership for 21st Century Learning, 2011; Amabile, 1996; Craft, 2005; Pink, 2005; Plucker, Kaufman, & Beghetto, 2013; Simonton, 2000; Zhao; 2012). Creativity is regarded as one of the most important resources, if not the most, for today’s globalized and technologically advanced world (Florida, 2004). Creative individuals have the skills to think critically, problem solve, adapt and innovate (Csikszentmihalyi, 2009), all highly desirable characteristics of a college and career ready individual. Responding to this call for creative individuals for the 21st century workforce, nations are quickly revolutionizing their education agendas by adding a “creativity mandate.” In East Asian countries, such as China, Singapore, and in South Korea “creativity” is explicitly written as an additional competency in their national education standards (Pang & Plucker, 2013; Lee, 2001). Meanwhile in the U.S., creativity, although not specifically mandated, is viewed as an essential “Learning and Innovation” skill (Plucker, Kaufman, & Beghetto, 2013).

Despite the reception of creativity as a critical 21st century skill, teaching for creativity has yet to manifest in mainstream education models worldwide, where traditional methods of teaching and learning persist (Beghetto, 2007; Dacey & Lennon, 1998; Robinson, 2015; Schacter et. al, 2006). This research study sought to understand how a mainstream education setting, a traditional K-12 school, could incorporate an alternative learning environment, specifically a Makerspace program, to cultivate creativity while achieving traditional content objectives. This research study is a significant endeavor, as recently the Maker movement has gained momentum in schools (Voussoughi & Bevan, 2014). Yet, empirical research on Makerspace implementation and effect on creativity and traditional outcomes is scant. As Beghetto (2010) proposes,
“creativity researchers must develop, test, and implement new pedagogical models that simultaneously support the development of creative potential and academic learning” (p.459).

This study seeks to contribute to Beghetto’s (2010) call for research by adding to the increasing body of knowledge on creativity and learning in schools.

**Discussion of Major Findings**

For this case study, as evidenced through research participant interviews, document and artifact analysis, and measured by the Tinkering Learning Dimensions Framework (Bevan et al., 2015), the NEW rubric (Henricksen et al., 2015), and the SCALE (Richardson, 2016), the Makerspace alternative learning environment did indeed foster creativity in this group of diverse, multi-cultural students. While students began with different self-perceptions of their respective creative ability, from low confidence in creative ability to high confidence in creative ability, by the end of the Makerspace experience, every student reported they felt more confident in their creativity. Not only could students say they were more confident in their creativity, they could describe creative behaviors and strategies they engaged in, provide examples of their creative work, and critique their products with regards to creativity. Notably, students also met traditional academic goals, with the exception of the language arts persuasive writing standard. Meeting grade level content standards was a significant finding as the Makerspace experience occurred during the traditional school day rather than an after school setting or during an enrichment period.

It is important to note that developing creativity was not simply a task that asked students to come up with new ideas or present them in unique ways. As Amabile (1996) points out, creativity is a complex construct, the synergy of several components (domain knowledge, creative processes, task motivation, and the social environment) working together in what
Amabile (1996) calls the Componential Theory of Creativity. Student participants understood the multi-faceted nature of making a creative product. Annie described her experience in making suggesting, “Everything is just like going on in our brain, like a tornado!” Similarly, during Unit 1, Chris and Jason shook their heads and said, “This is too much!” referring to the work involved creating a final product, from research and ideation to prototyping, testing, and presenting. The complexity of moving from idea to final product was illustrated in Sang-Ook’s self-portrait as a Maker, an idea as a consequence of connections to and from other ideas, skills, and knowledge (see Figure 32).

![Figure 32. Sang-Ook’s portrait of a Maker](image)

Mindful of this complexity, how did students develop creativity over six-weeks in a Makerspace program while achieving traditional standards objectives? The findings revealed three major themes in relationship to the overall purpose of the study. They are as follows:

1. The Makerspace curriculum and environment gave students the opportunity to develop a “creative agency”
2. The Makerspace curriculum and environment gave students the opportunity to develop “creative fluency”

3. The Makerspace curriculum and environment encouraged creativity and innovation in the context of traditional curricular content objectives.

Students developed creativity and mastered academic goals as a result of the interaction between the student and content rich design thinking routines; the student and the physical space; the student and his or her teachers and peers.

![Diagram of Makerspace Curriculum and Environment]

*Figure 33. Creative Agency and Creative Fluency as a result of interactions in the Makerspace*

Additionally, to check themes regarding increased creative agency and fluency, findings from the Tinkering Learning Dimensions Framework were aggregated to determine a class average of activity in the Makerspace. The result demonstrates the class increased their engagement (i.e. spending time tinkering), initiative (i.e. takes risks), social scaffolding (i.e. develops ideas through environment), and developed understanding (i.e. utilizes/applies a
strategy towards an outcome) (see Figure 34). This data was cross-referenced and compared with data from student and teacher interviews, observations, and student artifacts.

![Image of a graph showing average of individual interview participant percentage of time evidencing tinkering learning dimension while in the Makerspace class (Unit 1; Unit 2; Unit 3)]

Figure 34. Average of Individual Interview Participant percentage of time evidencing tinkering learning dimension while in the Makerspace class (Unit 1; Unit 2; Unit 3)

The Makerspace curriculum and environment gave students the opportunity to develop “creative agency.” Empowering students with creativity skills and tools was a main focus of the Makerspace program. The Makerspace curriculum and environment supported these skills by: 1) Using a Design Thinking Routine to attack objectives and problem-solve; 2) Naming and practicing creative activity, behaviors, and ways of thinking; and 3) Providing the expectation and opportunity to solve a academic content-based problem through a tangible product for audience worthy presentation. Students were also expected to demonstrate knowledge through traditional assessments and checks for understanding.
**Design thinking routine.** Students practiced the design thinking routine through three units. By the end of the three units, students were able to independently generate ideas, prototype, test, improve, create a final product, and present and learn. Students who began the program with low creativity confidence attributed their uncertainty to lack of opportunity and time to be creative and their lack of ability to generate ideas. Through design thinking, students were given time and space to generate and improve on ideas. Design thinking compelled students to take risks, fail, try again, and succeed. Annie discusses the ability to take risks in the Makerspace,

Yeah, I feel like I'm much safer in the Makerspace because I can take risks…like "OK, what happens if we do that?" and then if it doesn't work, OK we won't do that again. But if I go up like in Math class and someone asks me what's the answer to that, I'm like "That's the answer." and "That's wrong, what are you doing?" You look stupid. It's like "OK, that hurts."

As Annie demonstrates, students felt “safer” to take risks and present ideas while learning in the Makerspace. Engaging in design thinking encouraged students to feel comfortable with ideation and tinkering. Some students chose to generate ideas tinkering while others chose to plan their ideas on paper. Some students, seemingly off task, were given time to sit and think without reprimand. This comfortable rhythm of thinking, ideating, prototyping, testing, and improving gave students critical skills for idea generation and increasing creativity. Further, the Makerspace teachers trusted the students as designers, to complete their responsibility at their own pace. The design thinking environment empowered students with creative agency.

**Naming and practicing creative activity, behaviors, and ways of thinking.** Because many students began the program unable to identify and describe creativity in more specific
terms, the Makerspace curriculum and instruction incorporated “creativity objectives.” For example, students were specifically asked to “tolerate ambiguity.” Mr. Stewart was heard saying, “It’s OK if you don’t know the outcome, I don’t know either!” Similarly, students were asked to “persevere.” The researcher participant held high expectations for student products by asking variations of the question “How can you make it better?” Students were also observed persevering without a prompt, through their design thinking routines they were compelled to try and try again. Creativity objectives were introduced as targeted skills and modeled for students. Students were given language to critique their own work, describing evidence of creative elements (i.e. novel, different, effective) and need for improvements.

During Unit 2, after direct instruction on divergent thinking, Myunghee wrote as her personal goal, “I want to make a car different from others.” Comments such as this example, comments from individual interviews, and observations show that students internalized the specific language and objectives that went along with identifying creative behaviors. In turn, students practiced these behaviors. As students spoke of creativity and practiced creative behaviors, these routines quickly became habits, as Sang Ook succinctly stated, “I made a new habit for try and try again.” Simonton (1990) claims creativity can be thought of as a habit, creative people habitually engage in creative endeavor. Creative habits became a part of a student’s identity in the Makerspace.

**A content-based product oriented assessment.** The Makerspace curriculum tasked students with solving a grade level academic content-based problem by creating a tangible, unique, final product for presentation. At the start of every unit, students were presented with a wicked problem inspired by the 5th grade standards based curriculum. The students were tasked with designing a solution to the problem. Thus, the students became engaged not just as learners
and consumers of content objectives, but as designers and innovators, thinking deeply about the content as a problem and designing possible solutions. They were pressed to make something NEW (novel, effective, whole) for an audience. Evidence shows this product orientation engaged students in their work. Student investment in the creative process as well as the creative outcome encouraged a creative identity. Further, students showed pride in their design while persuading others to accept the final product. This additional skill of persuasion enhanced the creative person as persuading an audience to accept an idea is a powerful creativity skill (Simonton, 1990).

**The Makerspace curriculum and environment gave students the opportunity to develop “creative fluency.”** Spending time tinkering in the Makerspace classroom environment and with classroom materials increased “creative fluency.” Creative fluency meant that students had automated ideation, design, and product oriented techniques while becoming more adept at the use of the physical space, tools, materials, and resources. The teacher was also a critical resource and peers were actively sought out for help and inspiration. This fluid movement between the individual, the physical space, and social environment in the Makerspace increased student engagement, ideation, and production.

**The physical space.** Students had to renegotiate preconceived notions of the classroom space. While the Makerspace teachers had set up the environment to compel students to be independent, to take risks, to use new materials, to move about the space, some students demonstrated caution and confusion. Learned behaviors from previous classroom experiences, especially for students from East Asian schooling, held students back from exploring and tinkering. Teachers had to model and encourage independence in the physical space. Teachers explicitly instructed students to use the space for their creative endeavors, from use of tools, to
choosing materials, to arranging an optimal workspace. As a result, all students became more assertive within the Makerspace by Unit 3. Understanding student beliefs and preconceptions on schooling, proved critical for optimizing the Makerspace classroom experience. Additionally, accommodating for individual differences created a Makerspace accessible to all.

In this case study, the Makerspace was adjusted to fit two students with special needs, one with ADHD (Jason) and one with ESL needs (Jin Hai). Jason was overwhelmed with the noise and activity, thus a quiet space was designated, where he could tinker (taking apart a Vex robot) to take a break. Also, constraining Jason to a few tools and materials, helped him organize his thoughts. Scaffolding Jason’s use of the physical space helped his planning and execution. Jin Hai received “hands on” vocabulary instruction regarding tools and concepts. The Makerspace teachers gave him one-on-one assistance and repetition and clarification of directions. More importantly, the freedom to move and talk in the Makerspace allowed Jin Hai opportunity to practice his language skills in an informal setting. His classroom teacher noticed Jin Hai was less quiet and used his limited English more frequently in the Makerspace.

The flexibility of the physical space quickly allowed for differentiated instruction and multiple points of entry. Hesitant students learned to assert themselves in the space, while students with special needs understood how to use the space to accommodate their skill level and behaviors. As students accessed the physical with more fluency and confidence, creative ideas and expression increased. As Jason mentioned the Makerspace allowed, “The [my] creative juice, all of it, went straight to the brain.”

**The social space.** Teachers and students created a creative culture and climate. Chris said in his final interview, “[The Makerspace] is really fun and that we get to make stuff, and it's like making stuff but learning at the same time.” As evidenced in observations and analysis of
interviews, the idea of “fun” permeated the environment. Although, at times, students shared conflicting views and students argued, it was observed students helped each other and shared joyous moments in success, and disappointment in failure. The students had fun and were engaged.

The Makerspace teachers helped create this climate by taking on several roles. The Makerspace teacher acted within a traditional educator role as expert and instructor, while incorporating a progressive role as advisor and guide. With new tools and a new curriculum, the Makerspace teacher took on an additional role as co-learner. Research shows teachers, like managers of organizations, set the culture and climate tone through their behaviors, language, and actions (Craft, 2006; Amabile, 1996/2012). Similarly, the Makerspace teachers encouraged a creativity climate through their practice and comfort acting as expert teacher to novice learner. First, the Makerspace teachers shared expertise in pedagogy (the researcher participant) and in making (Mr. Stewart). Mr. Stewart’s expertise in carpentry, electronics, robotics, was essential. Meanwhile, the researcher participant’s experience with pedagogy guided the curriculum with intention and adjusted the instruction to fit student needs. Classroom management regarding resources (Mr. Stewart) and regarding behavior (the researcher participant) was critical for student success. At the same time the Makerspace teachers tolerated a significant amount of ambiguity within this new learning space and new instruction. This role as a novice encouraged equity within the Makerspace community, where student and teachers could possibly reverse roles.

The Makerspace teachers also modeled and celebrated creativity. Through their language, enthusiasm, and tolerance of “chaos,” students understood their ideas were welcomed.
Mr. Stewart presented his philosophy of teaching as having a greater scope beyond learning objectives. He said,

In the Makerspace they are learning their grade level of objectives, but they’re learning so much more than that, they’re learning critical thinking and problem solving. I think that sometimes teachers come in here and they see the chaos, and they can’t handle it. Perhaps they think that students aren’t learning. These teachers are going to have reimagine or rethink what education is.

The Makerspace teachers enjoyed the “chaos” as much as the students. They celebrated successes and empathized with failures. They adjusted the curriculum and environment to make sure all needs were met, thus optimizing the students’ experience. This was especially important regarding “grit and perseverance” and “celebrating failure.” While recent education buzz words encourage these ideals, the Makerspace teachers noticed, at times, teaching grit and “it’s ok to fail,” was counterproductive. It was important to reflect on the reasons for failure (i.e. perhaps the lesson needed to be retaught differently, perhaps the student did not have the correct materials). Further, empathizing with frustration versus asking students to immediately persevere forged a co-learner relationship between the student and teacher. The various roles the Makerspace teachers embodied helped build a culture and climate fostering creative fluency.

Peer relationships also encouraged creative fluency. Similar to artist colonies, think tanks, or writers guilds, making together was inspirational. Students shared knowledge and taught each other skills. Dewei (a student participant, not an individual interview participant) became the expert electrician and taught his classmates how to make circuits. Nathan was adept at hacking materials and gave plenty of suggestions to his peers. The project of the European map is a perfect example of shared ideas. Each country’s region was painted with the respective
flag as a backdrop. This was not a project requirement, it was a consequence of one student’s idea and the idea was passed along to the other groups. In the end, the project came together cohesively. When Annie was asked how she felt that everyone took her idea she said, “I feel proud because everyone must have thought I had a good idea.” This sharing of ideas and expertise became seamless by the end of Unit 3.

The Makerspace curriculum and environment emphasized traditional curricular objectives. Students scored remarkably well on their traditional achievement tests and quizzes. All but two of the students scored 80% or above on all their social studies and science assessments. Having not studied for these tests, as these students had done in traditional class, the students and teachers were all surprised at the outcome. Exam questions ranged from low level understandings (definitions and labelling) to open ended questions (i.e. Describe the economy of Europe). Students were able to respond to these questions not through memorization of facts, but through mastery of facts. Through the making process students had multiple opportunities to explore and express the concepts. Students, however, did not score well on their persuasive essays. While students did well in their oral presentations, students did not perform as well in their writing, as judged by a persuasive writing rubric. Students who had earlier been identified as good writers scored well, but those who had earlier been identified as poor writers did not. For example, an excerpt from Chris’ essay persuading audiences to appreciate his puppet theater is below 5th grade expectations:

You can make your own puppets and then get inside the box and make a show or entertain your friends. Or you can use the puppets I made… I showed it to the class and everyone laughed and thought it was cool. So if you want, you can have a puppet theater too!
In reflection, writing objectives could have been more intentionally taught. Students could have been pulled in small groups to participate in a mini-lesson on writing. This was identified as a missed opportunity because students had acquired the vocabulary, the process, and passion for the topic.

Yet, the Makerspace curriculum and environment taught students traditional content objectives for science and social studies. During student interviews, all students (from students with generally low to high previous grades) understood, retained, and applied content knowledge. Jason remembered, “I learned Newton’s Law for every action there is an opposite and equal reaction…so when I snap the rod back the car will move because the energy is transferred.”

**Summary.** The SYIS K-12 Makerspace curriculum and environment gave students creative agency and the opportunity to become fluent in making and creativity processes. These two advantages encouraged a student’s creative expression, process, and output. At the same time, students learned valuable content material and were able to meet their traditional goals. As discussed in the next section, a creative individual needs both competencies, fluency in creativity processes and domain knowledge.

**Discussion of Findings in Relation to the Theoretical Framework**

Amabile’s seminal Componential Theory of Creativity (Amabile, 1996) regards creativity as the result of three components within the individual: 1) Creativity Relevant Skills; 2) Domain Relevant Skills; and 3) Intrinsic Motivation with the additional encouragement of one outside force, 4) the Social Environment. She states that these four components encompass the optimal state for creative engagement and production. To be creative, an individual needs to have creativity skills (i.e. tolerance of ambiguity, divergent thinking, and persistence), domain
relevant skills (i.e. expertise in content and use of materials), intrinsic task motivation (i.e. engagement despite obstacles), and the opportunity to work in a creativity-encouraging environment. The Componential Theory of Creativity (Amabile, 1996) grounds this research study’s findings in empirically based, seminal research on creativity.

The Componential Theory of Creativity was an appropriate framework for this study of creativity in a K-12 educative environment because, as Amabile (1996) points out, schools tend to predominantly teach domain skills (content) for mastery with much less emphasis on the other three components of creativity, the creativity processes (thinking strategies; confidence in one’s own creativity), task motivation (student engagement and accountability), and the social environment that supports creative activity and behaviors. For this case study, the Componential Theory of Creativity provided a lens from which to view creativity in the individual, how to track evidence of increase in creativity, and how to identify gaps or rival theories. Thus, the theoretical framework informed individual interview questions, was cross-referenced with observation tools, and rubrics for creativity evaluation (see Table 17).
The findings suggest that each component contributed to a student’s success for creative expression, and lacking one or another component had a significant impact. When students had strong domain knowledge, creative fluency, were intrinsically motivated, and the social environment encouraged their efforts, students were able to create exemplar final products. When students lacked in one component or another, their final products needed improvement. This finding supports Amabile’s (1996) theoretical framework regarding creativity.

To illustrate, the Unit 1 lesson asked students to research a geographic region of Europe (domain knowledge) and to create an interactive, information map to represent their knowledge (creativity relevant skills). The students needed to complete the project (task motivation) using the resources (social environment) of the Makerspace environment. According to a comparison

<table>
<thead>
<tr>
<th>Amabile’s Componential Theory of Creativity</th>
<th>Traditional Learning Goals</th>
<th>Tinkering Learning Dimension Framework</th>
<th>Support of Creativity in A Learning Environment (SCALE)</th>
<th>NEW (Novel, Effective Whole)</th>
<th>Individual Interview Questions (sample questions)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain Relevant Skills</strong></td>
<td>Content Knowledge</td>
<td>Developing Understandings</td>
<td>X</td>
<td>Is Effective: meets objectives, useful</td>
<td>Do you get good grades in school?</td>
</tr>
<tr>
<td><strong>Creativity Relevant Processes</strong></td>
<td>Thinking strategies and student expression</td>
<td>Engagement</td>
<td>Learner Engagement</td>
<td>Is Novel: uniqueness, surprise is shown</td>
<td>Are you a creative person?</td>
</tr>
<tr>
<td><strong>Task Motivation</strong></td>
<td>Student Engagement and accountability</td>
<td>Initiative/Intentionality</td>
<td>Learning Climate</td>
<td>Is Whole: took time to present near-perfect production values</td>
<td>Would you rather figure out a problem on your own or get help from the teacher?</td>
</tr>
<tr>
<td><strong>Social Environment</strong></td>
<td>The Classroom</td>
<td>Social Scaffolding</td>
<td>Physical Environment</td>
<td>X</td>
<td>What types of schools have you attended?</td>
</tr>
</tbody>
</table>
analysis of preliminary interview responses, and aggregating observation notes and scores from the Tinkering Learning Dimensions framework, students could be evaluated per creativity component. Unit 1 indications are shown and compared to Unit 3 indications (see Table 18).

Table 18

*Students’ indication of components from Amabile (1996) Theory of Componential Creativity*

<table>
<thead>
<tr>
<th>Name</th>
<th>Social Environment</th>
<th>Domain Relevant Skills</th>
<th>Creativity Relevant Processes</th>
<th>Task Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Grades in school)</td>
<td>(Self-report)</td>
<td>(Observed engagement)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Grades in Makerspace)</td>
<td></td>
<td>Unit1/Unit3</td>
</tr>
<tr>
<td>Chris</td>
<td>High</td>
<td>Low/Average</td>
<td>High/High</td>
<td>Average/High</td>
</tr>
<tr>
<td></td>
<td>Homeschooled in the U.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nathan</td>
<td>High</td>
<td>Low/Average</td>
<td>High/High</td>
<td>High/High</td>
</tr>
<tr>
<td></td>
<td>Waldorf schooling in Germany</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annie</td>
<td>Average</td>
<td>Average/High</td>
<td>Average/High</td>
<td>High/High</td>
</tr>
<tr>
<td></td>
<td>SYIS (American International School)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ellen</td>
<td>Average</td>
<td>Average/High</td>
<td>Average/High</td>
<td>High/High</td>
</tr>
<tr>
<td></td>
<td>SYIS (American International School)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jason</td>
<td>Average</td>
<td>Low*/Average</td>
<td>Average/High</td>
<td>Low/Average</td>
</tr>
<tr>
<td></td>
<td>SYIS (American International School)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Song-Yun</td>
<td>Low</td>
<td>High/High</td>
<td>Low/High</td>
<td>High/High</td>
</tr>
<tr>
<td></td>
<td>South Korea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myunghee</td>
<td>Low</td>
<td>High/High</td>
<td>Low/Average</td>
<td>High/High</td>
</tr>
<tr>
<td></td>
<td>South Korea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sang-Ook</td>
<td>Low</td>
<td>High/High</td>
<td>Low/Average</td>
<td>Average/High</td>
</tr>
<tr>
<td></td>
<td>South Korea</td>
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<tr>
<td>Chaoxiang</td>
<td>Low</td>
<td>Average/Average</td>
<td>Low/Average</td>
<td>Average/Average</td>
</tr>
<tr>
<td></td>
<td>Chinese International School (English section)</td>
<td></td>
<td></td>
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<tr>
<td>Jin Hai</td>
<td>Low</td>
<td>Low*/Low-Average</td>
<td>Low/Low-Average</td>
<td>Average/Average</td>
</tr>
<tr>
<td></td>
<td>Chinese Private School</td>
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</tbody>
</table>

The students exemplified the theoretical framework’s principles of creativity in a real world setting. For example, Chris identified with a creative individual in the preliminary
interview and discussed his motivation to make things during his homeschooling. He admitted he was not a “great” student. Chris thus presented as a high creativity, low domain skills student. In observations of Unit 1, he was observed engaged yet coping with high levels of frustration. He did not want to brainstorm or research, he wanted to just start tinkering. However, without the domain knowledge, Chris did not know where to begin and what to make. After receiving instruction from his teachers, and spending time researching, Chris was able to make something to reach unit objectives.

On the other hand, Song-Yun presented as a high domain knowledge and low creativity skills student. In her preliminary interview, Song-Yun demonstrates her vast knowledge and motivation to learn and do well in school. Yet, she displayed low confidence in her creativity, “I’m a little bit creative.” For the same Unit 1 project, Song-Yun was engaged in the research phase, but avoided tinkering and making. A comparison of the two projects (see Figure 35) is telling.
According to the Componential Theory of Creativity, although both projects touch the surface on creativity, and both students received high marks on their creative presentation and traditional assessment of an overview of Europe, the students fell short of the theoretical framework’s definition of creativity. When viewed through the NEW rubric one project lacks innovation (i.e. elements are standard), while the other project lacks substance (i.e. lack of content). The Componential Theory of Creativity demonstrates the substantive nature of creativity and the complexity and seriousness developing creativity requires.

As students progressed through the program, the Makerspace curriculum and instruction intentionally and iteratively taught creativity relevant skills and gave opportunity to practice these skills. The curriculum and instruction taught content objectives, domain knowledge, and
assessed for understanding. The social environment encouraged students to be intrinsically motivated and engaged in solving the problem to make something NEW. Overtime, these components: domain relevant skills, creativity relevant skills, intrinsic motivation with the support of the social environment helped students increase their creativity, albeit, incrementally.

Another example demonstrates how Sang-Ook a low creativity, high domain student from Unit 1, was able to bridge his domain knowledge with his increased practice and knowledge of creativity skills to make a unique final product for Unit 3 (see Figure 36).

![Figure 36. Sang-Ook’s increasing creativity over time](image)

A spotlight on Jin Hai is indicative on how Amabile’s (1996) theory can be applied to increase an individual’s creativity. Jin Hai, an ESL student, began the program demonstrating
low creativity skills, low domain knowledge, low task motivation, and coming from a school system with low expectations for creativity, and high expectations for test scores. Jin Hai faced several challenges working and learning in the Makerspace classroom. Yet, with the support of the Makerspace environment and curriculum, over time, Jin Hai was able to incrementally increase his creativity. He learned creativity skills, was given extra support for understanding domain knowledge, was observed engaged and motivated during the Makerspace class where his peers and teachers encouraged him.

As an example of change over time, the Makerspace program began with an introductory PowerPoint on “What it means to be a Maker.” Students were shown cross-cultural examples of Makers and their inventions. Afterwards students were asked to take exactly 15 minutes to draw and label what they thought of themselves as Makers. At the end of the program, students viewed the same PowerPoint and received the same assignment. This drawing comparison, along with evidence of Jin Hai’s performance in the Makerspace, shows that there is incremental growth in Jin Hai’s creativity. Where he did not like drawing before, and showed that he had little idea of making and being creative, Jin Hai writes in his final entry, “I think a lot of ideas in the Makerspace, and I make a lot of things. I am happy in the Makerspace” (see Figure 33). In this one sentence, Jin Hai explains he has domain relevant skills (thinks of ideas), he has creativity relevant processes (makes a lot of things), and has task motivation (happy in the Makerspace). Jin Hai draws all the things he made in the Makerspace, evidence of a growing portfolio of creative projects.
The Componential Theory of Creativity (Amabile, 1996) supports the findings of this investigation of creativity and learning in the Makerspace. Amabile (1996) explains creativity is not the result of one person’s genius or talent, in fact creativity is the result of a confluence of factors. Several studies confirm Amabile’s (1996) theory, that creativity is the result of using creative approaches for thinking differently, of being intrinsically motivated in the process, and having expert knowledge of the content, and knowing how to use available resources (Csikszentmihalyi, 1996; Simonton, 1990). Within this regard, the Makerspace program’s aim was to deepen understanding of content, to increase practice with creativity skills, and to increase motivation and engagement through an encouraging environment. In turn, by the end of the program, participant students who may have not identified as creative or may have not been singled out by their teachers for creativity could show their creativity.

Amabile’s (1996) framework provides an important perspective for teaching for creativity in the classroom. Creativity should be regarded as a complex activity. Creativity
cannot be taught as a separate competency; creativity needs to be taught within the context of a knowledge domain. Thus, teachers, who are motivated to teach for creativity, yet worried about changing their curricular units, can in fact imbed creative learning in their current lessons. Further, students cannot be quickly labeled as creative or not creative. A student who demonstrates creativity, but is off topic does not exhibit creativity because he or she is not working within the domain or context of the lesson. This student needs support in understanding the content, and applying his or her creativity to that topic. A student who demonstrates high content knowledge, receiving high marks on traditional tests, may not show creativity, but can be taught how to express himself or herself creatively. It is within the intersection of domain knowledge and creativity skills, with the desire to create, where a supportive environment, such as a Makerspace, can encourage a student’s creativity.

**Discussion of Findings in Relation to the Literature Review**

The findings reflect a strong connection to the literature reviewed in Chapter II. The literature examined in Chapter II revolve around four themes in relationship to this study:

- The definition of creativity
- Creativity in the classroom
- Makerspaces
- East-West conceptualizations of creativity

**What do you mean, “be creative?”** Ellen had a good point, when she asked this question during Unit 1. What does it mean to be creative? How can we teach this critical skill if we don’t know how to define and identify this complex construct? Plucker et al. (2004) state that creativity researchers must define creativity explicitly otherwise it can become a “hollow construct” (p. 90). With this suggestion in mind, creativity was explicitly defined for student
participants. While students suggested their own conceptions of creativity in the preliminary interviews, most often defined as something “original,” “different,” and “interesting,” creativity in the Makerspace was defined as a set of processes according to Amabile’s (1996) theoretical framework. Students were taught creativity comes from a set of processes, including risk taking, persistence, tolerance of ambiguity, and making something worthy of presentation and knowing how to defend their product. In addition, the final product was evaluated for creativity, using the NEW rubric (Novel, Effective, Whole) (Henricksen et al., 2015).

Identifying creativity processes and creativity products in the Makerspace was connected to Beghetto and Kaufman’s (2009) 4C model of creativity. Beghetto and Kaufman’s (2009) seminal research on creativity identified for types of creativity, “mini-C” creativity attributed to individuals who demonstrate joy in tinkering; “little-C” creativity demonstrated in everyday expressions of creativity; “Pro-C” as professional creativity, demonstrated in individuals who have a habit of creativity required by their professional activity; and “Legendary-C” creativity that engages a wide audience and can change world views. As demonstrated on the Tinkering Learning Dimensions Framework, by the end of the program, Makerspace student participants engaged in mini-C creativity by tinkering and making. Makerspace student participants also created little-C products, meaningful projects that demonstrated their creativity.

By identifying creativity processes (in the context of Amabile’s theory and mini-C tinkering) and creativity products (in the context of the NEW rubric and little-C), teachers and students were able to explicitly and deliberately reflect on their work with regards to creativity, and make adjustments and improvements on their next tasks. Beghetto and Kaufman (2009) suggest self-assessments are appropriate for examining the Mini-c level. The authors add that self-assessments can significantly benefit students by asking them to focus and reflect on their
creative capacity. Additionally, they help educators identify creative potential in students (Beghetto & Kaufman, 2009).

**Creativity in the Classroom.** Regarding creativity in the classroom, the literature review overwhelming suggested that creativity is not a prioritized concern for teachers (Beghetto, 2010; Schacter et al., 2006; Grigorenko & Sternberg, 1997). Although in recent years, creativity has become a more accepted classroom value (Aljughaiman & Mowrer-Reynolds, 2005; de Souza Fleith, 2000; Hartley & Plucker, 2014). Recent creativity mandates in education policy around the world and the Partnership for 21st Century Skills in the U.S. supports this noticeable shift in valuing creativity in the classroom (Beghetto, 2010; Hui & Lau, 2010). Yet, real time studies of classrooms across the nation, found little evidence of creativity being supported in the classroom (Aljughaiman & Mowrer-Reynolds, 2005; Beghetto, 2010; Schacter et al., 2006). The research suggests teachers do not prioritize creativity because of commitments to traditional standards and testing (Aljughaiman & Mowrer-Reynolds, 2005; Beghetto, 2010); teachers do not know how to teach for creativity (Sternberg, 2015); and creativity is often viewed as a distraction (Beghetto, 2007).

When the investigation engaged in peer ratings on the SCALE (Support of Creativity in a Learning Environment) (Richardson, 2016), responses from the head director and the traditional classroom teacher reflected these views on creativity in the classroom. Dr. Young and the 5th grade teacher were concerned whether the student participants were engaged in “deeper understanding.” They also observed students “off task” while the Makerspace teachers viewed the same behavior as “on task.” These different perspectives are indicative of the challenges facing teaching for creativity. An education setting without a common vision and understanding for progressive teaching and learning cannot support a creativity-fostering environment.
Hong et al. (2007) found teachers who led classroom environments supporting creativity had sophisticated beliefs about the nature of knowledge and intrinsic interest in creative work (p. 205). These teachers also reported having a goal orientation for mastery of skills. Mr. Stewart, the participant Makerspace teacher, as evidence by his commentary in interviews, shared a similar perspective on teaching and learning. To reconcile the differences between traditional teachers, such as Dr. Young and the 5th grade classroom teacher with Mr. Stewart’s progressive views on education Hong et al. (2007) suggests on going professional development in current research on creativity and learning, on mastery learning, and creating a school climate encouraging teachers’ personal creativity, could lead to more creativity in the classroom.

**Makerspaces.** The Makerspace at SYIS, established by Mr. Stewart and the researcher participant reflected the literature review’s recommendation for creative learning spaces. Through a comprehensive literature review, Davies et al. (2013) found school environments fostering creative development in students allowed for flexible use of space and time; offered safe and respectful relationship between teachers and learners; gave students choice of expression and materials; was open to play; and gave learners autonomy. The same study found the relationship between teachers and learners, including high expectations, mutual respect, exchange of dialogue, and embracing flexible perspectives also encouraged creative output (Davies et al., 2013). Students also modeled behaviors of teachers who expressed creative attitudes. The literature determined creative environments encouraged opportunities for working collaboratively with peers, which included peer and self-assessment (Davies et al., 2013).

In the same way, the SYIS Makerspace, as evidenced on the SCALE (Richardson, 2016) supported creative learning through a flexible learning space and a creativity encouraging social space. Students were given choice of expression and materials, and they were open to play.
“Open to play” was a difficult concept for teachers who peer rated the environment, while Makerspace teachers gave the environment high marks for student engagement, peer ratings showed concern over student’s “on task” behavior, the “play” was marked as “off task” behavior. Further, peer raters were concerned with the conflicts among students collaborating on a project. These stressful moments could have been mitigated with more time spent practicing and modeling collaboration and working in group settings. Nevertheless, students learned valuable skills on how to resolve disagreements and to work together.

Evidence from the Tinkering Learning Dimensions Framework showed students using several sophisticated dispositions in the Makerspace: 1) Engagement; 2) Initiative and intentionality; 3) Social scaffolding; and 4) Development of understanding. Through these activities students were able to increase their creativity while meeting their traditional educational goals. As Bevan et al. (2015) insist, “If the invitation to creativity is accompanied by intentional structure and guidance, maker activities can be channeled to support deep student learning” (p. 28).

Regarding the Makerspace in the classroom, Voussoughi and Bevan (2015) noted a suggestive trend to separate the Makerspace from the education field. Makerspace advocates feel that schools are restricting environments, anti-ethical to the Makerspace. This investigation showed that the Makerspace is a valuable learning environment for all students, and can work within the confines of a traditional brick and mortar school. It would be remiss to not offer this opportunity to students, based on nuanced assumptions of what learning and schooling represent. Further, for this study Makerspace teachers were called “teachers” while Makerspace advocates insist on calling Makerspace educators “facilitators” (Halverson & Sheridan, 2014). Evidence from this research study shows that teachers took on the traditional role as expert in content
(teaching content; use of materials) and expert in pedagogy (modifying instruction to meet special needs of students; classroom management) while facilitating, guiding, and co-learning with the students. When asking Mr. Stewart about his role in the Makerspace, he says, “It is still a teacher role, but I am also an advisor. When students ask questions, I point them in the general direction to find some answers, and they go off and try and figure it out.”

As Voussoughi and Bevan (2015) suggest, Makerspace aversion to curricular and content driven pursuits may “shortchange” the possibilities a Makerspace setting can offer for applied learning. In this case study it was important for students to engage in making within an intentionally planned and developed curriculum. Without this course work, problem based outcomes, and reflection students may have enjoyed tinkering yet the effort would not have been grounded in meaningful, deeper learning of content, skills, and discourse.

**East-West conceptualizations of creativity.** The diversity of student participants, from an international school in China, offered an interesting perspective on creativity. The school wide student population consists of 45% Korean students, 25% U.S. American students, 11% Chinese students, and the remaining 19% from countries around the world. The sampled population reflected these demographics the 5th grade class consisted of 18 students (7 Korean, 4 Chinese, 4 American, 2 Latin American, and 1 German). The setting was an opportunity to study creativity in a cross-cultural setting. Creativity researchers suggest cross-cultural studies enrich the knowledge about the nature of creativity (Niu & Sternberg, 2001; Rudowicz, 2003). Further, Giroux (1992) suggests, that educators must commit to individual differences as central to schooling (p. 45). Keeping these two suggestions in mind, the researcher referred to the literature review on Eastern and Western conceptualizations of creativity. The review informed the proposition:
Students will evidence different levels of creativity, with students of Western education experiences and backgrounds evidencing greater creativity in comparison to students of Eastern education experiences and backgrounds.

Recent cross cultural studies of creativity found participants of East Asian backgrounds consistently performed at lower levels of creativity than their Western counterparts (Niu & Sternberg, 2001/2003; Wang & Greenwood, 2013). Niu and Sternberg (2003) suggested the East Asian education system is one major consequence accounting for this discrepancy. Wang and Greenwood (2013) found similar results; the Chinese student participants perceived “their own lack of creativity was largely the consequence of the Chinese educational system” (p. 638).

Preliminary interviews from this study reflected findings from the research. Students from South Korean or Chinese education system lacked confidence in their creativity. When asked to describe their previous schooling experiences, they felt that there was little room for creativity in that setting. As Song-Yun explained, “The teacher just gave you a topic and then the teacher say, do something like this, and then OK, then we’ll copy a little bit and then copy other partners, something like that. So everyone is the same.” At the same time, students from a Western education felt confident about their creativity and could indicate examples of their creativity.

Yet, after spending six-weeks in the Makerspace, all students, regardless of background, stated that they felt creative. They pointed out times when they had expressed their creativity and were able to discuss the meaning of creativity. Still, the East Asian students were humble in their creative ability. For example, Myunghee claimed, by the end of the program, she was a “little bit creative,” even when she scored high on her final products and gained valuable skills in tinkering. Even so, all students showed an increase in creativity, confirming Runco (2003)
theory of personal creativity, that assumes, “creative potential is a part of the basic human
tendency to construct (personal) interpretations and assimilate information as we experience it”
(p. 321). Given the opportunity to experience and practice innovation in an encouraging
environment, everyone, despite ability, background and learned behaviors, can be creative
(Csikszentmihalyi, 1996; Glaveanu and Tanggaard, 2014; Runco, 2003). The photo below (see
Figure 38) shows Myunghee’s “Me as a Maker” drawings from before the program and after the
program. The first photo shows general ideas of what it means to be a maker, in the second
photo Myunghee gives specific examples and feels, “More creative than before.”

![Figure 38. Myunghee’s increasing creativity over time](image_url)
Conclusion

Through a qualitative exploratory case study, this research sought to understand how creativity is developed in a diverse group of students. The study responded to the following research questions:

1. How does a Makerspace curriculum, activities, and classroom environment foster creativity in a class of culturally diverse adolescent students?

2. How does a Makerspace curriculum, activities, and classroom environment support student learning of targeted academic subject matter objectives in a class of culturally diverse adolescent students?

Over the course of six weeks, the research study observed the activity of a multi-cultural, diverse group of students (n=18) in the Makerspace setting. Highlighted individual students (n=10) shared their stories and ideas; their reflections gave an invaluable account of the experience. The Makerspace teacher was interviewed and his perspective gave voice to the backstage events and planning needed to make this program possible. Student artifacts collected showed progress and evidence of creativity. Through the analysis of this data, the researcher determined the Makerspace program fostered creativity in all students, while supporting student learning of academic content.

Results of this study showed the Makerspace curriculum and environment gave students the tools and resources needed to achieve fluency in creative endeavor. As a result this fluency, students became creative agents. By the end of the six weeks, all students could recall a time they were creative, all students thought they were creative individuals, and all students could identify and engage in creative behaviors.
It is important to note, the shift toward creativity was incremental, and a difficult journey for some students. Several students began the program unsure of their creativity. These students had spent a majority of their schooling in traditional systems where rote learning was a pedagogical priority. At the same time, students who felt creative and eager had to be directed to keep focus on curricular goals. All students had to reconcile their capacity for creativity with their content knowledge, while keeping their motivation and spirits high in the face of a challenge. The challenge was not merely presenting something unique or different, as general beliefs on creativity suggests. The challenge was to present something new, effective, and whole.

**Significance of the Study**

This research study confirms Runco’s (2003) theory of creativity and presents a window into the possibilities of what a Makerspace program can bring to a traditional education setting. First, the Makerspace program gave students an opportunity to practice creative agency while mastering content objectives. Second, the study dispelled several stereotypes and myths regarding creativity. Third, the study provided an idea on what a re-imagined classroom, such as the Makerspace class presented, could look like for 21st century learning. The findings of the study respond to the question that is often asked of a Makerspace, “What is learned here?” (Voussoughi & Bevan, 2014). Yet, to illustrate the *significance* of this study, perhaps the reader can ask the same regarding traditional classroom environment, “What is learned here?” and compare outcomes.

**Opportunity.** Evidence shows the Makerspace curriculum, activities, and environment inspired students to become creative agents, persistent learners, and confident in their work. Students learned hard skills (i.e. use of tools) and soft skills (i.e. research) to make something
tangible and presentable to the world. They learned creative processes such as design thinking, ideation, and tolerance of ambiguity, while practicing 21st century essential skills including critical thinking, collaboration, and communication. Perhaps most notable for students, was the sense of engagement and joy they found in the students. Over and over again, students mentioned “fun” to describe the Makerspace. Students were observed engaged beyond on task, not noticing the time pass. They complained when it was “time to clean up and go,” so much so that students asked to work on their projects during their scheduled free time.

At the same time, as evidenced by student test scores, students mastered traditional academic content. The 5th grade students were used to a traditional, mainstream learning routine: presentation of content by the teacher, completing assignments based on the content, call and response discussion, and completing a unit test to check for understanding (Beghetto and Kaufman, 2014). Findings from this study demonstrated the Makerspace design thinking routine and the traditional, mainstream learning routine arrive at the same outcomes on test scores, if not better for Makerspace students (i.e. Jason’s, the student with ADHD, passing scores).

Comparing the traditional classroom to the Makerspace learning environment is a valid consideration. Arguably, students miss critical opportunities for learning, growth, experience, and joy when confined to a traditional classroom routine. They miss the opportunity to become creative agents and achieve “creative fluency.” The findings from this study are significant for educators who want to provide these critical opportunities.

It seems educators are eager to embrace the Makerspace movement within schools and libraries (Halverson & Sheridan, 2014; Zhao, 2012) as a way to incorporate 21st century learning skills such as creativity. The results of this study confirm and encourage the Maker Movement within the K-12 setting yet with a sense of caution. This study signifies the importance of
structuring “making” with well-developed lessons that include rich interdisciplinary content, checks for understanding and progress monitoring, and rubrics for reflection and feedback. The study suggests the environment must also be structured to create conditions that facilitate collaboration and careful playing. Teachers must explicitly model language objectives and tinkering to encourage optimal student engagement and discourse about their practice as makers and 21st century learners. As antithetical to “making” as this structure presents (Voussoughi & Bevan, 2015), the study highlighted participants developing creativity and expertise within the context of curricular objectives. Without this context, students may have tinkered without mastery of skills and objectives and without internalizing and reflecting on their learning and activity.

Dispelling stereotypes and myths. The literature pointed to differences in cross-cultural conceptions of creativity, especially between East Asian and Western societies (Niu & Sternberg, 2001/2003; Rudowicz, 2003; Wang & Greenwood, 2013). In these studies, Western participants were more apt to assert their creativity while East Asian participants were more hesitant. Preliminary interviews with students from this study reflected this dichotomy. Yet, evidence shows, the Makerspace program dispelled these differences in creativity self-efficacy and performance. All students at the end of the six-week program, regardless of differences, developed a creative agency, confirming Runco’s (2003) position, everyone has creative potential that is either developed or stifled by societal pressures and by opportunities (or missed opportunities) for experience and practice (Csikszentmihalyi, 1996; Glaveanu and Tanggaard, 2014; Runco, 2003).

Further, myths on creative individuals as “gifted and talented” or “rebellious” were challenged. Creativity has often been associated with “giftedness,” yet as Hennessey & Amabile
(2010) indicated, these two constructs should not be equated because it often limits creative opportunities to high achieving students. Similarly, this study’s results show creativity should not be equated with “giftedness.” In the Makerspace, high achieving students struggled along with low achieving students. Song Yun, the highest achieving student of the 5th grade (as measured by grades and awards), experienced her first failure while engineering her mousetrap car, to the point where she “dreamt about the problem” and fixed it “in my dream.” At the same time, creative individuals might be associated with misbehaviors and students who frequently cause classroom distractions (Beghetto, 2007; Wetsby & Dawson, 1995). As a result, it could be assumed that “active” students might excel in a creative learning environment. Jason, the student with ADHD, could fit this category; a student with need of frequent movement, impulsive responses to classroom questions, and an avid comic drawer. Yet, Jason found the freedom of choice and materials overwhelming, which led to unsafe behaviors that caused him to be removed from the class. With accommodations, Jason was able to channel his “creative juices” (as he describe them) to be productive and focused in the Makerspace.

Dispelling these stereotypes and myths is a significant outcome of this study. Although it was important to account for differences to optimize the Makerspace experience, with support, all students, (i.e. high achieving, low achieving, students with special needs and diverse backgrounds) were able to explore their creative agency at their own pace and approach.

Change. The study recorded the development and implementation of the Makerspace program. It is important to note the endeavor was not necessarily an upheaval of any current programs. The program was embedded into the structure of the school day, using the same curricular objectives and lesson plan template. The Makerspace was created from an old computer lab of typical classroom size, using limited funds and up-cycled materials. Yet, while
the Makerspace functioned in a traditional school space, the *change* in student learning was significant with increased opportunities to practice 21st century skills. Change in the classroom’s physical and social environment also supported 21st century learning. Notably, teachers and students changed their preconceived notions of teaching and learning. These changes had a positive effect on students’ engagement and capacity to be creative while achieving traditional standardized outcomes.

Keeping these changes in mind, the Makerspace presents a convincing model for reimagining the classroom. The study suggests several recommendations for starting and developing an educationally successful Makerspace program:

1. It is important that Makerspace teachers have a maker skill set (carpentry, electronics, robotics) as well as pedagogical knowledge. While co-learning is an important part of Makerspace teaching, having Mr. Stewart’s knowledge of tools and making was essential to the program.

2. The Makerspace physical environment must be a flexible space, have a variety of workstations, and tools and materials readily available

3. The Makerspace program must be supported with a curriculum that includes essential questions, intended outcomes, planned activities, and differentiation. The design thinking routine serendipitously mirrors a traditional unit lesson (i.e. the Understanding by Design framework). The school’s current curriculum can be used to inform Makerspace projects
4. Accounting for individual differences without tracking student ability (i.e. gifted and talented or special needs) is paramount

**Limitations**

Several limitations in this case study may have influenced results. First, the researcher’s role as researcher participant is of concern. Engaging in the study as a researcher participant opens the study to several vulnerabilities. The researcher’s closeness to the Makerspace program, as co-developer, and closeness to the students, as co-teacher could lead to over-interpretation or skewed representation of observations and analysis of the data. I attempted to account for these issues by collecting multiple sources of data, including live recordings of students working and photographs. I welcomed peer ratings from teachers not participating in the study and presented their rival perceptions in the reporting of the findings. Further, Mr. Stewart read the study’s findings for member checking. His feedback helped improve the study’s accuracy and credibility.

Further, individual student interview responses may not necessarily reflect a student’s true feelings or honest assumption of their creativity and their experience in the Makerspace program. Although students understood that I did not give out grades on their PowerSchool report cards, and that any evaluation in the Makerspace was self-reflective, students may have exaggerated their response. Students may have felt compelled to report differently than their actual beliefs. I attempted to control for this by allowing semi-structured interviews to evolve to open ended questioning. When students made general responses, I followed up by asking for specific details and examples, to ensure accuracy of responses.

A study of a complex construct such as creativity presents several challenges to validity and reliability. First, creativity is an abstract phenomenon that is hard to describe or measure.
Second, evaluation of creativity is inherently subjective. Further, creativity is also elusive, as Chris mentions in his preliminary interview, “I am creative when I’m in a good mood.” Thus findings for this Makerspace program cannot be generalized.

Understanding these limitations, the researcher took great care to record a wide variety of data from multiple sources. Further, the researcher established case study propositions to focus the study and the collection of data. At the same time, the researcher remained open to rival propositions allowing the data to emerge on its own.

Future Research

This exploratory case study of a group of multicultural students’ experience in a K-12 Makerspace program offered a rich illustration of how this learning environment fosters creativity within each student participant. The wide lens this study took in investigating creativity offered a foundation for further meaningful research in the area. The study could be replicated in a different Makerspace setting, for example from an international school to a domestic U.S. based public school. It would be interesting to compare outcomes between research studies, investigating for differences and gaps. This could detail essential elements for incorporating a Makerspace program.

Creativity researchers and researchers interested in investigating the effects of the Makerspace environment on students and learning could also hone in on various aspects of this study. Several interesting moments emerged during this study that merit further investigation.

A closer look at special populations, specifically students with ADHD/students with English as a Second Language, is recommended for future research. This study was fortunate enough to have a representative population. ADHD and ESL students in this study were supported with typical accommodations for their needs. Yet, both students quickly increased
their percentage of engagement, developing understandings, tinkering, and ideation over the course of the six weeks. Further, their test scores showed an improvement over typical classroom test scores. It would be interesting to understand the benefits and challenges of Makerspace learning for special populations.

A study of integrating a non-traditional learning space into a traditional learning environment could assist administrators planning for a Makerspace program in their schools. The differences between the Makerspaces’ teachers and Dr. Young and the 5th grade teacher’s responses on the SCALE was an impetus for critical discussion regarding the purpose of teaching and learning; the difference between enrichment courses and core content learning; and 21st century 4Cs learning. These differences merit an exploration of the Makerspace program implementation and sustaining it through a common school wide vision.

A direct investigation of the Makerspace teacher and the variety of roles and skills the Makerspace teacher requires is a significant research inquiry. Mr. Stewart’s expertise with hard skills (i.e. carpentry, robotics) was invaluable. Further, his creative spirit (i.e. risk taker, tolerance of ambiguity) and personal progressive philosophy of education allowed the Makerspace to emerge without reservation. At the same time, “Mrs. MaryAnn’s” commitment to research based best practices in instruction ensured structure, evaluation, and classroom management. It is unknown whether the Makerspace program could achieve similar outcomes without this balance of expertise.

A focus on student’s products and inventions and their evaluations of their work warrants investigation. The NEW rubric was used as tool for personal reflection, group critique, or one and one conferencing with the teacher. The rubric was “stress free” as students graded their own
work. It would be interesting to see if an extrinsic motivator, such as true grade in Power school reporting, would change or improve outcomes.

**Recommendations**

Based on the findings of this investigation, several recommendations regarding fostering creativity in a Makerspace setting are offered. First, as stated, individual differences must be accounted for, yet teachers must dispel stereotypes regarding backgrounds and myths of gifted and talented, hyperactive students. The Makerspace is a place for every student, leveling the playing field as a consequence of the variety of skills, talents, knowledge, and strengths Makerspace projects tap into. Second, students need to be supported with a common vision and common language for creativity. Makerspace teachers can intentionally name and model creative behaviors, and understand that a student seemingly “off task” student may be thinking or tinkering towards an idea. At the same time, consistently encouraging “persistence,” “grit,” and “celebrating failure” can be counterintuitive. When students are frustrated, not empathizing with the student might be damaging. Further, when “try again” or “it’s ok that you failed” are too common and consistent, teachers might need to make curricular/instructional adjustments.

Third, the Makerspace teachers, along with school wide support, must commit to teaching and learning “differently.” The change does not have to be revolutionary, yet preconceived notions of an education must be renegotiated. A design thinking routine can increase creativity skills while encouraging students to master content goals; Makerspace fun, flexibility, and tinkering is not a “waste of time” or an after school activity, students learn important skills and knowledge; and respecting students’ capacity to self-direct, to choose, to work at their own pace, and to be accountable for their work is a liberating concept. Much like
students solving a “wicked problem” (see Figure 39), with intentional planning, evaluation, reflection, and dedication, a Makerspace program can work inside a traditional school space.

Figure 39. It works! Student expressions testing their prototypes with success

Personal Comments

The research study began with a muse, the story of Max in *Where the Wild Things Are* by Maurice Sendak (1963). Max is sent off to bed without his supper “for creating mischief of one kind of the other.” Max, not to be undone, conjures up a magical setting in his room and sails off on an imaginative journey to the land of the wild things. In the same way, the research has taken course, since that beginning, on a great journey of discovery. The idea of creativity began as a “wild rumpus” and today I understand creativity as a sophisticated, complex construct; a wild rumpus tempered with resilience, hard work, and expert knowledge encouraged within a creative community. I imagined students would jump at the chance to be creative, to embrace the
freedom of flexibility and choice, and they showed me caution. I assumed the Makerspace setting would be the ultimate accommodation for a student with ADHD, yet, at times the setting was too overwhelming. Highly creative students showed their talents, but needed support in making meaningful, knowledge based projects for presentation. I heard words from a student that I have never heard in my 18 years of teaching, “Mrs. MaryAnn I dreamt about the problem! And I fixed it in my dream!” There is no deeper learning that what this comment from Song Yun illustrates. I watched Mr. Stewart, an amazing first year teacher, tirelessly plan and arrange, and bring resources and grand ideas to the Makerspace project. Annie’s words illustrated the Makerspace program best when she called it “A tornado in my brain.” Over six weeks, every moment told a story, and evidenced student learning and growth in so many directions.

Now that the winds have subsided, and as Sendak’s story ends with Max returning to his home for contemplation, I believe I only touched the surface of Makerspace happenings and student experience. It is evident students became more creative, they attested to this in their interviews. Their words were compared to their artifacts, and that data was compared to their observation checklists. My results were member checked by Mr. Stewart. Yet, the vignettes within this research project merit further investigation, as stated above. These types of investigations will contribute to recommendations on how to best implement a Makerspace program, a promising model for learning, in a K-12 classroom. It is the hope of this researcher that this investigation may inspire educators to teach for creativity, for all students despite differences, and provide this opportunity through a Makerspace program.
References


Brandau, H., Daghofer, F., Hollerer, L., Kaschnitz, W., Kellner, K., Kirchmair, G., ... & Schlagbauer, A. (2007). The relationship between creativity, teacher ratings on behavior,


Fried, B., & Wetstone, K. (2014). President Obama at the White House Maker Faire:“Today’s DIY is tomorrow’s ‘made in America’”[White House blog post].


Perrine and Broderson


Torrance, E. P. (1972). Can We Teach Children to Think Creatively?


## Appendix A

The Tinkering Learning Dimensions Framework: Classroom observation tool

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicators</th>
<th>Descriptors: Learners demonstrate:</th>
<th>Cross-reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement</td>
<td>Spending time in Tinkering activities</td>
<td>play, envision, make, explore materials, try something over and over, etc</td>
<td>Creativity</td>
</tr>
<tr>
<td></td>
<td>Displaying motivation through affect or behaviors</td>
<td>-show emotions such as joy, pride, disappointment, frustration -remain after they appear “finished,” and start something new</td>
<td>Relevant Skills</td>
</tr>
<tr>
<td>Initiative and Intentionality</td>
<td>Setting one’s own goals</td>
<td>-set goals / pose problems-plan steps for future action-develop unique strategies, tools, objects or outcomes-state intention to continue working outside Studio</td>
<td>Intrinsic</td>
</tr>
<tr>
<td></td>
<td>Seeking and responding to feedback</td>
<td>-actively seek out feedback or inspiration from materials/environment-anticipate further outcomes-innovate approaches in response to feedback</td>
<td>Motivation</td>
</tr>
<tr>
<td></td>
<td>Persisting to achieve goals in the problem space</td>
<td>-persist toward their goal in the face of setbacks or frustration within the problem space-persist to optimize strategies or solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taking intellectual risks or showing intellectual courage</td>
<td>-disagree with each other's strategies, solutions, or rationales -try something while indicating lack of confidence in outcome</td>
<td></td>
</tr>
<tr>
<td>Social Scaffolding</td>
<td>Requesting or offering help in problem solving</td>
<td>-request or offer ideas and approaches-offer tool(s) or materials in service of an idea</td>
<td>Social</td>
</tr>
<tr>
<td></td>
<td>Inspiring new ideas or approaches</td>
<td>-notice, point out, or talk about others’ work -innovate and remix by using or modifying others' ideas or strategies-leave something of their work behind to share with others</td>
<td>Environment</td>
</tr>
<tr>
<td></td>
<td>Physically connecting to others’ work</td>
<td>-produce work that physically interacts with other learners' work</td>
<td></td>
</tr>
<tr>
<td>Development of Understanding</td>
<td>Expressing a realization through affect or utterances</td>
<td>-show excitement when expressing a realization-claim to realize or newly make sense of something</td>
<td>Domain</td>
</tr>
<tr>
<td></td>
<td>Offering explanation(s) for a strategy, tool or outcome</td>
<td>-offer or refine explanation(s) for a strategy, tool or outcome, possibly by testing and retesting</td>
<td>Relevant</td>
</tr>
<tr>
<td></td>
<td>Applying knowledge</td>
<td>-connect to prior knowledge, including STEM concepts-employ what they have learned during their explorations-complexify by engaging in increasingly complicated and sophisticated work</td>
<td>Skills</td>
</tr>
<tr>
<td></td>
<td>Striving to understand</td>
<td>-indicate not knowing (e.g., through surprise, bewilderment, confusion) and remain in the problem space to explore their confusion and build an understanding</td>
<td></td>
</tr>
</tbody>
</table>

Appendix B
Tinkering Learning Dimensions observation checklist example

<table>
<thead>
<tr>
<th>Jason*</th>
<th>Key:</th>
<th>Green= Unit 1 (9 days); Orange= Unit 2 (10 days); Purple= Unit 3 (6 days)/ X=evidence of learning dimension; 0=lacks evidence of learning dimension; A=removed from class for behavior issues; n/a= absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Engagement</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>Spending time in Tinkering activities</td>
</tr>
<tr>
<td>X</td>
<td>A</td>
<td>play, envision, make, explore materials, try something over and over, etc</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>Displaying motivation through affect or behaviors</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>- show emotions such as joy, pride, disappointment, frustration</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>- remain after they appear “finished,” and start something new</td>
</tr>
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<td></td>
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<tr>
<td></td>
<td></td>
<td><strong>Intrinsic Motivation</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>Setting one’s own goals</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>- set goals / pose problems</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>- plan steps for future action</td>
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<td>X</td>
<td>X</td>
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<td>- state intention to continue working outside Studio</td>
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</tr>
<tr>
<td>X</td>
<td>X</td>
<td>- anticipate further outcomes</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>- innovate approaches in response to feedback</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>Persisting to achieve goals in the problem space</td>
</tr>
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<td>X</td>
<td>X</td>
<td>- persist toward their goal in the face of setbacks or frustration within the problem space</td>
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<td>X</td>
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<td>X</td>
<td>- try something while indicating lack of confidence in outcome</td>
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<td>Social Environment</td>
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<tr>
<td></td>
<td></td>
<td>- leave something of their work behind to share with others</td>
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<table>
<thead>
<tr>
<th>Domain Relevant Skills</th>
<th>Expressing a realization through affect or utterances</th>
<th>Offering explanation(s) for a strategy, tool or outcome</th>
<th>Applying knowledge</th>
</tr>
</thead>
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<tr>
<td></td>
<td>- show excitement when expressing a realization</td>
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<td>- connect to prior knowledge, including STEM concepts</td>
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<tr>
<td></td>
<td></td>
<td></td>
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<th></th>
<th>Striving to understand</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- indicate not knowing (e.g., through surprise, bewilderment, confusion) and remain in the problem space to explore their confusion and build an understanding</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C

5th Grade Overview of Europe unit test
Open ended questions

1. Discuss the ECONOMY of Europe. Identify the industries of some of these European nations. Would you say that Europe has a strong economy? Why?

   Economy of Europe is mostly about trading. I would say that Europe has a strong economy because it can import and export (trading) so they can earn lots of money. Trading was the main economy of Europe and it made them rich. Don’t forget agriculture, manufacturing, and banking!

2. Discuss the GEOGRAPHY of Europe. How does geography effect country boundaries? How does geography effect the economy?

   The geography of Europe were they had seas, rivers, and mountains, etc. Most of the country boundaries are based on the geography. If they have rivers and seas their economy is likely to be trading or catching fish because that is the main thing they can do. The economy follows the geography of a country.

3. Discuss the POLITICS and HISTORY of Europe? What kind of government did Europe have in the past? What types of government does Europe have now? Why do you think the countries of Europe decide to unite into one European Union?

   In past, most of them had monarchy. In WWS, they had some dictators, but now there are many republic (democratic) countries. Europe is made out of small countries. To beat the bigger countries, they should unite and become up a team. They will be more stronger by that. So European Union was made.

4. Of all the European countries, which culture interests you the most? Would you like to visit this country? Why?

   Italy’s culture was interesting because their main economy was about fashions and designs. It has a lot of seas bordering it, but their main economy is not trading or something that is related to ocean. (I’m only talking about nowadays)
Appendix D

5th Grade laws of motion quiz

1. The first law of motion states
   a. that an object at rest will remain at rest.
   b. that an object in motion will remain in motion.
   c. that an unbalanced force can change the velocity of an object.
   d. all of the above.

2. Which of the following is not used to reduce friction?
   a. wheels
   b. ball bearings
   c. oil
   d. rough surfaces

3. An example of balanced forces is
   a. a person skating back and forth on an ice rink.
   b. a tire with treads gaining speed on an icy road.
   c. two soccer players running in opposite directions.
   d. a book resting on a desk.

4. A force that sets an object into motion is
   a. balanced.
   b. friction.
   c. unbalanced.
   d. inertia.

5. The force that works against motion is
   a. friction
   b. newton
   c. direction
6. For every action there is an equal and opposite reaction is which of Newton's Laws of Motion?
   a. First
   b. Second
   c. Third

7. Which is the best example of gravity?
   a. A car hits a tree, and its motion stops
   b. A breeze blows, and a sailboat moves
   c. A book is pushed, and it moves across the table
   d. A person drops a ball, and it falls to the ground

8. Why are we able to walk on Earth?
   a. Sun
   b. force
   c. gravity
   d. motion

9. A ______ is a push or pull and can make an object stop, speed up, slow down, or change direction.
   a. gravitation
   b. work
   c. force
   d. inertia

10. If gravitation suddenly stopped, Earth would move ____________.
    a. in orbit with the sun
    b. in the opposite direction
    c. nowhere
    d. in a straight line
Appendix E
SYIS 5th Grade Persuasive Essay Writing Rubric

Writing Samples from Unit 3 Express Yourself projects

Song Yun receives a 100% for her writing. Song Yun is normally excels in writing.

Chris receives a 60% for his writing. Chris is normally performs below grade level in writing.

The Ballerina Dancer
A Toy by Song-Yun

The Ballerina Dancer is an incredible toy that is perfect for any little girl’s room. This is a decorative toy, yet, you can play with it too! The dancer is dressed in a pink tutu and her brown hair is high in a bun. She is in a leaping position, with her arms pointing back, and her leg pointed behind. The movement is beautiful. Little toys surround the ballerina and watch her dance.

Little girls can make the Ballerina Dancer move by turning the crank. The crank turns the rod, and that spins the cam. The cam then pushes the ballerina dancer up and down, while spinning her around and around. It is truly a neat mechanism. The box is designed so that little girls can see the gears moving. A clear plastic covers the gears, so curious hands can look but they cannot touch. The Ballerina Dancer toy can inspire imagination for dancing as well as engineering. Because, remember, a girl can do anything— from being a dancer to being an engineer.

The Puppet Theater— By Chris

The Puppet Theater is cool because you can play inside it with your friends. You can make your own puppets and then get inside the box and make a show or entertain your friends. Or you can use the puppets I made. I made Minecraft puppets and drew the setting and wrote the script. I showed it to the class and everyone laughed and thought it was cool. So if you want, you can have a puppet theater too! You can be creative like me!
# Appendix F

NEW rubric and final project sample

## NEW CREATIVITY RUBRIC:

<table>
<thead>
<tr>
<th>Novel</th>
<th>1—Complete lack of anything unique or novel, and/or a lack of content and substance to offer opportunities for novelty.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2—Fairly lacking in unique, fresh or novel qualities. Most elements are quite standard and unconventional.</td>
</tr>
<tr>
<td></td>
<td>3—Relatively standard approach. While there may be a few unique qualities, it does not necessarily stand out among other projects (average).</td>
</tr>
<tr>
<td></td>
<td>4—Some qualities of uniqueness, and relatively interesting, fresh, unique</td>
</tr>
<tr>
<td></td>
<td>5—Strong qualities of uniqueness, and exciting or interesting to peers and teachers; is very novel or different from other examples in the class.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effective</th>
<th>1—Complete lack of effectiveness, and lack of content or substance relevant to objectives; The final product does not work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2—Fairly ineffective. The final product may not work, yet contains some elements of design and effort.</td>
</tr>
<tr>
<td></td>
<td>3—Somewhat effective approach relevant to objectives; however there remain some flaws or areas that need to be improved</td>
</tr>
<tr>
<td></td>
<td>4—Effective approach relevant to objectives. The final product works, with little need for improvement.</td>
</tr>
<tr>
<td></td>
<td>5—Excellent and highly effective. The final product works, succeeds in meeting objectives</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Whole</th>
<th>1—Little or no aesthetic qualities. Poor, or complete lack of, production values, and indicates little or no thought to the design of the project.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2—Few aesthetic qualities, showing weakness in aesthetic appeal or production values. Clear flaws or minimal thought given to the design of the project.</td>
</tr>
<tr>
<td></td>
<td>3—Some aesthetic qualities, but also somewhat conventional or standard aesthetic appeal. Some thought to the design of the project is evident, though overall the production values and aesthetic appeal are fairly average; reasonably well done, but lacking in any “stand out” appeal.</td>
</tr>
<tr>
<td></td>
<td>4—Good aesthetic qualities, and sharp or polished production values. The aesthetics qualities help make the project interesting and thought-provoking to teachers and peers.</td>
</tr>
<tr>
<td></td>
<td>5—Excellent or exceptional aesthetic qualities. Flawless or near-perfect production values; approach provides rich sensory interest (visual, auditory, etc.), and all aspects of the design of the project are well thought-out to provide aesthetically cohesive, or a “whole” project that is exciting, thoughtful and stimulating to teachers and peers</td>
</tr>
</tbody>
</table>

15-11: HIGH CREATIVITY  
10-6: AVERAGE CREATIVITY  
5-1: BELOW AVERAGE
Song Yun was proud of her final project, “I succeeded here.” As we look at her Automata, the dancing girl, Song Yun gives herself a 15/15 on the NEW rubric. The project is unique, it works (the turning mechanism), and the project is neatly crafted.

Song Yun’s Unit 1 group project. She stayed in her comfort zone, researched and wrote the facts in bullet point format, rather than take a risk and represent the information in another way. Yet, the group gives themselves a 15/15 on the rubric.

### NEW CREATIVITY RUBRIC

#### Novel
1. Complete lack of originality or novelty, and a lack of content and substance to offer opportunities for novelty.
2. Faulty looking in unique, fresh or novel qualities. Most elements are quite standard and uninteresting.
3. Relatively standard approach. While there may be a few unique qualities, it does not necessarily stand out among other projects (average)
4. Some qualities of originality, and relatively interesting, fresh, unique

#### Effective
1. Complete lack of effectiveness, and lack of content or substance relevant to objectives. The final product does not work.
2. Faulty effectiveness. The final product may not work, but contains some elements of design and effort.
3. Somewhat effective approach relevant to objectives; however, there remains some flaws or areas that need to be improved.
4. Effective approach relevant to objectives. The final product works, with little need for improvement.

#### Whole
1. Little or no aesthetic quality. Poor, or complete lack of production values, and includes little or no thought to the design of the project.
2. Few aesthetic qualities, showing weaknesses in aesthetic appeal or production values. Clear flaws or minimal thought given to the design of the project.
3. Some aesthetic qualities, but also some conventional or standard aesthetic appeal. Some thought to the design of the project is evident, though overall the production values and aesthetic appeal are fairly average; reasonably well done, but lacking in any “stand out” aspect.
4. Good aesthetic quality, and sharp or polished production values. The aesthetic qualities help make the project interesting and thought provoking to teachers and peers.

#### 15/15: HIGH CREATIVITY

[9-10: AVERAGE CREATIVITY]

[1-2: BELOW AVERAGE]
Appendix G
Individual Student Semi-Structured Interview Questions

I. Pre-interview/Pre- Makerspace Experience Interview Questions
Introduction: Hello _________, I am Mrs. MaryAnn. I am here helping Mr. Stewart, the Makerspace teacher, teach you in the Makerspace class. We hope the class will be an enjoyable and meaningful experience for you. Before we start the program, can you tell me a little bit about yourself? (Name, Age, Cultural background, primary language, years in international school, years in national school, favorite subject, etc.)

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Questionnaire category</th>
<th>Research Question Cross reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In this class we intend do our [classroom content] work and be creative in our work, what does it mean to be creative? Would you say you are a creative person? Can you give me an example of when you were creative?</td>
<td>Creativity Self-Efficacy Beliefs</td>
<td>RQ 1</td>
</tr>
<tr>
<td>2. What do you think about creativity? (Do you think it's important to be creative? Do you value creativity?)</td>
<td>Creativity Values</td>
<td>RQ 1</td>
</tr>
<tr>
<td>3. Tell me about the types of schools you have attended. Were the opportunities to be creative?</td>
<td>The Social Environment</td>
<td>RQ 1, 2</td>
</tr>
<tr>
<td>4. Are you a good student? How do you know?</td>
<td>Domain-relevant skills</td>
<td>RQ 2</td>
</tr>
<tr>
<td>4. In class, how do you learn best? For example, do you like to listen to the teacher and have the teacher tell you what to do? Do you want the teacher to tell you the facts? Or do you like to figure it out by yourself?</td>
<td>Creativity-relevant processes/ Domain-relevant skills</td>
<td>RQ 1, 2</td>
</tr>
<tr>
<td>5. Tell me about when you are working on classroom projects and assignments. What are your favorite types of assignments (i.e. Do you enjoy traditional assignments like worksheets and textbook work, writing essays scored on a rubric? Choice work?)</td>
<td>Creativity-relevant processes/ Domain-relevant skills</td>
<td>RQ 1, 2</td>
</tr>
<tr>
<td>6. When you don’t know how to do something, how do you figure it out? What keeps you motivated to figure out what you don’t know?</td>
<td>Creativity relevant processes/ Intrinsic motivation</td>
<td>RQ 1</td>
</tr>
<tr>
<td>7. Have you heard of a Makerspace? What do you think we will do here? How does the opportunity to participate make you feel?</td>
<td>Open</td>
<td>RQ1</td>
</tr>
</tbody>
</table>

II. Progress monitoring midpoint- interview
Introduction: Hello __, I am interested in learning about your experience in the Makerspace. During our discussion, you can tell me anything you want, for example an instance where you felt especially interested or confused.

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Questionnaire category</th>
<th>Research Question Cross reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Are you enjoying the Makerspace? What do you like best about it? What would you change? What does the teacher do to help you learn?</td>
<td>The Social Environment</td>
<td>RQ1</td>
</tr>
<tr>
<td>2. What are you learning in the Makerspace? Can you tell me about it and give me an example?</td>
<td>Domain-relevant skills</td>
<td>RQ 1, 2</td>
</tr>
<tr>
<td>3. Do you feel like you were able to explore your creativity? What creative processes did you engage in? How did you know that you were being creative?</td>
<td>Creativity-relevant processes/Creativity Self efficacy</td>
<td>RQ 1</td>
</tr>
<tr>
<td>4. When did you feel excited or bored? What was most engaging? Why?</td>
<td>Intrinsic motivation</td>
<td>RQ 1</td>
</tr>
<tr>
<td>5. Do you think this way of teaching and learning is valuable? Or would you rather be in a traditional classroom setting?</td>
<td>Creativity values/The Social Environment/ Domain relevant skills</td>
<td>RQ 1, RQ 2</td>
</tr>
</tbody>
</table>
### III. End of 8-week program interview questions

**Open-ended warm up questions**

*Hello ______, we have completed our 6-week Makerspace program! What do you think? During our discussion you can feel free to tell me anything about your experience in the class.*

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Questionnaire category</th>
<th>Research Question Cross reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How did you feel in the Makerspace? (What did you enjoy? What did you not enjoy?)</td>
<td>Creativity-relevant processes, Creativity values, intrinsic motivation, the social environment</td>
<td>RQ1</td>
</tr>
<tr>
<td>2. What were we learning in the Makerspace class? (i.e. Did you understand the objectives of the class? What did you learn? Do you think you are able to be creative and learn subject matter content at the same time? Do you think it is better to learn the material in a regular classroom? Can you tell me why you think that?)</td>
<td>Domain-relevant skills</td>
<td>RQ2</td>
</tr>
<tr>
<td>3. In the Makerspace classroom, did you learn anything about being creative? Can you give me an example? What creative thinking strategies did you learn in the Makerspace? Do you think these strategies would be useful for other coursework? For your school? For your life after schooling? Give me examples</td>
<td>Creativity-relevant processes, the social environment</td>
<td>RQ2</td>
</tr>
<tr>
<td>4. How did the teacher help? (What did the teacher do to help you learn the material? What did the teacher do to help you develop your creativity?)</td>
<td>The social environment</td>
<td>RQ2, RQ3</td>
</tr>
<tr>
<td>5. If a new student came to SYIS, what would you tell them about the Makerspace?</td>
<td>Open</td>
<td>Open</td>
</tr>
</tbody>
</table>
Appendix H

Makerspace Teacher Semi-Structured Interview Questions

Hi Mr. Stewart. I am happy to be planning the Makerspace program, curriculum, and instruction with you. We will meet weekly to plan for the classroom instruction. We will also evaluate and reflect on the experience of the students. Each week we will discuss the following.

1. Preliminary Interview

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Questionnaire category</th>
<th>RQ Cross reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Could you tell me about your background? Your experience as a teacher and area of expertise?</td>
<td>Values creative learning, traditional achievement</td>
<td>RQ1, RQ2</td>
</tr>
<tr>
<td>2. Please tell me about your ideas for the Makerspace here at SYIS. How did you think of the concept?</td>
<td>Values creative learning, traditional achievement</td>
<td>RQ1, RQ2</td>
</tr>
<tr>
<td>3. What is your vision for the Makerspace? How do you see it working and the context of like traditional K-12 schools?</td>
<td>Values creative learning, traditional achievement</td>
<td>RQ1, RQ2</td>
</tr>
<tr>
<td>4. Explain how you will apply this vision? What do you think the program will look like in a daily classroom? What will be the organizational structure? How will you incorporate traditional curriculum and how will you evaluate?</td>
<td>Values creative learning, traditional achievement</td>
<td>RQ1, RQ2</td>
</tr>
<tr>
<td>5. What are some challenges you think you will face? With students, with teachers? With classroom management?</td>
<td>Values creative learning, traditional achievement</td>
<td>RQ1, RQ2</td>
</tr>
</tbody>
</table>

II. Mid-interview questions; Reflections on Makerspace program

Hello Mr. Stewart. I would like to take time to reflect on the Makerspace program and ask some specific on next step. Please tell me your impressions on the progress of the program. What are your thoughts?

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Questionnaire category</th>
<th>RQ Cross reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the curricular objectives for the week? What instructional strategies will we use to meet these objectives?</td>
<td>Achieves curricular objectives, Domain-relevant skills</td>
<td>RQ1, RQ2</td>
</tr>
<tr>
<td>2. How will we assess the curricular objectives for the week using traditional methods?</td>
<td>Achieves curricular objectives, Domain-relevant skills</td>
<td>RQ2</td>
</tr>
<tr>
<td>3. What creativity relevant processes will we teach this week? What instructional strategies will we use to encourage use of creative processes in the Makerspace?</td>
<td>Creativity-relevant processes</td>
<td>RQ1</td>
</tr>
<tr>
<td>4. What resources will we need to achieve the curricular objectives and the creativity relevant skills objectives?</td>
<td>The environment</td>
<td>RQ2, RQ3</td>
</tr>
<tr>
<td>5. What will we do to make sure that, despite differences in creativity, all students are engaged in creativity relevant skills?</td>
<td>Creativity-relevant skills, intrinsic motivation</td>
<td>RQ2, RQ3</td>
</tr>
<tr>
<td>6. Do you have any questions, concerns, or ideas you would like to add to the program?</td>
<td>Open</td>
<td>Open</td>
</tr>
</tbody>
</table>

III. Final Interview: Hello Mr. Stewart. I would like to take time to reflect on the Makerspace program and ask some specific on next step. Please tell me your impressions, reflections on the progress of the program. What are your thoughts?

<table>
<thead>
<tr>
<th>Interview Question</th>
<th>Questionnaire category</th>
<th>RQ Cross reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do you think students were able to develop their creativity? How did they meet traditional objectives?</td>
<td>Achieves curricular objectives, Domain-relevant skills</td>
<td>RQ1, RQ2</td>
</tr>
<tr>
<td>2. How will we assess the curricular objectives for the week using traditional methods?</td>
<td>Achieves curricular objectives, Domain-relevant skills</td>
<td>RQ2</td>
</tr>
<tr>
<td>3. What creativity relevant processes will we teach this week? What</td>
<td>Creativity-relevant</td>
<td>RQ1</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>instructional strategies will we use to encourage use of creative processes in the Makerspace?</td>
<td>processes</td>
<td></td>
</tr>
<tr>
<td>4. What resources will we need to achieve the curricular objectives and the creativity relevant skills objectives?</td>
<td>The environment, RQ2, RQ3</td>
<td></td>
</tr>
<tr>
<td>5. What will we do to make sure that, despite differences in creativity, all students are engaged in creativity relevant skills?</td>
<td>Creativity-relevant skills, intrinsic motivation, RQ2, RQ3</td>
<td></td>
</tr>
<tr>
<td>6. Do you have any questions, concerns, or ideas you would like to add to the program?</td>
<td>Open</td>
<td></td>
</tr>
</tbody>
</table>
Appendix I

SCALE (Richardson, 2016) with Sample

The 5th Grade Teacher’s Responses on the SCALE

<table>
<thead>
<tr>
<th>SCALE Component</th>
<th>Rating</th>
<th>Evidence/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learner Engagement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students are involved in tasks that are open-ended and/or involve choice.</td>
<td>0 1 2 3</td>
<td>The students had the choice of design.</td>
</tr>
<tr>
<td>Students are involved in activities that may include inquiry, project based learning, or interdisciplinary tasks.</td>
<td>0 1 2 3</td>
<td></td>
</tr>
<tr>
<td>Students use multiple perspectives/viewpoints/ways of knowing or various modes of investigation/problem solving.</td>
<td>0 1 2 3</td>
<td>They used problem solving often throughout this project to solve various issues that arose as they worked.</td>
</tr>
<tr>
<td>Students demonstrate interest in or enthusiasm for the activity beyond being “on task.”</td>
<td>0 1 2 3</td>
<td>The majority of the students really enjoyed the Maker Space. Students got excited when they heard we were going to the Maker Space. Some students recognized the challenges this space provided and did not show as much enthusiasm. However, each student stepped up to the challenge and worked to succeed.</td>
</tr>
<tr>
<td>Students spend time developing ideas for deeper understanding and/or reflecting on their learning.</td>
<td>0 1 2 3</td>
<td>The students took time to develop their thoughts and experiment. If a project did not succeed, then they took it back to the work table to try to tweak or change the errors.</td>
</tr>
<tr>
<td>Students work at their own pace and/or time is used flexibly.</td>
<td>0 1 2 3</td>
<td>Some students worked quickly to create a product while other students took time processing their thoughts before starting.</td>
</tr>
<tr>
<td><strong>Physical Environment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A variety of resources are available and accessible to students.</td>
<td>0 1 2 3</td>
<td>There is a variety of resources available. It would benefit the students for a greater quantity of tools, but this allowed for the students to plan when to use the tools.</td>
</tr>
<tr>
<td>Examples of student work appear in the space.</td>
<td>0 1 2 3</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>A variety of work stations or areas are available to students.</td>
<td>0 1 2 3</td>
<td></td>
</tr>
<tr>
<td>There are 6 tables available for student work. At each table, there is a white board installed on the table top. There is also a power tool work station and plenty of floor space.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The furniture allows for multiple arrangements and configurations.</td>
<td>0 1 2 3</td>
<td></td>
</tr>
<tr>
<td>The furniture is portable and installed on wheels. This allows for stations to move easily.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Learning Climate**

<table>
<thead>
<tr>
<th>Students are involved in discussions among themselves, with or without the teacher, that deepen their understanding.</th>
<th>0 1 2 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughout the whole project time, students worked with each other to develop thoughts and build a stronger idea.</td>
<td></td>
</tr>
<tr>
<td>The students are caring, respectful, and value differences.</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>It seems like this was a struggle for them at times. Students often got into disagreements and sometimes required outside intervention to find a solution.</td>
<td></td>
</tr>
<tr>
<td>The teacher is a facilitator, co-learner, explorer, or inquirer with students.</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Since the project was very student driven, I as the teacher, was able to come alongside them to facilitate learning. By asking questions requiring the student to explain their thinking, I was able to learn along with them and further their understanding.</td>
<td></td>
</tr>
<tr>
<td>Mistakes, risk-taking, and novel ideas are valued or encouraged.</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>Without failing during a creation, the project could not improve. Therefore, failing was encouraged as a stepping stone to success.</td>
<td></td>
</tr>
</tbody>
</table>

## ESTABLISHED GOALS

### 5th grade World Geography

1. Understand how to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.
2. Understand the physical and human characteristics of places (geography, culture, language, economy, politics).
3. Understand that people create regions to interpret Earth's complexity.
4. Understand how culture and experience influence people's perceptions of places and regions.

### Common Core ELA and Math Standards

### Transfer

- Students will be able to independently use their learning to compare and contrast Europe to Asian continent, to the governments and economies of their own home countries.
- Develop and use models.
- Ask questions and Design.
- Construct explanations and design solutions.
- Students will be able to apply creative thinking routines to unit problem towards a solution.

### Meaning

#### UNDERSTANDINGS

**CREATIVITY PROCESSES:**
1. Uses ideation process and thinking routines (look closely, find complexity, explore opportunity); design thinking routine
2. Perseveres through trial and error
3. Tolerates ambiguity
4. Process- Mini-C (tinkering learning dimensions rubric)
5. Product- Little –C (NEW rubric)

#### ESSENTIAL QUESTIONS

- How does geography, climate, vegetation determine a nation’s politics, culture, and economy?
- How can a map be useful?
- What can a map tell us?
- How can I show what I learned in a creative way?
- What strategies can I use to be creative?

### Acquisition

**Students will know...**

**Students will be skilled at...**
| ✔ Europe geographic regions | ✔ Map skills: understanding the map as a tool for many uses |
| ✔ Locate countries on map | ✔ Design skills |
| ✔ Climate, vegetation, geography | ✔ Creativity processes ideation, tolerance of ambiguity |
| ✔ European major historical events | |
| ✔ Aspects of European culture | |

**Stage 2 - Evidence**

<table>
<thead>
<tr>
<th>Evaluative Criteria</th>
<th>Assessment Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Objectives: Students will locate European regions on map</td>
<td>PERFORMANCE TASK (S): Design journal work (graphic organizers); Whole class discussion and check ins</td>
</tr>
<tr>
<td>Students will describe climate, vegetation, and geography of Europe</td>
<td>Summative: Traditional objectives: Multiple choice and essay test</td>
</tr>
<tr>
<td>Students will explain how each factor effects politics, economy, and culture</td>
<td>Final product presentation</td>
</tr>
<tr>
<td>Presentation rubric</td>
<td></td>
</tr>
<tr>
<td>Creativity Objectives: Tinkering Learning Dimensions framework</td>
<td>OTHER EVIDENCE: Student thinking routines, activity, as measured by Tinkering Learning Dimensions Framework</td>
</tr>
<tr>
<td>NEW rubric</td>
<td></td>
</tr>
</tbody>
</table>

**Stage 3 – Learning Plan**

*Daily Lessons*

*Day 1 Establish Makerspace norms, Me as a Maker pp, introduce design journal, begin to explore environment (meeting area, moveable tables and writing tools) – Day 2 What can a map tell us? Wicked problem introduction: Day 3- Review objectives, vocab, Make groups, ideation techniques; Day 4—plan, research..... Day 9 Presentation*
### Appendix K

Unit 2- Makerspace- 5th Grade Science (Forces and Motion) Abridged Lesson Plan

**Building a Mousetrap Car**

<table>
<thead>
<tr>
<th>ESTABLISHED GOALS</th>
<th>Stage 1 Desired Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTION AND STABILITY (NGSS)</td>
<td><strong>Students will be able to independently use their learning to...</strong></td>
</tr>
<tr>
<td>1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.</td>
<td>✓ Define problems and Ask questions</td>
</tr>
<tr>
<td>2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.</td>
<td>✓ Plan and conduct investigations</td>
</tr>
<tr>
<td>3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.</td>
<td>✓ Construct Explanations and Design solutions</td>
</tr>
<tr>
<td>4. Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects</td>
<td>✓ Students will be able to persevere through trial and error, tolerate ambiguity, and engage in risk taking when prototyping a design</td>
</tr>
<tr>
<td>5. Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.</td>
<td>✓ Students will be able to apply creative thinking routines to unit problem towards a solution</td>
</tr>
<tr>
<td>(Newton’s laws)</td>
<td>✓ Students will make connections with a theme in the language arts text (Island of the Blue Dolphins) with a real life world problem</td>
</tr>
</tbody>
</table>

**UNDERSTANDINGS**

**CREATIVITY PROCESSES**

1. Uses ideation process and thinking routines (look closely, find complexity, explore opportunity); design thinking routine
2. Perseveres through trial and error
3. Tolerates ambiguity
4. Openness to experience (risk taking)
5. Demonstrates divergent thinking/breaks from set
6. Process- Mini-C (tinkering learning dimensions rubric)
7. Product- Little –C (NEW rubric)

**SCIENCE** Students will understand

1. How to represent and describe motion in a variety of ways
2. Identify Newton’s laws in a variety of situations
3. Apply Newton’s laws in a variety of situations
4. Plan, investigate, and design an automobile using simple machines, force, and friction to make the automobile move

**INTERDISCIPLINARY UNIT**

**LANGUAGE ARTS**

**CCSS**

Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text

Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question

**ESSENTIAL QUESTIONS**

How can you use Newton’s laws of motion to describe an object at rest and an object in motion?

How might you use your knowledge of Newton’s laws to engineer an automobile?

How does Newton’s laws of motion affect the design and function of an automobile?

How can you transfer a theme from a novel to a real world experience?

How can you learn from a character in a novel and apply that knowledge?

What strategies can I use to be creative?
3. For every action, there is an equal and opposite reaction

Integrate information from several texts on the same topic in order to speak about the subject knowledgeably.

**Acquisition**

**Students will know...**
- Essential vocabulary:
  - Potential energy, kinetic energy, rest, motion, force, friction, power, acceleration, speed, direction

**Students will be skilled at...**
- Design thinking strategies
- Creativity relevant skills
- Engineering
- Use of materials

1. Measure and calculate speed of their mousetrap car
2. Assess impact of force and friction on object
3. Justify evidence of Newton’s laws
4. Demonstrate understanding of essential vocabulary

---

### Stage 2 - Evidence

<table>
<thead>
<tr>
<th>Evaluative Criteria</th>
<th>Assessment Evidence</th>
</tr>
</thead>
</table>
| Multiple choice and short answer assessment Mousetrap car presentation with calculations Creativity and Innovation/NEW rubric Tinkering Learning Dimensions framework observation check list Anecdotal evidence Design journal notes | PERFORMANCE TASK(S):
- Forces of Motion Test
- Design, Build, Present Mousetrap car |

<type here>

OTHER EVIDENCE:
- Design journal, anecdotal interviews with students

---

### Stage 3 – Learning Plan

**Resources:**
- [http://www.cfep.uci.edu/cspi/docs/lessons_secondary/Mouse%20Trap%20Car%20Lesson.pdf](http://www.cfep.uci.edu/cspi/docs/lessons_secondary/Mouse%20Trap%20Car%20Lesson.pdf)

**Day 1:**
WICKED PROBLEM: Building a survival automobile- how might Karana navigate the island? How can she escape? What about your stories of survival, some are stuck on an island, some in a desert, what if you had the engineering skills to design a transport vehicle? We are going to explore how we can put things in motion and how we can make them stop? Does anyone know how we might put something in motion? Push! (force)

Let’s try to push three things in motion just by pushing…

Explore concept of motion in cars
How do things move and how do things stop?
Guided instruction: Model forces and motion lab

**Day 2:** Forces and Motion Lab
1. Do the experiment
2. Fill out experiment paper
3. Vocab

**Day 3:** Intro how to build a mousetrap car, design thinking routine- look closely at example mousetrap cars, examin complexity, find opportunity, plan with partner, begin research

Day 4....MAKE!....Day 10… Present
Appendix L

Unit 3- Makerspace- 5th Grade DIY Express Yourself (Automata) Abridged Lesson Plan

Building an Automata or Choice Project

<table>
<thead>
<tr>
<th>ESTABLISHED GOALS</th>
<th>Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persuasive Essay (CCSS)</td>
<td>Students will be able to independently use their learning to...</td>
</tr>
<tr>
<td>Write opinion pieces on topics or texts, supporting a point of view with reasons and information.</td>
<td>✓ Define problems and Ask questions</td>
</tr>
<tr>
<td></td>
<td>✓ Plan and conduct investigations</td>
</tr>
<tr>
<td>Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.</td>
<td>✓ Construct Explanations and Design solutions</td>
</tr>
<tr>
<td>Provide logically ordered reasons that are supported by facts and details.</td>
<td>✓ Students will be able to persevere through trial and error, tolerate ambiguity, and engage in risk taking when prototyping a design</td>
</tr>
<tr>
<td>Link opinion and reasons using words, phrases, and clauses</td>
<td>✓ Students will be able to apply creative thinking routines to unit problem towards a solution</td>
</tr>
<tr>
<td>Provide a concluding statement or section related to the opinion presented</td>
<td>✓ Students will present a unique and different final product</td>
</tr>
<tr>
<td></td>
<td>✓ Students will use persuasion skills during presentation</td>
</tr>
</tbody>
</table>

| MEANING |
| UNDERSTANDINGS |
| CREATIVITY PROCESSES |
| 1. Uses ideation process and thinking routines (look closely, find complexity, explore opportunity); design thinking routine |
| 2. Perseveres through trial and error |
| 3. Tolerates ambiguity |
| 4. Openness to experience (risk taking) |
| 5. Demonstrates divergent thinking/breaks from set |
| 6. Use persuasion to “sell” an idea |
| 6. Process- Mini-C (tinkering learning dimensions rubric) |
| 7. Product- Little –C (NEW rubric) |

| SCIENCE |
| -How to plan, investigate, design, and build a project of choice using a variety of tools, materials, and background knowledge (i.e. cams and rods; simple machines; force and friction; electrical circuits) |
| -Understand the complexity of simple machines cams and rods in Automata |

| Interdisciplinary Unit |

| LANGUAGE ARTS |
| CCSS |
| During an oral presentation, Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose. |

| ESSENTIAL QUESTIONS |
| How can I express myself through a final product I design? |
| How do I plan and execute my idea? |
| How can I persuade others to accept my idea? |
| What creative strategies do I engage in to make a final product I am proud of? |
### Acquisition

**Students will know...**
- Essential vocabulary: Simple machine, work, cams, rods, axel, crank, creativity, unique, surprising, aesthetic, appealing, audience

**Students will be skilled at...**
- Design thinking strategies
- Creativity relevant skills
- Engineering
- Use of materials
- 1. Ideate, plan, design, prototype, and test, and present an original idea
- 2. Persuade an audience to accept the idea through an oral presentation

### Stage 2 - Evidence

<table>
<thead>
<tr>
<th>Evaluative Criteria</th>
<th>Assessment Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW rubric</td>
<td>PERFORMANCE TASK(S): Design, Build, Present a unique Automata or an object/invention of your own design</td>
</tr>
<tr>
<td>Tinkering Learning</td>
<td>Oral presentation of product</td>
</tr>
<tr>
<td>Dimensions framework</td>
<td>Written persuasive essay of product</td>
</tr>
<tr>
<td>observation check list</td>
<td></td>
</tr>
<tr>
<td>Anecdotal evidence</td>
<td></td>
</tr>
<tr>
<td>Design journal notes</td>
<td></td>
</tr>
<tr>
<td>Oral presentation/persuasive essay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OTHER EVIDENCE: Design journal, anecdotal interviews with students</td>
</tr>
</tbody>
</table>

### Stage 3 – Learning Plan

**Resources:**
- [https://www.exploratorium.edu/pie/downloads/Cardboard_Automata.pdf](https://www.exploratorium.edu/pie/downloads/Cardboard_Automata.pdf)
- [https://www.youtube.com/watch?v=Q3Am4wu8Nvs](https://www.youtube.com/watch?v=Q3Am4wu8Nvs)

**Day 1:**

WICKED PROBLEM: How can we express our creativity? How can we make something unique that is useful, interesting, and beautiful? Remember we are ethical makers, We make things to help, not to hurt. We make things to improve the world, not to destroy.

Introduce idea of Automata- explain what Automata are, watch youtube clip. Show example system of axels, cams, a moveable toy. You can choose to do an automata OR you can do your own creative idea.

Take out your design journals and draw your design. You need to get your design approved by your teacher.

**Day 2:** Independent work

**Day 3:** Independent work

**Day 4:** Independent work/Writing

**Day 5:** Independent work/Writing

**Day 6:** Oral presentations (essays due tomorrow)