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Dietsche, Kevin B. ***Measuring Creativity Employing the Design Build Process within a PK12 Fabrication Laboratory***

Abstract

Creative problem solving is addressed as playing a major role in education and employment now and in the future. The author examined the role of the Design Build Process and its ability to address creative problem-solving using Fabrication Laboratory equipment. The author seeks to give educators an educational development tool in which high school educators can utilize within their Technology Education program. The method utilizes a Quasi-Experimental design with treatment groups using the Design Build Process within a Fabrication Laboratory setting. The curriculum allows the instructors to implement projects that fit the goals and objectives of the course that they are teaching while enhancing creativity within their students. The null hypothesis was accepted in that no significant difference was found in creativity between the control and treatment groups. However, qualitative data suggested that several merits exist in teaching creativity within the Design Build Process.

Acknowledgements

Throughout the process of completing this doctorate at the University of Wisconsin-Stout, I encountered many obstacles. At times it felt like I was swimming across a river and would never make it. Then, at one point in time I realized I was half-way across, and it would probably make sense to finish swimming the rest of the way across. The only way to make it across this river was by the grace of God, and with help and encouragement from several individuals.

My gratitude begins with my co-workers, classmates, and friends. I reflect often on the way in which different people would reach out at just the right time to offer encouragement, learned wisdom, and timely advice.

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Chapter I: Introduction

Innovation and entrepreneurship are crucial for long term economic development within any given country (OECD, 2007; Rosenberg, 2004; West, 2011). Reynolds (2009) studied countries within the Organisation for Economic Co-operation and Development (OECD) and found that all 35 countries viewed technological development and innovation as crucial to their economic stimulus packages following the economic downturn of 2008. As a result, West (2011) points out that many nations around the world are investing in technological innovation to jump start economies that were weakened by financial downturn.

Technological innovation plays an important role in supporting the United States economy. Innovation within industries such as agriculture, energy, transportation, manufacturing, and healthcare have an overwhelming impact on economic stability and growth. For example, the energy industry within the United States plays an essential role in the economic stability and growth of the country. As America seeks to provide energy for itself, technological advancements in drilling and hydraulic fracturing (fracking) of shale formations have increased the United States oil production to be able to cover 80% of world demand (Worland, 2018).

Although there is a clear need for innovative technology within industry sectors, public opinion surveys reveal interesting results. McGinn (2009) interviewed nearly 5000 adults in the United States, China, the United Kingdom, and Germany and found that nearly two thirds of respondents believe innovation will be key to American success over the next 30 years. The survey also showed that Americans and Chinese view the need for innovation in entirely different manners. Forty one percent of Americans were found to believe that the U.S. was ahead of China whereas 81% of Chinese believed America was winning the innovation race. Americans believed that they were falling behind on innovation while other countries moved forward. This may in fact be the case, and Americans may have good cause for pessimism in this area.

One place to look for the cause of this pessimism lies within a college entrance exam taken by American high school students throughout the country. Each August, the American College Test (ACT) releases a Condition of College & Career Readiness report. The most recent report consisted of 6 major findings that were summarized as "the United States is a STEM-deficient nation" (American College Testing, 2017, p.1). The results showed that in the years between 2015-2017 20-21% of all students taking the ACT exams were prepared for a STEM career. Adding to the pessimism related to the innovation race is the pace of technological change coupled with a massive demographic shift which results in a grave shortage of workers in science, technology, engineering, and mathematics (STEM) (Murphy, 2017). It is expected that a shortage of approximately 1 million STEM professionals will exist in the coming decade and a need exists to fill an impending skills gap to retain historical preeminence in science and technology (Olson & Gerardi, 2012). An estimate from the Manufacturing Institute (2015) points to a need for 3.5 million jobs in the coming decade with an estimated 2 million of those jobs going unfilled. Although the numbers and projections are all different in their own way, the conclusion that can be drawn is the same. The United States will need to teach students to be creative and innovative to remain competitive on a global scale and to find ways in which to fill the impending skills gap.

This need for innovation and creativity to keep pace with the global economy and impending skills gap is reflected in reports put forth within education. It has been known for some time that change in education needs to take place. However, it has taken time for the educational community to pin point what exactly that change needs to be. In 1983 the National

Commission on Excellence in Education was established and mandated to report on the quality of education in the USA. The report stated, "history is not kind to idlers...the time is past when American's destiny was assured simply by an abundance of natural resources and inexhaustible human enthusiasm" (National Commission on Excellence in Education, 1983, p. 2). Following in 1990, the American Society for Training and Development released a national study on the educational system suggesting that the change needed was that of strong employer involvement within education to aid in training future employees with basic future workplace competencies (Carnevale, A.P., Gainer, L.J., & Meltzer, A.S., 1990). In 1991 the Secretary's Commission on Achieving Necessary Skills (SCANS) report began adding clarity to the educational change needed. This report laid out workplace competencies that were applicable in education and transferable to employment (Packer, 1992). These reports followed by the 2011 *Skills Gap Report* have begun to solidify the need for basic workplace skills, but just as importantly the need for innovative thinking being taught within education as essential for the future of America (Eisen, P., Jasinowski, J., Jerry., & Kleinert, R., 2005). The National Center on Education and the Economy or NCEE (2007) reiterates this by saying "creativity and innovation are the key to a good life, in which high levels of education and a very different kind of education than most of us have had, are going to be the only security there is" (p.8-9) for the future of our nation.

The NCEE (2007) makes note that our educational systems were built for another era in which workers only needed rudimentary education. Singh (2006) reiterates these needs by describing the story of a mediocre American education system and called for the creation of quantifiable educational achievement that would enable students to be prepared for jobs in the 21st century global economy of which at the forefront includes skills of creativity and innovation.

The importance of innovation is not lost on the American people. Pink (2006) said "the future belongs to a very different kind of person with a very different kind of mind-creators and empathizers, pattern recognizers and meaning makers…. these people will reap society's richest rewards and share its greatest joys" (p.14). Friedman and Mandelbaum (2011) wrote on the importance of creativity and innovation by saying:

> Going forward, we are convinced, the world increasingly will be divided between high imagination-enabling countries, which encourage and enable the imagination and extras of their people, and low imagination-enabling countries, which suppress or simply fail to develop their people's creative capacities and abilities to spark new ideas, start up new industries and nurture their own 'extra'. America has been the world's leading high imagination-enabling country and now it needs to become a hyper-high-imagination-enabling society. That is the only way we can hope to have companies that are increasingly productive and many workers with jobs that pay decent salaries. (p. 151)

Friedman and Mandelbaum (2011) reflect something that Guilford (1967) stated several years ago. Guilford (1967) saw creativity as an innate part of life. Creativity deals with problem solving which is considered an essential skill "for life on this planet" (p. 10). Education in enlightened countries according to Guilford (1967), has been able to pass along the "accomplishments" from one generation to another but has done so in an "authoritative manner" not allowing the passing of such information in a way that is creative. Guilford (1967) argued the need for creative education in which students would be "self-starting, resourceful, and confident, ready to face personal, interpersonal, and other kinds of problems" (p.10). He felt that this kind of education would indeed fulfill mankind's most serious and profound problems. These problems are being addressed in today's educational system by educators who are teaming up in a variety of states with policy makers, business, and industry to create science, technology, education, and math (STEM) initiatives.

Statewide STEM initiatives exist to increase students interest in STEM-related fields and the number of STEM-ready students across the nation. For example, in 2011 the Iowa Governor's STEM Advisory Council initiated the STEM Scale-Up Program which has shown to aid in raising scores in science, math, and reading (Governor's STEM Advisory Council, 2017). In New Jersey, a public/private program entitled the *STEM Scholars Program* works to create opportunities for high school youth by pairing them with PhD programs to have a positive impact related to STEM careers on participants (Testimonials, 2018). The state of Washington has created a STEM education Innovation Alliance that works with the Career and Technical Education system in bringing awareness, interest, achievement, and focus on degree completion with students in the state (Washington State, 2018). These types of programs and many others like them are in direct response to a need for greater interest in STEM related fields. However, Wisconsin has taken a slightly different approach in its investment into STEM education in its search to provide innovative education that will prepare students for the STEM workforce.

As with many economies, the Wisconsin economy is driven by manufacturing (MPI, 2013). For each dollar of manufactured goods produced, $1.43 of activity in other sectors are spurred on. This coupled with the fact that two-thirds of U.S. research and development capacity is focused on the manufacturing sector makes manufacturing the key economic driver (Working for America Institute, 2013). In recognizing this economic driver and the current economic and future workforce needs, Wisconsin former Governor Scott Walker, Lieutenant Governor Kleefisch, and the Wisconsin Economic Development Corporation (WEDC) teamed up to provide grants to school districts in the development of Fabrication Laboratories (In Wisconsin, 2017).

Fabrication Laboratories or Fab Labs were developed as an educational outreach component of MIT's Center of Bits and Atoms (CBA) (FAB, 2018). Fab labs have grown into a global network of over 150 labs which are used to connect people, communities, and businesses across the world to collaborate, problem solve, and brainstorm ideas (Belfast, 2018).

Although the Fab Lab was developed through MIT's CBA, high schools throughout Wisconsin have adopted the term, and the basic idea of the MIT Fab Lab, and have been urged to apply for Fab Lab grants (In Wisconsin, 2017). According to Scott Walker, former Governor of Wisconsin "Fab labs play a vital role in ensuring that today's students have the skills they need to compete for the jobs of the 21st century by providing hands-on experience in areas such as design, engineering, and complex problem-solving" (Walker, 2017, p.1). A high school fab lab is described as a "high-technology workshop equipped with computer-controlled manufacturing components such as 3d printers, laser engravers, computer numerical control routers, and plasma cutter" (Walker, 2017). The Fab Lab initiative is expected to "drive innovation and foster economic development throughout the community" (Walker, 2017, p.1).

Statement of the Problem

It has become a well-known fact that because of low performing test scores, an increase in demand within the STEM field, ever-advancing technology, and a decrease in trained workforce that policymakers at all levels of government are emphasizing the importance of educating individuals for STEM-related jobs including the Department of Education grant prioritization of STEM-related proposals (Caitlin, 2017). The question quickly becomes, how will the United States be proactive in the innovation race, fill workforce needs, and continue to be a technological innovative leader in a global economy that promotes economic development for the future and beyond? An opportunity exists as there is funding in fabrication laboratories in Wisconsin, and the purpose of fabrication laboratories is to drive creative thought and innovation. Teachers within fabrication laboratories are the catalyst in which creative thought and innovation can be taught. However, it is unclear what instructional strategies best foster that creativity and innovation within secondary school fabrication laboratories.

Purpose of the Study

The Design Build Process is an instructional strategy being used within a post-secondary Design for Industry course to promote creativity. The purpose of this study is to test whether the high school fabrication laboratory is a place in which creativity can be fostered utilizing the Design Build Process.

Research Hypothesis

Using the Design Build Process at the college level has shown that students generate creative ideas for solving problems presented in class. The null hypothesis of this study stated that the teaching of the Design Build Process will have no statistical significance on the growth of creativity of the students within the treatment group. The alternative hypothesis that guided this study is that the teaching of the Design Build Process will positively influence creativity of the students within the treatment group.

Significance of the Study

Little is known as to the effect of applying the Design Build Process within a fabrication laboratory to secondary students and their resulting growth in creativity. This study sought to utilize the creative design build process method within a Fabrication Laboratory and an assessment tool to measure the resulting growth of student creativity. The study has potential in identifying the Design Build Process as a teaching strategy that works beyond a college classroom in a PK12 setting. It could lead to future professional development for teachers who have access to Fab Labs and seek ways to integrate creativity into their curriculum. The development of the Design Build Process within a PK12 Fab Lab also helps to fill a need for a growing number of Fabrication Laboratories within the Wisconsin PK12 education system.

Assumptions of the Study

Several assumptions affect this study:

1. Creativity can be taught to students within a fabrication laboratory.
2. Creativity can be measured.
3. The Design Build Process can be taught to technology education instructors who will implement it with fidelity within their classrooms.

Limitations of the Study

A limitation exists in the term “fab lab”. The schools being selected are said to have fab labs, but do not follow a scripted meaning of the term regarding activities or outfitting of tools, materials, and processes taught within the so-called fabrication laboratories. Facilities therefore are outside of the researchers control.

Each school teaches different curriculum surrounding the fab lab or creates curriculum to be used in the fab lab as their technology education teachers see fit. This means that students may or may not have had prior exposure to fab lab equipment. Students therefore may already have a prescribed methodology of how they best see fit to operate equipment in a manner to creatively problem solve an applied creative problem-solving activity.

Selection of the students was unable to be random as students chose to sign up to take a class that utilizes a fabrication laboratory. Therefore, a nonequivalent design was utilized. A limitation involved with this type of design that was true for this study involved the lack of control for pretest differences known as selection bias. Selection bias was likely to occur and was unable to be accounted for as three different school districts were being selected of which all had different curriculum surrounding their fab labs. The curriculum surrounding the fab labs was not accounted for, and therefore was considered to potentially alter the results of the pretest results between participant selections. Another limitation existed in the number of responses that were recorded. Permission slips were handed out, and the researcher was hopeful that parents and students alike would sign and return in high numbers.

Definition of Terms

Several terms help to define this study as related to the Design Build Process.

Creativity. The use of the imagination to produce a quantity and variety of original ideas (Berkemer, 1989).

Creative problem solving. A framework of thinking and recognizing problems in a creative way that involves the testing and/or evaluating of solutions until the results of a problem are solved (Berkemer, 1989).

Design. The application of a creative problem-solving approach towards technical problems to produce new and/or useful products (Berkemer, 1989)

Innovation. The introduction of a new idea, method or device as a solution to a new or already identified need (Berkemer, 1989).

Problem solving. The process or act of finding a solution to a problem utilizing a framework of thinking that involves thinking of possible solutions, testing, and evaluating solutions (Berkemer, 1989).

Chapter II: Literature Review

According to the Boston Consulting Group (2011) creativity and innovation are the top ranked strategic imperatives in business and industry. Researchers agree that creativity is concerned with producing ideas that are original and useful to solve problems and exploit opportunities (Baer, 2006; Bottani, 2010). Fabrication laboratories (fab labs) are concerned with the development of students to learn the skills necessary to thrive in today's world of work serving as an economic development tool, providing resources for entrepreneurs, businesses, and inventors (In Wisconsin, 2017). The Design Build Process is an instructional strategy being used within a post-secondary Design for Industry course to promote creativity. Little is known as to the effect of applying the Design Build Process within a fabrication laboratory to secondary students and their resulting growth in creativity. This study sought to utilize the Design Build Process within a Fabrication Laboratory measuring the resulting growth of student creativity. Using the Design Build Process at the college level has shown that students generate creative ideas as measured by divergent thinking for solving problems presented in class (Berkemer, 1989). The null hypothesis of this study stated that the teaching of the Design Build Process will have no statistical significance on the growth of creativity of the students within the treatment group. The alternative hypothesis is that the teaching of the Design Build Process will positively influence creativity of the students within the treatment group.

This chapter reviews the literature surrounding the Design Build Process which involves iterative design processes that may be utilized to invoke creativity within students. Processes that support the creative design methodology include the engineering design process (EDP) and the creative problem-solving process (CPS). Creativity is discussed as it is the variable of which this study seeks to improve using the Design Build Process. A background of fabrication laboratories is discussed as the study will take place within them. Finally, the underlying theory of the Design Build Process is discussed giving a theoretical framework to the process.

Creativity

Creativity is an expected output of the Design Build Process. The following is seminole research regarding creativity in which research at the time of this study was based. Paul E. Torrance (1965) defined creativity as:

> The process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses or formulating hypotheses about the deficiencies; testing and retesting them; and finally, communicating the results.

This definition is reflected by several other authors who sought to take and apply creativity specifically towards solving problems (e.g., Crawford, 1937; Spearman, 1931; Wallas, 1926). Wertheimer (1945) took a similar approach to utilizing creativity for problem solving by breaking down and reconstituting what is known about something to bring new and fresh insights into the nature of that something.

Rickards (1985) thought of creativity as “the personal discovery process, partially unconscious, which leads to new and relevant insights”(p.5). Rickards (1988) also strongly suggested that creativity is a universal human process that allows an escape from the natural assumptions. Kelly (1955) and Rogers (1954) show similarities in their research by showing that we can be creative by gaining an understanding of how we view a subject. This meaning, that looking at something from a different perspective, or through another lens could render creativity. Creativity is something that occurs as we organize our thoughts in a way that leads us to a different, better, or new narrative of understanding within the subject or situation we are considering. Maslow (1954) thought of creativity as a source of discovery, novelty, and a deportation of ideas that currently exist within a given timeframe of thought. He looked at creativity as a characteristic that was essential and common in scientific research as scientists furthered the work of their predecessors, were cautious in producing accurate claims, and worked to further the unknown. He saw creativity as basic human nature, something everyone had, but did note that individuals had creativity at varying levels. He observed that children displayed creativity regularly, while adults seemed to lag. Newell et al. (1962) believed that creativity had certain criteria to be met, and that problem solving had a creative component. Haefele (1962) was certain that each person must be creative to some degree as throughout human history creativity was a necessity to basic survival and the furthering of mankind.

The notion of creativity is greatly concerned with the way in which things are imagined. Koestler (1964) thought of creativity as being able to continue on where language leaves off. Weinman (1991) and Gilliam (1993) observed creativity as an ability to look beyond the mundane and the obvious and to reject the snares of repetition and categories that commonly exist. Rather the suggestion was simple, creativity is the solution to the problem that has not yet been considered. Amabile et al. (1996) stated creativity as “the production of novel and useful ideas in any domain” (p. 1155).

Literature on creativity suggests that the three skills necessary within training programs for creativity are opportunity recognition, idea generation, and idea evaluation (Clapham, 1997; Csikszentmihalyi & Epstein, 1999; Lonergan et al., 2004; Milgram, 1990). Once opportunity recognition takes place, the creative process begins with idea generation. Guilford (1959) referred to the cognitive process involved as divergent thinking. He described it as the type of process that “goes off in different directions” (p.381) resulting in numerous possibilities.

Divergent thinking is the primary process measured by many creativity tests that have been shown to reliably predict creative potential (Runco, 1990). A wide variety of training programs have been developed to enhance creativity (Torrance, 1972; Treffinger & Gowan, 1971). Research has shown that many of these programs have positive effects on creative performance, particularly in divergent thinking showing creative potential (Rose & Lin, 1984; Torrance, 1972; Torrance, 1984). Torrance (1972) found that over a 90% success rate was achieved with training programs that contained procedures and variations of the procedures developed by Osborn (1963) and Parnes (1962) known as the Parnes-Osborn Creative Problem-Solving Process (CPS). The process is a multistage process involving primarily divergent thinking. The impact of the CPS process has been so great that may creativity training programs incorporate variations of these procedures (Gundry, Kickul, & Prather, 1994). Similarly, the Design Build Process being used in this study uses aspects of the CPS process.

Teaching Creative Thinking

Creative thinking is often thought to be very important, and not easily obtained. Either one has it, or one does not. For example, in a study that engaged advertising directors, a director made the following comment regarding creativity; “as far as talent goes, you either have it or you don’t” (Mallia, Windels, & Broyles, 2013, p. 346). A director goes on to say that creativity “can’t be taught, you have to think a certain way, have a certain skill set” (Mallia et al., 2013, p. 346). Research on creativity, however, contradicts this view and provides evidence that creative skills can be improved. In the field of visual arts for example, Lindstrom (2006) found that creativity can be honed through practice. Furthermore, Griffin (2008) found that the use of heuristics, free-writing, and reframing a problem several times aids in the generation of creative solutions in solving a problem. Educators and their students can greatly benefit from research on building creativity (Otnes, Aviatt, & Treise, 1995).

Creativity has been shown to improve through divergent thinking techniques using metaphors and semiotics (Cheung, 2011). Scott (2004) researched courses that specifically teach creativity, and found that divergent thinking, problem solving, problem finding, conceptual combination, and idea generation where most important within curriculum. The creative thinking process has been identified by educators through research as containing important aspects that are most beneficial to students. Aspects include conceptual and strategic thinking for students in both introductory and advanced level courses (Robbs & Wells, 1999).

Creativity, whether taught in business, industry, or in the educational environment have been researched to show similarities in the way in which learning takes place (Dudek, 2000). In a comprehensive study Davies et al. (2013) found that "teaching creativity" had several factors essential to learner success.

- flexible use of space and time
- availability of appropriate materials
- work time out-side the classroom/school
- playful or games-based approaches with a degree of learner autonomy
- respectful relationships between teachers and learners
- opportunities for peer collaboration
- partnerships with outside agencies
- awareness of learners needs
- non-prescriptive planning

Research also examines what educators who teach creativity believe should be taught in creativity courses. Stuhfult and Berman (2009), examined 36 creative strategy course syllabi within a variety of disciplines which showed instructors focus on building skills in strategic thinking, concepting and developing portfolios of work along with recognition to students that produce exceptional creative work. Educators see a need for students with strong conceptual abilities, presentation skills, execution, relatability, and strategic thinking (Robbs, 1995). Educators were also adamant that students be taught to believe in the value of teamwork, be able to present on their solutions, and be able to navigate agency politics. Robbs (1995) adds the importance of students within creativity classes being exposed to award shows. This helps students see the best of the craft and fosters competition while pushing the envelope of creativity forward.

Design Build Process Background

The Design Build Method (DBM) was started in a class entitled *Design for Industry* at the University of Wisconsin-Stout; the researcher has learned this method through teaching and mentorship by Dr. Jerome Johnson. At the inception of the class, the intent was not to create a process of its own. The class was built in an environment which was perhaps considered "inappropriate and unacademic" as the class focus was heavily placed on creativity (Berkemer 1989, p. 30). The development of the class took place in the late 1960's and typically contained students that were trained within the Industrial Arts program (now Technology Education) exclusively (Berkemer, 1989). The projects and materials associated with teaching the course were influenced by the existing skills of these students. Students at that time took coursework that focused heavily on a project-process orientation which meant that the Design for Industry course naturally focused on the same type of curriculum. By the late 1980's the reverse was true. Students began focusing more on design, and less on process. From the late 1980's to the present, two things can be said of the development of course content. The first being that the instructors understanding of creativity and the design process have influenced the processes within the class, and second, the evolution of the class has morphed through the perceived needs of the students (J. Johnson, personal communication, March 14, 2018). It is from these two understandings that a process has evolved, which is now known at the University of Wisconsin-Stout to be the Design Build Process named by Jerome Johnson and Kevin Dietsche. Therefore, the Design Build Process is a product of several years of changing and morphing through program curriculum changes, student needs, and instructor perception as to what was needed to teach design and creativity within the Design for Industry course.

The Design Build Process involves a project-based approach, thus Design Build. Johnson (personal communication, March 14, 2018) described the process as iterative by nature, and projects within the Design Build Process are kept to a short timeline so students practice, develop, and grow abilities within the process. Within each iteration that the student works through within the instructional strategy, a tangible project is a key component to the completed process. Projects are assigned within a given class and require material processing ability. As such, the first content taught in tandem with drawing skills is the safe operation of material processing equipment, which consists of general wood working equipment (e.g. table saw, jointer, planer, router, chisel, lathe). Added throughout the course using projects is digital fabrication equipment that include a laser engraver and 3d print equipment. Characteristics of the projects maintain an emphasis on creative problem solving and the process that entails.

The instructor guides students through the process in a manner that invokes creativity and solutions in problem solving, and involves developing an unusual, unique design. This contrasts with curriculum that the student may see elsewhere throughout their coursework as they are encouraged to think outside of the box, and not to focus directly on a product, but rather an unusual solution utilizing a design style or a mix of design styles while using creative problem-solving behavior. Design styles may include the popular design processes such as the Engineering Design Process. Creative thinking is encouraged, and therefore students may also be taught creative thinking processes such as the Creative Problem-Solving Process. As students begin the iterative process of solving the design problem given to them, they are expected to research U.S. patents, not replicating an existing patent, and to gather ideas to cross-pollinate solutions from other disciplines in a manner that solicits complete or partial application of an existing product in a new manner.

Projects within the Design Build Process are game-like in nature and require the student to accomplish a task quickly within a strict set of constraints. Since individual and collective problem solving are somewhat different processes, projects are divided between individual and team activities. A typical project assignment within the DBP would find a student brainstorming ideas, recording ideas on paper through means of sketching, and brainstorming with classmates (if the project requires group work).

Design Build Projects. Within each of the projects listed within Appendix A-E, as well as other projects not listed here, each project deals with encouraging the student to break the barrier of what they have seen, to step outside of what they know and to creatively solve a problem through designing and building something that is entirely unique and stands alone in its ability to solve the problem. Within this portion of the Design Build Method, practicality is not always the right answer. Instead, something that is whacky, new, and further from what is deemed common place within society is deemed to be a better-quality product. The product is creativity alongside the solution to the problem rather than simply the solution to the problem. Several criteria are used in developing projects for use as a Design Build project. These criteria as listed by Berkemer (1989) include:

1. Projects must be familiar (to the degree that they do not call on experiences or knowledge the student does not have, or cannot readily obtain, or cannot extrapolate from) in subject matter, and in the tools, materials, and processes required.
2. Projects must have the potential of a wide variety of solutions.
3. Projects must inspire creativity and enthusiasm.
4. Projects must be representative of what the student is expected to learn.

Each of these criteria require attention to the technical background of the students by the instructor. Criterion 3 raises the question of what factors inspire enthusiasm, and which inhibit creativity. Within the Design Build Process handouts are utilized (see examples in Appendix A-E) along with the instructor explaining the project. Handouts provide information relative to the project goals, material, methods, timeline, and constraints. The instructor follows up with the students answering any questions that may arise and clarify issues after the handouts are distributed. The instructor discussion and handouts are designed to be motivational to student creativity as much as possible. At the time of the study, students within the Design for Industry class were required to complete four to six projects within a semester which consists of four lab hours per week for 16 weeks. Projects differ from semester to semester which minimizes the possibility of solutions being passed from students one semester to the next. Appendices A, B, C, and D are example projects that might be used within a given semester.

Appendix A shows a project entitled *Marshmallow Challenge* that is generally a group project. It is utilized in a manner that allows students to work in groups. It requires very little expertise but is an aid in giving students a chance to practice collaboration, innovation, and creativity.

Appendix B depicts the project *For Those Who Need it Most.* This project is an in-depth group project that requires the student to learn the Stanford design school method of problem solving (empathy, define, ideate, prototype, test) and apply it towards developing solutions for problems affecting persons dealing with a disability. Part of the major challenge associated with this project involves the students having to solve a problem and produce a solution with the given materials, and equipment available.

Appendix C shows the *Makin' Models* project which gives a review of several design styles. Within this project students are tasked with researching a design style, preparing sketches, and preparing two models, one of which is of low fidelity, the other a high-fidelity model. Students are instructed to prepare a seven-minute presentation that cannot include a PowerPoint on the history, aesthetics, designers associated with the style, and methods utilized in model construction.

Appendix D entitled *Puzzled* depicts a project that is intended as a solo endeavor for the students. It is based around the theoretical framework of Fredrick Froebel and his work dealing with creative play (Frobel, 1912) as well as Piaget's work dealing with cognitive growth and his concepts dealing with the need for children to act on the world to develop conceptually (Wadsworth, 1996). Students are asked to develop a prototype that is of heirloom quality that focuses around a proposed puzzle, game, or toy that is of an original design. The puzzle must be electrical, mechanical, fluidic, or structural by nature.

Design Build Project outcomes and evaluation. The Design Build projects assigned are the means used to teach and provide experience in creativity and problem solving. The nature of the projects are designed to change in several ways as the Design Build methodology progresses from easy to difficult/complex. As such, the problems within each project are meant to become more difficult to solve. Each project therefore, when delivered in a class setting, increases in points awarded for a final grade. The process of evaluation does not take place for a Design Build project at the end of the project, but rather includes formative assessment along the way occurring throughout the project at both scheduled and random intervals. During the class period while students are working on their project, students receive individual counseling as they work out their ideas and solutions. Informal critiques are given of their work as it progresses. This is intended to give individual students assistance with their unique problems and enables the instructor to perform ongoing evaluation of each student. By the end of each project, the instructor should have a variety of data on which to conduct a summative evaluation. The instructor should be accumulating the following evidence used towards assessment:

1. Class notes. While meeting with students during the project progression, the instructor records observations of the students as groups and as individuals.
2. Student logs. Students record the evolution of their work, this includes drawings and descriptive text for each project.
3. End products. The students completed solutions to the assigned problem.
4. Recorded results of end-product testing. The students record the successes and mishaps of product testing with the final test being a functional result.

This evidence is used by the instructor to gauge each student's position and success relative to the goals of the project and relative to that of the goals of the course. In evaluation, the criteria used by the instructor to evaluate students are process, product, and performance. These criteria are defined by Berkemer (1989) as:

Process: The production of numbers of ideas and the ability to change direction in thinking (different paths and patterns of thought) to produce different ideas or view the problem differently.

Product: The originality and appropriateness of the ideas produced. The final solution's uniqueness. The student's ability to develop ideas and to provide detail, refinement, and evolution. The quality of fabrication.

Performance: The degree to which the product meets the prescribed goals relative to the level of performance of the group or against an established criterion. (p. 70)

These evaluation criteria remain constant but shift in importance which is reflected in the number of points awarded for each category. Students are made aware of this shift and are able to adjust their priorities as necessary.

The resulting student evaluation is that of a norm-referenced evaluation meaning that the student's product is measured against the performance of the group. The concept of performance and providing performance ratings as part of the scoring is utilized to motivate students to apply themselves and to display their projects to the class in an exciting and engaging manner.

Berkimer (1989) had several findings regarding this approach to teaching and evaluating his students. Overall, in answering the question of whether creative skills can be improved, the answer was yes, and to a significant degree. The curriculum design was deemed "successful in nurturing and developing creative problem-solving abilities" (p. 165). He found that students appeared to be more capable of being creative without formal training, that teaching problem solving was best facilitated through assigned projects, parallel examples helped students work through problems at hand, students were enthusiastic and creative towards real world technical problems, group brainstorming benefited individual efforts, teaching applied creative problem solving required a high degree of effort and flexibility on the instructors part, student aided product testing was beneficial for students and as well as the teacher, it was essential to create a design problem within the student's ability, new projects needed to be continuously created, often times student technical questions could not be answered by the instructor, and problem solving required specialized facilities.

Framework Underpinning the Design Build Process

The sequence of projects within the Design Build method is designed to introduce students to a framework for creative problem solving and to give them practice in applying that framework to tasks that have direct transfer to their careers. Brandt (1986) stated that teaching creative thinking through design problems has a certain ecological validity. Design problems ask students to do the sort of tasks you want them to learn to do. He also indicated that teaching design as a method of teaching creativity works because creativity involves a creative product, or a structure adapted to an intended purpose. In this way the Creative Design Build projects serve not only as a methodology in which to teach creativity, but the resulting projects are also a mastery test of creativity in and of themselves.

The creative problem-solving process (CPS) is a framework that has been used successfully in many programs of creative problem solving throughout the country and has been adapted to the Design Build Method. Alex Osborn is credited with putting together the seminole building blocks of the Creative Problem Solving (CPS) process which became an explicit, understandable, relatable process underpinning most of the work developed on CPS (Isaksen, & Treffinger, 2004). Osborn popularized the process by practicing brainstorming in the 1940's and 1950's (Rickards, 1988). Osborn broke down brainstorming into two categories: structured and unstructured. Unstructured brainstorming had no guiding principles or agreed upon procedures while structured brainstorming followed what at the time was considered a classical approach. Within the classical approach Osborn (1953) utilized what he called deferment of judgment. This was an aid to creativity and was later supported by Parnes (1962). This "deferment of judgment" utilized during brainstorming involved four rules as laid out by Osborn (1953, 1957, 1963, 1967):

1. Criticism is not permitted – adverse judgment of ideas must be withheld.
2. Free-wheeling is welcome- the wilder the idea the better. One should not be afraid to say anything that comes into one's mind. This complete freedom stimulates more and better ideas.
3. Quantity is required- the greater the number of ideas, the more likelihood of winners.
4. Combinations and improvements should be tried out. In addition to contributing ideas of one's own, one should suggest how ideas of others can be improved, or how two or more ideas can be joined into a still better idea.

Osborn's brainstorming technique took what researchers had been working towards for several decades. It successfully connected the need for creativity and brought it alongside problem solving. In his book, *Wake Up Your Mind,* Osborn (1952) displayed the first tangible CPS process laid out in seven steps: orientation, preparation, analysis, hypothesis, incubation, synthesis, and verification.

Since Osborn's first model, the process for brainstorming has been modified several times. Sidney Parnes began work with Osborn and worked to bring creativity to within reach in all aspects of everyday living (Isaksen & Treffinger, 2004). They had a common goal of teaching their students how to bring creativity into every aspect of life. After Osborn's passing in 1966, Parnes and his contemporaries continued work on the CPS model (Isaksen & Treffinger, 2004). The model began to morph and develop to meet the needs of the time and was fine-tuned throughout the decades. Parnes and his colleagues developed what is known to be called the "Osborn-Parnes" approach which involved addressing a need for validating an instructional program that was set out to deliberately develop creative problem-solving talents (Isaksen, S., & Treffinger, 2004). As research progressed, Parnes and Brunelle (1967) concluded with overwhelming evidence that indicated creative ability as measured by existing tests of their time, could be increased. Yet again, Parnes and Reese (1970) showed that a programmed course revolving around creative behavior improved creative problem-solving skills within their existing students.

The Creative Problem-Solving process has been modified for use in the Design Build Process, and the two are compared in Table 1. Being that the Design Build Process is iterative and can be repeated multiple times before finding a solution whereas the CPS process is linear with a defined ending, the Design Build Process follows phases as described by Berkemer (1989).

The comparison of the CPS model and the DBP in Figure 1 show Osborn's step one and two (orientation and preparation) aligning most closely to the DBP phase one (identify the problem). Osborn's step three aligns closely to the DBP phase two of research and analyze. Step four and five of the CPS (hypothesis and incubation) aligns with phase three of the DBP (generate ideas). Step six of CPS (synthesis) aligns closely with the DBP phase four (experiment and refine) and step seven of CPS aligns closest with phase five of the DBP which pertains to the final solution to solving a problem.

Osborn's CPS	Berkemer's DBP Phases
1. Orientation: Pointing up the problem	1. Identify the problem: Establish goals or objectives, identify elements that a good solution must incorporate.
2. Preparation: Gathering pertinent data	2. Research and Analyze: List what you know
3. Analysis: Breaking down the relevant material	3. Generate Ideas: Develop checklists, brainstorming, Synectics, bionics, forced relationships, etc.
4. Hypothesis: Piling up alternatives by way of ideas	
5. Incubation: Letting up to invite illumination	4. Experiment and refine: Verifying the tentative solutions through models, mock-ups
6. Synthesis: Putting the pieces together	
7. Verification: Judging the resultant ideas.	5. Final solution: prototype, finished drawing, presentation.

Figure 1. Comparison of Osborn (1952) CPS Process to Design Build Process phases (Berkemer, 1989).

Evolution of the Fabrication Laboratory

Mitchell and McCullough (1994) were leaders in proposing the use of rapid prototyping and computer numerical controlled fabrication for scale models and for producing and building parts. They are quoted saying:

> Rapid-prototyping machinery can be used not only for direct transformation of CAD models into fabricated objects, but also to produce molds and dies needed to reproduce those objects in other materials or in multiple copies. (p. 432)

They went on to say that "Increasingly, it is feasible to use rapid prototyping devices to generate physical scale models from digital information." (p. 461)

These statements describe what is considered an engineering laboratory. Three types of engineering laboratories are thought to exist (Feisel & Rosa, 2005). The first type of engineering lab is a research laboratory, one that is used to seek broader knowledge that can be generalized and systemized and contributes knowledge to the overall field of knowledge. The second is a development laboratory, described as a laboratory of which the objective is to obtain experimental data to guide professionals in designing and developing products. This type of laboratory is used to gather measurements of performance and aids in determining if a design performs as intended. The third type of laboratory is an instructional laboratory. The instructional laboratory has objectives based in both research and development but are defined through carefully designed learning objectives. This definition also can be closely applied to what are known as digital fabrication laboratories.

The Fabrication Laboratory or Fab Lab concept falls within what is defined as a digital fabrication laboratory. It originated at the Massachusetts Institute of Technology (MIT) as an outreach component of a project entitled "How to make almost everything" with a purpose of being able to create a technological work/learning area (Willemaerts et al., 2011, p. 1). A Fab Lab is a place that is equipped with the tools for every aspect of the technology development process. This would include the ability to design, fabricate, test, debug, monitor, analyze, and document individual user processes to a greater audience. Each Fab Lab begins with a common set of tools. In describing a Fab Lab Neil Gershenfeld (credited founder) explained the Fab Lab as weighing approximately 2 tons, and costing about $100,000 (Chandler, 2016). By this, Gershenfeld was describing the equipment that includes 3-D scanning and printing, large-format and precision machining, computer-controlled lasers and knives, surface-mount electronics production, embedded programming, and computing tools for design and collaboration. The purpose of all these tools was to be able to locally produce and customize products that are mass-produced today such as electronics purchased by consumers or household items such as furniture.

The mission of the Fab Lab experience involves more than being able to make almost anything but also is meant to encourage formal and informal education (Mikhak et al., 2002). According to Mikhak et al. (2002) the Fab Lab is the next phase of the digital revolution that goes beyond personal computation to personal fabrication. This phase is described as having a far-reaching impact that is able to reach to a global audience. The revolution of the Fab Lab is described by Mikhak et al. (2002) in parallel to that of the revolution within the field of photography. At one time, photography, photo processing and manipulation was limited to the professional photographer. Today a growing number of devices can take pictures, and anyone can enjoy a great deal of software that allows manipulation of pictures. In much the same way, the Fab Lab revolution has allowed people to have access to a wide collection of tools that allow fabrication on a personal level.

Richards (2016) explains that the fab lab concept worked its way into the high school setting as regional employers saw the value of the concept that was popularized by MIT. As of Spring 2015 five MIT-approved Fab Labs existed in Wisconsin. With the popularity of the concept, and regional employer interest, several Wisconsin high schools began purchasing fab lab equipment with donations from local employers who saw the benefits of investing in materials that would produce graduates familiar with this type of equipment and who would possibly be future employees. According to Richards (2016) schools such as Milwaukee High School utilized funds offered by Caterpillar and local business to purchase the typical MIT suggested fab lab equipment. Within the high school, students take classes that revolve around technical engineering. Interest in this class has more than doubled since the school brought in fab lab equipment (Richards, 2016) showing that the Fab Lab is an attractive place in which students are able to use and learn techniques and skills associated with fabrication laboratory equipment. Anecdotal evidence suggests that students enjoy taking Fab Lab classes in order to solve open ended problems, utilize new highly technological equipment, and to prepare for engineering fields after high school (Richards, 2016).

Although the MIT Fab Lab and network has specific equipment and protocols, high schools throughout Wisconsin have adopted the term and the basic idea of the MIT Fab Lab, maintaining what is considered a digital fabrication laboratory. Since 2017, former Governor, Scott Walker has been promoting the widespread use of digital fabrication laboratories within the high school setting, and grants have been made available to purchase equipment. According to Walker, "Fab labs play a vital role in ensuring that today's students have the skills they need to compete for the jobs of the 21st century by providing hands-on experience in areas such as design, engineering, and complex problem-solving" (Walker, 2017, p.1). A high school fab lab, in Wisconsin is described as a “high-technology workshop equipped with computer-controlled manufacturing components such as 3d printers, laser engravers, computer numerical control routers, and plasma cutter” (Walker, 2017). As of December 2018, 43 Wisconsin schools have been awarded fab lab grants under Wisconsin Fabrication Laboratories grant (WEDC, 2019). Worldwide as of October 2017 the number of fab labs was 1,186 with the United States leading the count at 160 (Patty, 2017).

Pedagogical Methods Underlying Laboratory Instruction

An important issue regarding laboratory instruction relates to the pedagogical methods utilized within the fab lab. John Dewey (1938), proposed the introduction of experimental work in education regardless of age range. He suggested that scientific methods be used:

> I see at bottom two alternatives between which education must choose if it is not to drift aimlessly. One of them is expressed by the attempt to induce educators to return to the intellectual methods and ideas that arose centuries before scientific method was developed. Nevertheless, is folly to seek salvation in this direction. The other alternative is systematic utilization of scientific method as the pattern and ideal of intelligence exploration and exploitation of the potentialities inherent in experience”. (Dewey, 1938, p. 86-86).

This emphasis on the scientific method did not mean that it was to be an explicit way in which to revolutionize education, but rather, that the scientific process be used in a way to provide a pattern of sorts in which educators should adapt to situations, subjects, and students.

David Kolb (1984) created what is known as the Experiential Learning Theory (ELT) to unify perspectives such as Dewey’s. The ELT defines learning as “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb, 1984, p. 41). Kolb's (1984) ELT revolves around six propositions. The propositions are as follows:

1. Learning is best conceived as a process, not in terms of outcomes.
2. All learning is re-learning.
3. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world.
4. Learning is a holistic process of adaptation.
5. Learning results from synergetic transactions between the person and the environment.
6. Learning is the process of creating knowledge.

To put these principles into practice Kolb (1984) developed an ELT model that portrays opposing ways in which a learner processes experience alongside two related ways of transforming experience. These are known as concrete experience (CE), and abstract conceptualization (AC) which are opposites to reflective observation (RO and active experimentation (AE). This process of learning is displayed in Kolb's (1984) idealized learning cycle as being important to experience, reflect, think, and act. The process relies on the learner to have a concrete experience. This experience is the basis on which the learner is able to observe results and reflect on those results.

Experiential learning within a laboratory has shown results through the bridging of theory and experience while actively engaging students through project based instructional curriculum (Dunlap et al., 2008; Clark et al., 2010). Research has also shown that Kolb's (1984) model, does not always happen in sequential ordered steps, but rather that the steps overlap (Forrest, 2005), and as such, Kolb's (1984) model commonly takes place in studies that apply hands-on activities (Clark et al., 2010; Raschick et al., 1998) that allow re-iteration leading students to deeper learning and longer retention of information (David et al., 2002). This is similar to the Design Build Process as the process relies on multiple iterations of students solving different problems throughout the course. Re-iteration therefore is found in both the Design Build Process and in Kolb's experiential learning theory.

When it comes to laboratory learning and the way in which students think, it is important to think about thinking the way in which Seymour Papert would think. Seymour Papert's work can be traced historically back to Piaget's work on developmental psychology and to today's trends in technology education, especially fabrication laboratories (Blikstien, 2013). Papert has been at the center of three landmark events in research: child development, artificial intelligence, and technologies for education. Papert was a philosophy student at South Africa's University of Witwatersrand where he received a PhD in mathematics in 1952. Papert then went to St. John's College at Cambridge where as part of his second PhD work spent time at Henri Poincare Institute in Paris, where he met Jean Piaget. Piaget greatly impacted Papert's view on how children make sense of the world as active theory builders rather than miniature adults. Papert is responsible for what is known as the philosophy of Constructionism. Constructionism at its core is "a desire not to revise but to invert the world of curriculum-driven instruction" (Blikstien, 2013, p.2). Constructionism as a theory states that building knowledge occurs best through building things that are tangible and sharable, it is the idea that people learn effectively through making things (Akerman, Gauntlett, & Weckstrom., 2009, p. 56).

> Constructionism, in a nutshell, states that children are the builders of their own cognitive tools, as well as of their external realities. In other words, knowledge and the world are both construed and interpreted through action and mediated through symbol use. Each

> gains existence and form through the construction of the other. Because of this…learning through making sheds light on how peoples ideas get formed and transformed when expressed through different media, when actualized in particular contexts.” (Ackerman, 2004, p. 15)

Papert’s constructionism theory explaining how students learn is an important connection in how students learn in a fabrication laboratory as students build things that are tangible and sharable within a fab lab space. This pairs well with the design build process as students build projects within a fab lab utilizing problem solving methods.

Summary

The literature revealed that fabrication laboratories exist throughout high schools and within communities and are an ever-growing entity to empower ordinary citizens to improve their quality of life. It was found that creativity, although defined by various experts in many ways, is an essential component to a strong, vital, and healthy economy. The creative problem-solving process was also found to have a large impact on the way in which the Design Build Process has organized itself through its development into an educational strategy. The Design Build Process was found to be an educational strategy that has a high potential to proport creativity as it connects with Papert’s constructionism learning theory as well as Kolb’s experiential learning theory.

Chapter III: Method and Procedures

Innovation and entrepreneurship are crucial for long term economic development within any given country (OECD, 2007; Rosenburg, 2004; West, 2011). The National American College Testing agency (America, 2017) suggests that high school students are underprepared to fill jobs that require innovation and creativity. For some time, educational reports have been pointing towards change in education that would involve teaching skills such as innovation and creativity (National Commission on Excellence in Education, 1983; Carnevale, 1990; Eisen, 2005). Leading economists, Friedman and Mandelbaum (2011), have stated the need for creativity (which leads to innovation) as the only way in which the United States will be able to stay competitive on the world market keeping decent paying jobs for Americans. As a result, several science, technology, engineering, and mathematics (STEM) initiatives have been started across the nation to bolster success in students (Governor's STEM Advisory Council, 2017; Testimonials, 2018; Washington State, 2018; In Wisconsin, 2017). Wisconsin has begun investing in its schools with the fabrication laboratory initiative (In Wisconsin, 2017).

Low performing test scores in STEM, a need for creativity within the STEM field, ever advancing technology, and a decrease in appropriately trained workforce all add to answering the question of how the United States will be proactive in the innovation race, fill workforce needs, and continue to be a technological innovative leader in a global economy that promotes economic development for the future and beyond. An opportunity exists as there is funding in fabrication laboratories in Wisconsin, and the purpose of fabrication laboratories is to drive creative thought and innovation. Teachers within fabrication laboratories are the catalyst in which creative thought and innovation can be taught. However, it is unclear what instructional strategies best foster that creativity and innovation within the secondary school fabrication laboratories.

The purpose of this study was to test the potential of utilizing a fabrication laboratory within a high school setting to teach creativity, specifically using the Design Build Process as the educational methodology. The null hypothesis of this study stated that the teaching of the Design Build Process will have no statistical significance on the growth of creativity of the students within the treatment group. The alternative hypothesis that guided this study was that the teaching of the Design Build Process would positively influence creativity of the students within the treatment group. This chapter outlines how the study was framed to test the hypothesis. It covers research methodology, subject selection and description, instrumentation, data collection and analysis procedures, and limitations that define the research process.

Research Methodology

A quasi-experimental design using pretest-posttest nonequivalent control group was chosen because it would provide an in-depth review of the effect on creativity employing the Design Build Process within a high school fabrication laboratory. The "pretest aids in checking the similarity of the groups as the pretest scores are on the variables that have a strong relationship with the dependent variable" (Wiersma & Jurs, 2009, p. 169). The study was consistent with the pretest-posttest nonequivalent control group design as described by Wiersma and Jurs (2009). The design indicates that the structure involves a pretest-posttest without random assignment. One group receives the experimental treatment while another group serves as the control group and does not receive the experimental treatment. The groups are selected to be as similar as possible to fairly compare experimental and control groups. The design in this experiment was extended to include two experimental treatments while maintaining one control.

Pretest scores were used for statistical control to generate gain scores through comparison of posttest results.

Subject Selection and Description

Fabrication laboratories housed within Wisconsin secondary schools were chosen for this study based on convenience. The researcher created a list of past students, teacher colleagues and acquaintances who were teachers within a secondary fabrication laboratory and began contacting those teachers until three teachers were found who were willing to participate in the study. Two of the teachers selected were utilized within the experimental group, while the third was placed in the control group. In order to meet the researcher's criteria, each teacher was expected to be a secondary teacher and teach a class within a fabrication laboratory. Teachers had to be able to utilize a fab lab for 8 weeks of their school semester to complete the design build projects.

The selection of teachers was based on the need for one control group, and two experimental groups. This allowed the researcher to use multiple schools up to three if needed, or lesser schools with multiple teachers per school. The researcher elected not to utilize one teacher with multiple class sections as part of the study as the study intended to identify the ability of the Design Build Method to be taught with fidelity with various teachers who in turn deliver the content to their students.

School selection was based primarily by class size, age of the fabrication laboratory, and teacher experience within a fabrication laboratory. Class size was not to exceed 24 students as the researcher did not have access to ample pre and posttests due to funding restrictions. Class size had at a minimum 16 students to maximize the validity of the study. Age of the fabrication laboratory was expected to be consistent between all three teachers within two-five years. This was intended to keep the development of each fabrication laboratory and the development of the teacher within the fabrication laboratory at similar levels regarding curriculum, experience, and equipment utilized.

Instrumentation

The study utilized the Guilford Alternative Uses Test as the data collection tool to gain information about student growth regarding creativity. The Alternative Uses test was used as a measure of divergent thinking. Measuring a student's ability to think divergently is considered a reliable way in which to assess creativity (Runco, 2012). The Alternative Uses Test given in a pre and posttest format are estimated .91 reliable at a sixth-grade level, .86 reliable at a ninth-grade level, and .86 reliable at an adult level (Guilford, et. al., 1973). Alternative Uses has been found by several authors to measure divergent thinking, a key factor in measuring a person's potential ability to think creatively (Runco, 2012).

Alternative Uses is a test designed to measure flexibility of thinking in students which is reflective of a student's ability to think creatively (Wilson, Guilford, Chistensen & Lewis, 1954). Within the Alternative Uses test, each item represents the name of a well-known object, such as a paperclip, with a statement of its ordinary use. The examinee is to list as many as six other uncommon uses for each of the three objects listed within each part within the time given. The exam consists of two parts, and the examinee is given four minutes to complete each part with the complete exam taking eight minutes to complete. The exam contains two versions. Version one was given as a pre-test while version two will be administered as a post-test. Both the pretest and the posttest were administered by the researcher.

As part of the data collection process surveys were also administered. The researcher designed the survey questions around the hypothesis of the study. Survey questions included

Likert scale questions along with open ended questions. Likert scale questions were used as literature suggests it gives an ability to analyze separately "a set of items pertaining to one dimension" (Wiersma & Jurs, p.204, 2009). This combination was intended to allow respondents to answer questions with sensitivity and differentiation through open ended questions as well as give specific responses through a rating scale.

Prior to administering the surveys, external reviewers considered experts were utilized in validating the survey instrument. To accomplish this, two people were selected who have experience teaching creativity, and revisions were made to the survey according to the feedback given. After administration of the survey, all data was coded to protect confidentiality. A copy of the surveys is available in Appendix H and I.

Data Collection Procedures

The data collection process was carried out by the researcher. This aided in ensuring reliability as each school had the data collected by the same individual. The researcher utilized classroom teachers in order to gather consent forms. The researcher began with each school's students by giving them a hardcopy of the parental consent form which requires parental permission as well as student permission for the researcher to utilize student data from class (Appendix K).

Data collection took place in four stages consistent with the plan for the pretest posttest nonequivalent design: assign intact groups for the experimental and control treatments, administer a pretest to both groups, conduct experimental treatments with the experimental group only, and administer a posttest to assess the differences between the two groups (Creswell, 2013). This was followed up by a paper student survey administered by the researcher to the student, and a teacher survey administered by the researcher to the teacher. The teachers were also asked to complete a consent form prior to completing the study (Appendix L).

The first stage involved selecting three high schools to participate. Upon selection of the schools the researcher asked the schools for permission to complete the study and if the district had additional requirements for obtaining consent for students to participate in the research. Two of the groups were assigned to the experimental treatment while the third was assigned to the control treatment. The researcher worked with the teacher of each school district to set up times to come into the classroom of the experimental groups and Teacher B and Teacher C handed out consent forms (Appendix K) to the students and explained how the study was embedded in the course. The students were asked to seek parental consent as well as give their own consent if they wished to participate. If they did not wish to participate the data gathered by the teachers was not utilized within the study. The researcher ensured this by having students place names on the pretest, posttest, and survey. The names were matched with the consent forms received and only those data sets that had a matching name to the consent form were used. Data sets that did not have a consent form were destroyed. Teachers were asked to fill out a consent form (Appendix L) as they were key participants in the eight-week study.

The second stage was to administer the Alternative Uses exam to both the experimental and control groups, of which the researcher administered. Directions for this exam are found in the manual, which the researcher has permission to use for this study but cannot disclose within the study (see Appendix F).

Stage three consisted of having the high school technology education instructor for each experimental group carry out the experimental treatment. The experimental treatment consisted of having the classroom teacher administer three projects in an eight-week period that utilized fab lab equipment and the Design Build Process. Projects selected for the study were chosen based on the equipment available within their fab labs. Each school as part of their fab lab have a common set of woodworking equipment (table saw, planer, jointer, bandsaw, radial arm saw, chop saw), computer numerical control laser engraver, and a computer numerical control router. As the study took place at the beginning of the school year, the students were taught safety on the equipment as necessary to complete the projects part of the Design Build Process. Projects were designed around the safety instruction and incorporated the Design Build Process. The first project utilized the laser engraver, the second project utilized the CNC router, and the third and final project utilized a culmination of the woodworking equipment, laser engraver, and CNC router.

The fourth stage was to have all three groups complete the posttest form C of the Alternative Uses test. The protocol for administering these tests is found in the Alternative Uses test manual (see Appendix F). After the post-test was taken, two surveys were administered, one to the students, and the other to the classroom teachers. The surveys were administered as part of the data collection along with the experiment as this method was to strengthen the data collection part of this study (Creswell, 2013). Surveys were administered to the students by the researcher in a paper format. Teachers surveys were administered by the researcher in a paper format. Surveys were given to the teachers once the posttests were completed.

Instruction for the treatment was provided by the researcher prior to the start of the school year. The researcher invited the secondary teachers to the UW-Stout campus to instruct teachers at the same time in a three-hour instruction session. The outline for instruction followed the outline found in Appendix J. Instruction consisted of an overview of the study, a discussion of risks and perceived benefits, handouts that included a copy of the IRB approved study, parent permission letter (contains both signature line for parent and student), pretest and posttest handouts, project handouts and a lesson plan example. The instruction covered each of the project handouts in detail giving an eight-week timeline in which the study would take place from pretest to posttest. Instruction did not include an applied demonstration of a mock classroom, or a walk-through demonstration iteration of the Design Build Process. The researcher explained a typical DBP project and process, student responses, discussion of class culture, expected outcomes, and successful researched methods of growing creativity that have been infused in within the DBP.

Data Analysis

As teachers knew the students within the classroom, confidentiality was kept by having the researcher administer and file the exams. Exams and surveys of students were not looked at by the teachers, but only the researcher as the researcher did not know the students within the classrooms. Teacher surveys were also put into the folder and only viewed by the researcher. To protect confidentiality in data reporting, teachers were named as Teacher A, Teacher B, and Teacher C. As data was identifiable to the classroom of the school district being studied, names of the school districts that the data was collected from were omitted from publication or reporting.

After the administration of the pretest and posttest, the responses were analyzed using standard statistical methods to determine the effect, if any, of teaching the Design Build Process on the students creative thinking skills. Thirty-six possible responses existed on both the pretest and posttest. Both tests were scored similarly, one point given for each correct response. A pre/post paired samples t-test within the treatment group (as a combined group) was used as well as a pre/post paired sample t-test for the control group was used. Finally, pre/post-tests were compared between the treatment and control group using an independent samples t-test. This testing method was used because of its ability to compare test re-test data eliminating compounding errors in comparing group means.

In analyzing the qualitative data, surveys where designed to gather data regarding the student and teacher perception of the Design Build Methods effect on creativity through selected response Likert scale questions along with open-ended questions. Likert scale questions were examined through mean and standard deviation. Open ended questions were designed to give the researcher data that gave insight into the nature of teaching and learning utilizing the Design Build Process in connection with creativity. This data was analyzed using thematic analysis. Analysis was completed first by reading and re-reading data as a means of becoming immersed and familiar with the content. The researcher then began coding the data for common, succinct features within the data. Coded data was then used to search for themes that held broader patterns. Themes where then reviewed, synthesized, and defined to determine how each impacted the result of the study. Finally, themes were contextualized to aid in determining the results of the study.

Limitations

The sample size of this study was a limiting factor. Three high schools were selected as available to the researcher, of which one class from each school participated therefore limiting the sample. There was however, a need to limit the size of the study for practicality reasons for the researcher in managing the study.

Within each school district, enrollment was expected to be different for each class involved in the study. This was expected as course offerings were filled on a supply and demand basis. This was beyond the researcher's control.

Selection of the students was unable to be random as students chose to sign up to take a class that utilizes a fabrication laboratory. Therefore, a nonequivalent design was utilized. A limitation involved with this type of design that was true for this study involved the lack of control for pretest differences known as selection bias. Selection bias was likely to occur and was unable to be accounted for as three different school districts were being selected of which all had different curriculum surrounding their fab labs. The curriculum surrounding the fab labs was not accounted for, and therefore was considered to potentially alter the results of the pretest results between participant selections. Another limitation existed in the number of responses that were recorded. Permission slips were handed out, and the researcher was hopeful that parents and students alike would sign and return in high numbers.

Chapter IV: Results

Innovation and entrepreneurship are crucial for long term economic development within any given country (OECD, 2007; Rosenberg, 2004; West, 2011). According to the Boston Consulting Group (2011) creativity and innovation are the top ranked strategic imperatives in business and industry. It has become commonly known that because of low performing test scores, an increase in demand within the STEM field, ever-advancing technology, and a decrease in trained workforce that policymakers at all levels of government are emphasizing the importance of educating individuals for STEM-related jobs including the Department of Education prioritization of STEM-related grant proposals (Caitlin, 2017). The question quickly becomes, how will the United States be proactive in the innovation race, fill workforce needs, and continue to be a technologically innovative leader in a global economy that promotes economic development for the future and beyond? An opportunity exists as there is funding in fabrication laboratories in Wisconsin, and the purpose of fabrication laboratories is to drive creative thought and innovation. Teachers within fabrication laboratories are the catalyst in which creative thought and innovation can be taught. However, it is unclear what instructional strategies best foster that creativity and innovation within secondary school fabrication laboratories.

Researchers agree that creativity is concerned with producing ideas that are original and useful to solve problems and exploit opportunities (Baer, 2006; Bottani, 2010). Fabrication laboratories (fab labs) are concerned with the development of students to learn the skills necessary to thrive in today's world of work serving as an economic development tool, providing resources for entrepreneurs, businesses, and inventors (In Wisconsin, 2017). The Design Build Process is an instructional strategy being used within a post-secondary Design for Industry course to promote creativity. Little is known as to the effect of applying the Design Build Process within a fabrication laboratory to secondary students and their resulting growth in creativity. Using the Design Build Process at the college level has shown that students generate creative ideas as measured by divergent thinking for solving problems presented in class (Berkemer, 1989). This study sought to utilize the Design Build Process within a Fabrication Laboratory measuring the resulting growth of student creativity.

The purpose of this study was to test whether the high school fabrication laboratory was a place in which creativity could be fostered utilizing the Design Build Process. The Design Build Process (DBP) is an instructional strategy that at the time of the study was being utilized within a post-secondary Design for Industry course in order to promote creativity.

This chapter describes the results of the data collected from the three school districts involved in the study. This is accomplished using a paired samples t-tests, an independent samples t-test and a summation of the quantitative data received through the student and teacher surveys.

Sample Selection

Three technology education teachers within the K12 Wisconsin public school system known by the researcher participated in the study. Two of the teachers taught within a fabrication laboratory while the third had access to a fabrication laboratory which was utilized as the teacher saw fit. The two teachers that taught within the fabrication laboratory were placed in the treatment group while the third was placed in the control group. Selection was based on class size (16-24 students), age of fabrication laboratories (2-5 years old), and teacher experience. The treatment group consisted of School District B (SDB) and School District C (SDC). School District B consisted of approximately 500 high school students while SDC consisted of approximately 1400 students. The control group, School District A (SDA) consisted of approximately 950 students. The study took place within one classroom within each district. School District A's classroom had 24 students, of which 7 students returned permission slips. School District B's classroom had 20 students of which 11 students returned permission slips. School District C's classroom had 23 students of which 14 students returned permission slips. In total, 32 students of a possible 67 submitted permission slips and participated in the study. At the time of the study, each school's fab lab had access to a laser engraver, CNC router, CNC plasma cutter, computers with design software, a laser engraver, and 3d printer(s). Selection was completed with the intention of keeping the development of each fabrication laboratory and the development of each teacher within the fabrication laboratory at similar levels regarding curriculum, experience, and equipment utilized eliminating as many confounding variables as possible.

The study employed a pretest-posttest nonequivalent control group design within three high school technology education laboratories. Each district had access to a fabrication laboratory. School District A (SDA) was utilized as the control group while School District B (SDB) and School District C (SDC) were utilized as the treatment groups. The researcher trained the treatment group high school teachers in the Design Build Process prior to data collection. Data collection began at the beginning of the semester within all three districts. School District A was administered the pretest at the beginning of the eight weeks followed by the posttest at the end of the eight weeks. The treatment group was administered the pretest at the beginning of the eight weeks, taught the DBP within the fabrication laboratory, and concluded the eight weeks with the posttest, a student survey, and a teacher survey.

Data Analysis

Guilford's Alternative Use (Alt U) test was utilized to collect data through a pretest and posttest. The Alt U pretest and posttest were given as a form B and a form C. The two forms are similar in nature and involved two sections per test. The students were given four minutes to answer questions in the first section of the test and four minutes to answer the questions in the second section of the test (See Appendix F). The tests were scored based on 36 possible answers and one point given for each acceptable answer. A score closer to 36 showed that a student was more creative while a score closer to 0 showed that a student was less creative.

Test score results for the Alt U test can be seen in Table 1. There were 7 respondents in the control group, 11 in School District B, and 14 in School District C. The total number of respondents in the treatment group was 25. Scores are given for the control group and the treatment groups individually followed by an aggregate score for the treatment group.

Table 1

Test Scores

		Pretest		Posttest		Mean Difference Posttest-Pretest
		Mean	Standard Deviation	Mean	Standard Deviation	
Control (SDA)	n=7	8.43	7.50	13.57	10.08	5.14
Treatment (SDB)	n=11	8.45	3.10	15.27	5.06	6.82
Treatment (SDC)	n=14	9.64	3.05	13.57	5.6	3.93
Treatment Aggregate (SDB & SDC)	n=25	9.12	3.07	14.32	5.3	5.2

Table 1 shows an increase in the mean score within the control and the treatment group. The mean score difference between the pretest and posttest was greater for SDB than SDA or SDC. The mean difference was lowest in SDC, followed by SDA and SDB respectively. The standard deviation increased within all three groups between the pretest and posttest indicating a larger range of results. The standard deviation for the control group was nearly double that of the treatment groups, both pre and post-test.

Although violations of sample sizes below normality and non-normal distributions occurred within the data collection; Zimmerman (1997) demonstrated that the Type 1 error rate of the paired samples t-test remains close to the nominal significance level for varying correlation and sample sizes under normality. It was also found that under less than ideal conditions regarding the range of non-normal distributions the paired samples and independent samples t-test maintain Type 1 error robustness (Rasch & Guiard, 2004). Therefore, the following paired samples t-test and independent samples t-test where conducted.

A paired samples t-test was conducted using the data from Table 1 to evaluate the control group students' pre and post-test scores of Guilford's Alternative Uses test (Alt U). The results of the t-test indicate a statistically significant increase in Alt U scores from pretest ($M = 8.43$, $SD = 7.50$) to posttest ($M = 13.57$, $SD = 10.08$), $t(6) = -3.03$, $p = .023$, 95% CI [-.99, -9.29]. Specifically, the results suggest that students within the control group increased in creativity between the pretest and post-test.

Subsequently a paired samples t-test was conducted using the data from the treatment groups (Treatment Aggregate SDB & SDC) to evaluate the impact of the intervention on students pre and post test scores of Guilford's Alternative Uses test (Alt U). There was a statistically significant increase in Alt U scores from pretest ($M = 9.12$, $SD = 3.07$) to posttest (M

= 14.32, SD = 5.3), t(24) = -5.12, p = .00, 95% CI [-3.10, -7.30]. The results suggest that creativity increased within the treatment group between the pretest and posttest.

Following the paired samples t-test, an independent samples t-test was conducted for the pretest and posttest in order to compare results of Guilford's Alt U test between the control and treatment group. Within the pretest there was no significant difference in scores between the treatment (M = 9.12, SD = 3.07), and control groups (M = 8.43, SD = 7.5), p = .712, 95% CI [-3.10, 7.64]. Specifically, the results suggest that no significant difference existed within the control group students and the treatment group students in creative ability at the beginning of the study.

The independent samples t-test conducted to compare the Alt U for the posttest showed no significant difference in scores between the treatment group (M = 14.32, SD = 5.34), and control (M = 13.57, SD = 10.08), p = .792, 95% CI [-4.99, 6.49]. Specifically, this shows that although both groups grew in creativity through the duration of the study, the treatment group did not differentiate its growth as compared to the treatment group or vice versa.

Data was also collected by means of two surveys. The surveys were administered to the treatment group at the completion of the posttest. One survey was given to each student of the treatment group (See Appendix H) and one survey was given to each teacher of the treatment group (See Appendix I).

Students in the treatment group where administered a survey by the researcher in order to gather qualitative data to help better understand the pretest and posttest data. Questions 1 and 2 of the survey asked students to rate their perceived level of creativity prior to taking part in the study and upon completion of the study, one being low and four being high on a four-point Likert scale. Students within the treatment group perceived their average creativity to be a 2.22

at the beginning of the study and on average 3.05 at the completion of the study. Students saw a mean difference increase of .83. Figure 2 shows a graphical shift in difference in perceived creativity before and after the treatment groups intervention. As seen in Figure 2, several students felt they had increased in creativity. However, one student perceived themselves to contain little creativity before the intervention as well as after the intervention.

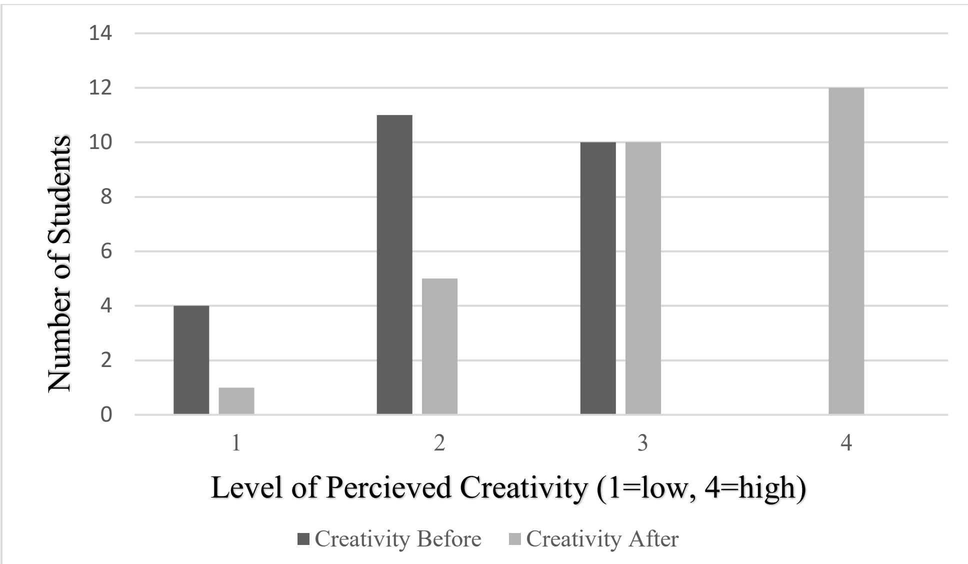

Figure 2. Creativity before and after intervention.

Question 3 asked “What observations have you made about yourself and your ability to be creative after the completion of the study?” Students sensed an increase in creativity at the completion of the study. One common theme found in the answers to this question was the idea of “thinking outside of the box” and using “things for a lot of different stuff”. Students commonly referred to the idea that they were able to look at different products and everyday things and if they “put their mind to it” they were able to “improve creative capacity”. Students also noted that they improved creativity when they were able to “practice” means of creativity through class exercises.

Question 4 asked students to reflect on the growth they saw within their classmates. Students generally saw their classmates as improving in creativity. A few select responses noted that “people think differently about creativity”. Others noted the “uniqueness” of their classmates and recognized that their classmates were “pretty smart”. Other students noted that classmates seemed to have “many more answers than before the study” and that “answers got weirder throughout the eight weeks” and that “some of the classmates had very unique ideas and could really make something cool”. A few students noted that classmates were “more creative than they were” and that “younger classmates where not as creative”. A small number of students noted that they themselves were not creative and that “there classmates don’t work as hard as they could”. Some students felt that their classmates where more creative than they were.

The 5th question asked students “what during the last 8 weeks did you find most useful in enhancing your ability to think creatively?” Students responded in a variety of ways, but commonly referred to exercises that where completed at the beginning of the class period. Specific activities included the “what is it?” game, using the “noodles and marshmallows to build a tower”, “sketching”, “designing projects”, “making things” and “thinking outside the box” activities. Students noted a need to have time to think creatively was important. They also noted that the instructor aided in enhancing creativity by making the students make projects that were “unique”. Others found that “hearing other peoples project ideas” helped them to be more creative along with “mixing other’s” ideas with their own ideas aided in unique design and creative solutions. One student described the Alt U exam as a “creativity boost”. A few students noted that they did not “notice any significant changes that enhanced creativity”.

At the conclusion of the posttest, teachers in the treatment group were asked to complete a survey. It was evident that both teachers surveyed had different experiences with the Design Build Process. Questions 1 and 2 asked the teachers to rate how they perceived their student's creative ability at the beginning of the study as compared to the end of the study. The questions utilized a four-point Likert scale, one being low and four being high. Both teachers perceived an increase in creative ability from the beginning to the end of the study. The teacher from SDB responded with a 1, while the teacher from SDC responded with a 2 giving an average of a 1.5 pre-intervention rating. The second question asked the teachers to rate their student's creative ability at the end of the study, again, one being low, and four being high. Both district's teachers responded with a three. This gives an average difference of a 1.5 increase between districts for a post-intervention rating as perceived by the classroom teachers.

The third question asked teachers for observations regarding student creativity as they went through the 8-week study. Similar themes between the two teachers included the idea that getting students to slow down and take time to work through the Design Build Process can be a challenge as students wanted to "jump right to the solution" and did not want to brainstorm "quantity over quality". Based on the data given, SDB's teacher had success in overcoming this with the use of "proper scaffolding" which allowed students to "generate and create creative solutions". This teacher found that students became "more excited to be creative because they had a format to help them get to a successful solution". School district C's teacher found resistance to change in "setting up and getting students to cooperate". This teacher spent a lot of time on "simple respect and following directions" within the classroom. The teacher from SDC noted that regarding teaching creativity "it really is a skill in getting ideas out" of the students.

Question 4 asked the teachers to share what they found "most useful while teaching creativity using the Design Build Process." In response the SDB teacher noted that it was "useful to start each class with a fun activity or exercise" to get students to start thinking creatively. The SDB teacher specifically referred to games such as "what is it?" and short projects such as "building spaghetti towers" where fun for the students and helped them to think outside of the box. The SDB teacher suggested that these activities helped students get into the problem-solving process with each project that they are giving the students the opportunity to be "successful, creative, and succinct in the way that they solve problems". School district C's teacher recognized the potential of the techniques within the Design Build Method but noted that a need for classroom control often took priority to the "brainstorming activities". The SDC teacher did note that thumb nail sketching went well.

Question 5 asked the teachers to identify what they found most challenging while teaching creativity using the design build process. Both teachers found it difficult to engage students in the problem-solving process. School district B's teacher found it useful to "build mockups and prototypes" to help students with this. SDC's teacher seemed to have difficulty getting the students to a point in which students could engage in the "team exercises" but thinks that the students did get a "good exposure to concepts" related to problem solving. School district C's teacher had difficulty infusing the Design Build Process into the classroom. The teacher stated a need to utilize a different course so that it "tailors to the design features" of the design build process. The teacher also found it challenging to implement the process with "department politics and other tech ed staff". Overall, both teachers had a similar difficulty in engaging students initially.

The final question asked the teachers to add any additional comments/recommendations they would like to make regarding teaching creativity using the design build process. Both teachers believed that ongoing teaching of the Design Build Process would improve their results. They felt that the "timeframe for teaching the process is something that needs to be ongoing" and that in another year or two they would be more "established and have better equipment and organization" within their classrooms. It was suggested that the teacher keep a portfolio being able to use "project ideas and refined concepts for each project/piece of equipment" to help the teacher improve as they teach the Design Build Process. Teachers do think that as they continue to teach and better learn the process that "students will grow even more creative" through the use of the Design Build Process.

At the completion of the teacher survey, the researcher had conversation with the School District B and School District C instructors. In the follow-up conversation it was discovered that the implementation of the Design Build Process was delivered differently between the two treatment groups. School District B completed the first three projects found in the Appendix (A,B, and C) while School District C completed only the second project (Appendix B). The SDC teacher noted a need to spend ample time working on items related to student discipline, relationships, and rapport with the students. The literature suggested a need for respectful relationships between teachers and learners to be established for the creative learning process to take place (Kolb, 1984).

Davies et al. (2013) suggested that in teaching creativity, it is essential that work time be allowed along with non-prescriptive planning, and flexibility within the work time needs to be evident to allow success in growing creativity. The teacher from School District C indicated that the teacher training may need to include these elements in the future to improve the teacher's ability to deliver the content.

Chapter V: Discussion

Innovation and entrepreneurship are crucial for long term economic development within any given country (OECD, 2007; Rosenberg, 2004; West, 2011). According to the Boston Consulting Group (2011) creativity and innovation are the top ranked strategic imperatives in business and industry. It has become commonly known that because of low performing test scores, an increase in demand within the STEM field, ever-advancing technology, and a decrease in trained workforce that policymakers at all levels of government are emphasizing the importance of educating individuals for STEM-related jobs including the Department of Education prioritization of STEM-related grant proposals (Caitlin, 2017). The question quickly becomes, how will the United States be proactive in the innovation race, fill workforce needs, and continue to be a technologically innovative leader in a global economy that promotes economic development for the future and beyond? Funding for fabrication laboratories exist in Wisconsin and provides an opportunity, and the purpose of fabrication laboratories is to drive creative thought and innovation. Teachers within fabrication laboratories are the catalyst in which creative thought and innovation can be taught. However, it is unclear what instructional strategies best foster that creativity and innovation within secondary school fabrication laboratories.

Researchers agree that creativity is concerned with producing ideas that are original and useful to solve problems and exploit opportunities (Baer, M., & Oldham, G. R., 2006; Bottani, 2010). Fabrication laboratories (fab labs) are concerned with the development of students to learn the skills necessary to thrive in today’s world of work serving as an economic development tool, providing resources for entrepreneurs, businesses, and inventors (In Wisconsin, 2017). The Design Build Process is an instructional strategy being used within a post-secondary Design for

Industry course to promote creativity. Little is known as to the effect of applying the Design Build Process within a fabrication laboratory to secondary students and their resulting growth in creativity. Using the Design Build Process at the college level has shown that students generate creative ideas as measured by divergent thinking for solving problems presented in class (Berkemer, 1989). This study sought to utilize the Design Build Process within a Fabrication Laboratory measuring the resulting growth of student creativity.

The purpose of this study was to test whether the high school fabrication laboratory was a place in which creativity could be fostered utilizing the Design Build Process. The Design Build Process (DBP) is an instructional strategy that at the time of the study was being utilized within a post-secondary Design for Industry course in order to promote creativity.

Using the Design Build Process at the college level has shown that students generate creative ideas for solving problems presented in class (Berkemer, 1989). The null hypothesis of this study states that the teaching of the Design Build Process will have no statistical significance on the growth of creativity of the students within the treatment group. The alternative hypothesis guiding this study is that the teaching of the Design Build Process will positively influence creativity of the students within the treatment group.

Several assumptions affected this study:

1. Creativity can be taught to students within a fabrication laboratory.
2. Creativity can be measured.
3. The Design Build Process can be taught to technology education instructors who will implement it with fidelity within their classrooms.

Fabrication laboratories housed within Wisconsin secondary schools were chosen based on convenience. The researcher created a list of past students, teacher colleagues, and acquaintances who at the time of the study were teachers within a secondary fabrication laboratory. Teachers were contacted until three were found that were willing to participate in the study. Two of the teachers were placed by the researcher into the experimental group while the third was placed in the control group. Selection was based on class size, age of fabrication laboratories, and teacher experience. Class sizes were expected to have a minimum of 16 students and no more than 24 students as the researcher did not have access to ample pre and posttests due to funding restrictions. Age of the fabrication laboratories were expected to be consistent between all three teachers within two to five years. This was done with the intention to keep the development of each fabrication laboratory and the development of the teacher within the fabrication laboratory at similar levels regarding curriculum, experience, and equipment utilized. A total 32 of a possible 67 students submitted permission slips and participated in the sample across experimental and control groups from the 3 public schools.

The study employed a pretest-posttest nonequivalent control group design within three high school fabrication laboratories using the Guilford Alternative Uses (Alt U) test. School District A (SDA) was utilized as the control group while School District B (SDB) and School District C (SDC) were utilized as the experimental groups. The researcher trained the high school teachers in the Design Build Process prior to data collection. Data collection began at the beginning of the semester within all three districts and proceeded for eight weeks. School District A was administered the pretest at the beginning of the eight weeks followed by the posttest at the end of the eight weeks. The treatment group was administered the pretest at the beginning of the eight weeks, taught the DBP within the fabrication laboratory, and concluded the eight weeks with the posttest, a student survey, and a teacher survey.

The remainder of this chapter is to summarize the findings of the exam data and survey data collected over the 8-week time period in which the control and treatment group participated in data collection. Discussion of the findings is followed by limitations to the research and the researcher's conclusion and recommendations.

Discussion of Findings

The null hypothesis of this study states that the teaching of the Design Build Process will have no statistical significance on the growth of creativity of the students within the treatment group. The alternative hypothesis guiding this study is that the teaching of the Design Build Process will positively influence creativity of the students within the treatment group.

Descriptive data from the Guilford Alternative Uses pre- and post-test showed an increase in creativity within the control group as well as an increase in creativity in the treatment group. An analysis of the paired samples t-test showed increases to be significant in both the control and treatment groups. However, when an independent samples t-test was applied to test for significance between the control and treatment pretest and the control and treatment post-test, no significant change in creativity was found between the groups while the standard deviation of the control group was nearly twice that of the treatment group. Based on the data, the null hypothesis was accepted that the teaching of the Design Build Process had no statistical significance on the growth of creativity of the students within the treatment group.

These findings suggested several possibilities to the researcher. Prior to conducting the research, the control group was designed to reside within a high school setting. The researcher did not specify nor control for the class content or student makeup. It was however determined that the class must have access to the school fab lab and utilize the lab as a part of its curriculum. Upon completion of the study, the researcher discussed with the control group teacher (SDA) the class content and methods utilized within the classroom. The control group participated in a course entitled “Energy Technology”. The method of instruction used in the control group revolved around the Engineering Design Process (EDP) and reflected the creativity process described by Torrence (1965) in teaching students design problem-solving. Torrance (1965) suggested that creativity involves being sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, identifying difficulty, searching for solutions, making guesses, formulating hypotheses, testing, retesting, and communicating results. This definition of creativity as a “process” reflects well on the nature of the Engineering Design Process and its ability to teach creativity when paired with projects that involve creative problem-solving. It may be concluded that the Design Build Process by its nature is similar in its ability to enhance creativity as that of its already existing counterparts that were already being taught within Technology Education during the time of this study. However, even though its ability to teach creativity may have been concurrent with other methods, the standard deviation suggested that the Design Build Process may have provided a higher degree of precision in enhancing creativity within the treatment group than did the curriculum taught within the control group.

The Design Build Process as outlined in the literature review and discussed by Johnson (personal communication, March 14, 2018) described the Design Build process as iterative, including the use of material processing ability and general knowledge of woodworking equipment. Through the researcher’s experience, it is known that this equipment is common within many technology education programs, alongside several other material processing types of equipment. The student’s ability to learn and manipulate equipment in the control group may have aided in creativity growth within this study. At the time of the study, traditional technology education equipment could be found within the school districts, as well as “fab lab” equipment consisting of computer numerical control equipment. Therefore, it is plausible that teaching students to utilize material processing equipment in a project-based environment does increase creativity, whether the Design Build Process is being taught, or another process or methodology. It is also critical to note the size of respondents in the control group within the study consisting of seven students. This number does not provide the desired minimal number of responses necessary to suggest with certainty the statistical accuracy of these conclusions.

Product, process, and performance are three outcomes of creativity and are sought when teaching the Design Build Process (Berkemer, 1989). Qualitative data from study surveys suggested that students were successful in creativity growth that aligned closely to the process outcome. Process refers to the student's ability to produce several ideas and to have an ability to change direction in thinking (different paths and patterns of thought) to produce difference ideas or view the problem differently. Students observed themselves saying they were able to "think outside of the box" and that as they practiced creativity and "put their mind to it" they continued to increase in creativity. Students also reflected on what they saw in their classmates pertaining to perceived creativity growth throughout the study. Students noted that each student would think "differently about creativity". Others noted the uniqueness of responses generated through the Design Build Process. The product and performance outcomes of creativity where not as prevalent in the outcomes. Both treatment group instructors noted in their responses that they needed more time to complete the Design Build Process. Product and performance outcomes are intended to focus on final solutions, appropriateness produced ideas, and the refinement and evolution of the projects. It was possible that limited data was garnered in these areas as students did not complete the required projects in the timeframe given.

Students suggested that "hearing other peoples' project ideas" helped them to be more creative along with "mixing" ideas between their own and their classmates aided in creativity. This is consistent with literature that suggests peer collaboration is an essential part of creativity (Davies et. al 2013). The qualitative findings pointed towards students increasing in creativity due to certain portions of the Design Build Process. In particular, the portions that allowed for group brainstorming and project-based work along with a teacher that allows ample time for creative thought. Student observations are consistent with Ackerman (2004) and the idea that learning through making sheds light on how peoples' ideas get formed and transformed when expressed through different media and actualized within context.

Feedback gathered from the teachers showed that the Design Build Process may have merit in certain areas regarding creativity growth in students. Teachers felt that continued teaching would increase their ability to teach their students creativity through the Design Build Process and that the "process needs to be ongoing". Both teachers rated their students in their perceived student growth. On average, they saw their students growing by 1.5 on a 4-point Likert scale. The idea that time and repetition where of importance was iterated by both instructors. This is consistent with the literature review as Davies et al. (2013) found that essential building blocks to creativity involve the flexible use of space and time, work time out-side the classroom/school. Lindstrom (2006) found that creativity can be honed through practice. Instructor feedback indicated a general perceived growth within the treatment group. Teachers within the treatment group noted difficulty initially in getting students to slow down and take time to work through the Design Build Process as students want to "jump right to the solution." The surveys also showed that students became "more excited to be creative because they had a format to help them get to a creative solution". The teachers noted brainstorming activities along with project-based activities were helpful in engaging students to think creatively.

The Instructor from School District C noted a challenge in school politics regarding the implementation of the Design Build Process. The challenge seemed to be regarding use of an open-ended problem-solving curriculum versus a prescribed curriculum that had outlined projects. The same instructor also noted a difficulty in classroom management. The instructor noted that a large portion of time was spent on classroom management, and not on teaching the Design Build Process. As the treatment group consisted of 25 students, and potentially half of those students belonged to School District C, it is unknown how the school and classroom climate may have affected this study.

In follow-up conversation with the treatment groups instructors it was discovered that the implementation of the Design Build Process was delivered differently between the two treatment groups. School District B completed the first three projects found in the Appendix (A,B, and C) while School District C completed only the second project (Appendix B). The SDC teacher noted a need to spend ample time working on items related to student discipline, relationships, and rapport with the students. The literature suggested a need for respectful relationships between teachers and learners to be established for the creative learning process to take place (Kolb, 1984). It was evident at the conclusion of the data collection that the student-teacher relationship may have impacted results in School District C hindering the results of the Alt U test.

Davies et al. (2013) suggests that in teaching creativity, it is essential that work time be allowed along with non-prescriptive planning, and flexibility within the work time needs to be evident to allow success in growing creativity. The teacher from School District C indicated that the teacher training may need to include these elements in the future to improve the teacher's ability to deliver the content. This was noted by the researcher as a possibility that the element of time was not only essential in the teacher's capability to teach creativity to their students, but also for the researcher to spend more time instructing the teachers that would deliver the content.

Conclusions

Based on this small sample the Design Build Process as it was delivered in this context and format does not significantly increase student creativity as compared to another technology education program's ability to teach creativity. Therefore, the null-hypothesis was accepted. However, most students and teachers felt that they had improved in creativity from the beginning of the study to the end, which is consistent with the descriptive data. Student and teacher survey data imply that certain merits exist within the Design Build Process. Students were exposed to several techniques and projects which they saw as helpful in aiding their growth in creativity. Teachers suggested that continued teaching of the Design Build Process would perhaps improve their ability to deliver the Design Build Process in a way that impacts student creativity to a higher degree. Based on the research findings the following conclusions were drawn:

- The way in which teachers teach creativity impacts the growth of student creativity.
- It takes time and practice to learn creativity.
- Group projects aid in the growth of student creativity.
- Qualitative evidence suggests that brainstorming activities aid in increased student creativity.
- K12 educators expressed that the Design Build Process can be a value-added tool in teaching within a Technology Education Fabrication Laboratory environment.

The results of the study showed that students that participated in the Design Build Process perceived growth in creativity when utilizing project based, applied learning, and perceived creative ability to be enhanced given the opportunity to brainstorm, reflect, and be challenged by their instructors.

Recommendations

The findings of this study lead to the following recommendations:

1. The sample size of this study affected its ability to reliably portray the quantitative data results to a larger generalizable audience. An increase in the number of students sampled within the control and treatment groups would give a better statistical indication of the effects of the Design Build Process on creativity. It is probable that the control group being part of a Technology Education program was exposed to a series of project-based pieces of curriculum. These variables need to be controlled for in future research.
2. Study of the Design Build Method needs to be continued or repeated. It is unclear as to the effect that SDB's teacher had in teaching the content as compared to SDC's teacher. Both teachers where given similar tools, but with different results.
3. The study needs to take place over a longer length of time. As noted by the teacher survey's, the timeframe in which the study took place did not allow the teacher to complete the design build process. Although students were exposed to a piece of it, the suggestion is that student's creativity would increase more as the teacher continued to teach the process. From a teaching standpoint, this is logical as the students are taught safety and machine operation alongside the design build process. Therefore, readjusting the study to either a 16-week study, which would allow

students to get comfortable with machines and then focus on the design build process, or adjust the study to take place in the later 8 weeks of the semester so that students already have a basis for material processing and equipment operation.

4. Explore opportunities to teach creativity within a Fabrication Laboratory in a manner that solely utilizes project-based, problem-solving activities, group brainstorming techniques, and a simplified Design Build Process format.
5. Teacher instruction for the Design Build Process took place over one evening session and did not include a demonstration of the curriculum. Future instruction may need to take place over a one- or two-week period and involve instruction that walks the teachers through the curriculum in an applied manner. Time is a key to success in teaching how to teach creativity and in learning creativity as a student.
6. Further development of the Design Build Curriculum needs to take place. Development may include a scope and sequence giving teachers an overview of the skills and content covered within the curriculum. This may aid in the teacher's ability to feel prepared and develop a classroom environment with respect and rapport that is conducive to teaching creativity.

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Appendix A: Marshmallow Challenge

The Marshmallow Challenge is a remarkably fun and instructive design exercise that encourages teams to *experience* simple but profound lessons in collaboration, innovation and creativity.

The Marshmallow Challenge

I work as a Fellow at Autodesk, the world's leader in 2D and 3D technology serving the Design, Engineering and Entertainment industries. I'm passionate about fostering design thinking, visual collaboration and team creativity.

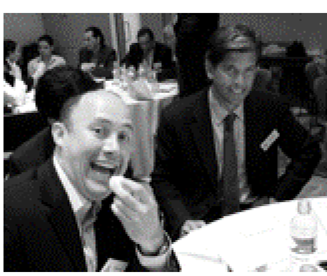
I believe the marshmallow challenge is among the fastest and most powerful technique for improving a team's capacity to generate fresh ideas, build rapport and incorporate prototyping - all of which lie at the heart of effective innovation.

For more information about my books, talks, visualizations and tools to foster innovation and team clarity, please visit TomWujec.com

Tom Wujec

If you need to kickstart a meeting, get a team into a creative frame of mind, or simply want to encourage your organization to think about what it takes to dramatically increase innovation, invest 45 minutes to run a marshmallow challenge.
The task is simple: in eighteen minutes, teams must build the tallest free-standing structure out of 20 sticks of spaghetti, one yard of tape, one yard of string, and one marshmallow. The marshmallow needs to be on top.

Surprising lessons emerge when you compare teams' performance. Who tends to do the worst? Why? Who tends to do the best? Why? What improves performance? What kills it?



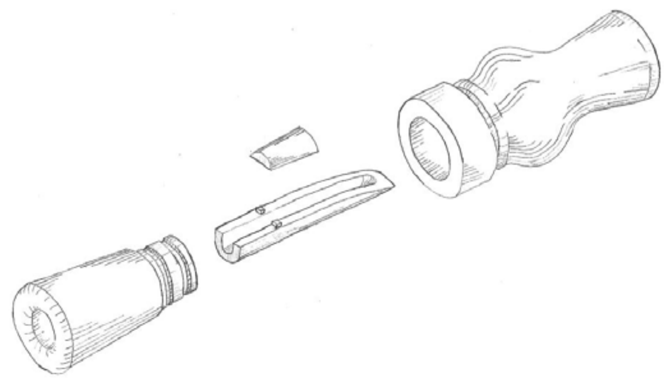
Appendix B: Sketch, Scan, Burn

ETECH-205 Design for Industry Name: ____________________

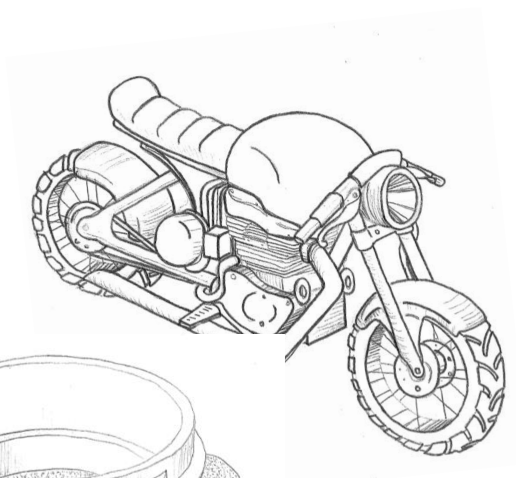
SKETCH, SCAN, BURN

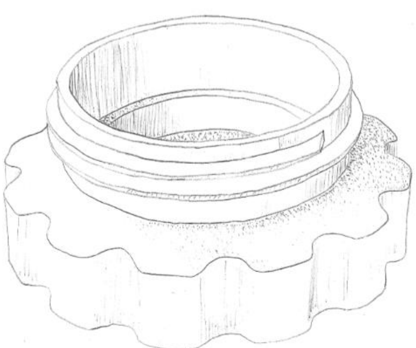
Due Date: _________________________

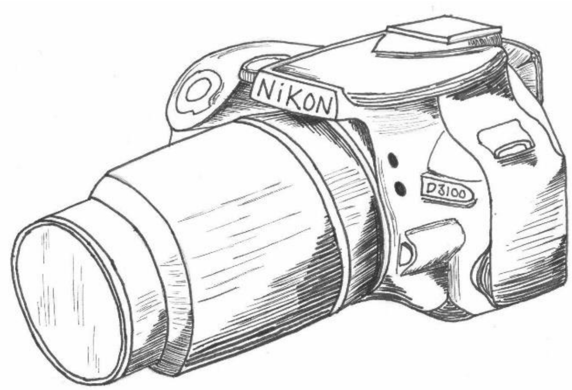
<u>Required:</u>
Prepare a pictorial sketch of an item of your choosing. It must include cylindrical features and be approved by the instructor. Use the shading processes described in the documentation from the United States Patent and Trademark Office http://www.uspto.gov/patents/resources/types/designapp.jsp#drawex Scan the image into a format accepted by CorelDraw®. Prepare material of your choosing for laser engraving. Again, instructor approval is required. Engrave the image onto the medium using the Epilog LASER engraver.

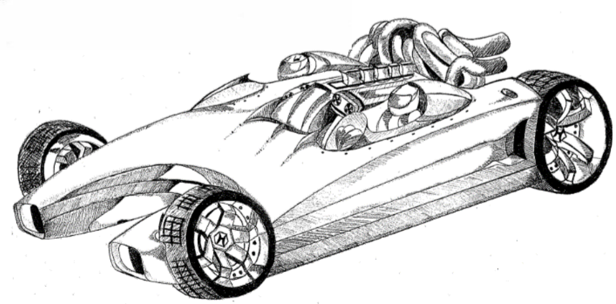


<u>Evaluation</u>: Mastery, 60 points.









Appendix C: Makin' Models

ETECH-205 Design for Industry Name: ______________________________

Name: ______________________________

Makin' Models

Due Date: _________________________

Required:

Review the *Compendium of Design Styles*. Select a design style from the list below and choose a household item made during the period that the design style was prevalent and replicate it as a model. Modify the original design. Prepare sketches of the item in pictorial and multiview form with dimensions. Construct two scaled, appearance models of the item: one of low fidelity, the other very high fidelity. Use an appropriate finish that replicates or simulates the methods initially used. Deliver a seven minute oral presentation to the class (do not prepare powerpoint presentation) that describes the aesthetic qualities of the item, the history of the style, designers associated with the style, and methods used to construct and finish the model.

Art Nouveau

Evaluation:	Mastery	
Sketches	10	______
Models		
Low fidelity	20	______
High fidelity		
Workmanship	40	______
Finish	30	______
Oral Presentation	20	______
	120	______

Asian

Victorian

MODERNISM

RUSTIC

Scandinavian

ARTS AND CRAFTS

NEOCLASSIC

CUBISM

Art Deco

Appendix D: For Those Who Need It Most

RD-205 Design for Industry

Name: ______________________________ Name: ______________________________

Name: ______________________________ Name: ______________________________

Name: ______________________________

For those who need it most.

Required:

Use the d.school method of problem solving (empathy, define, ideate, prototype, test) to develop solutions for problems affecting a person dealing with a disability. The eventual solution should be in the form of an aid or appliance. Perform an interview of the selected person. Walk a mile in their shoes to gain insight and empathy. Define a problem statement. Prepare a list of possible solutions. Construct low-resolution artifacts or models of the possible solutions. Conduct tests to inform the next iterations of prototypes.

Evaluation:

Clear, concise, actionable problem statement	10	Due Date: ____________________
Ideate several divergent solutions (30)	10	Due Date: ____________________
Low-fidelity model	30	Due Date: ____________________

Oral presentation including: 30 Due Date: ____________________

- summation of interview with client
- knowledge gained through empathetic actions
- problem statement
- constraints and goals
- technical literature review and prior art
- freehand sketches of possible solutions
- orthographic and pictorial line drawings
- computer or hand rendered models of the proposed solution.

Peer assessment: 20 Due Date: ____________________

ability to function effectively as a member or leader on a technical team.

TOTAL POSSIBLE 100

Appendix E: Puzzled

RD-205 Design for Industry Name: ______________________________

Puzzled

Discussion

In 1837, having developed and tested a radically new educational method and philosophy based on structured, activity- based learning, Fredrick Froebel moved Bad Blankenburg, Germany and established his Play and Activity Institute which in 1840 he renamed Kindergarten. Froebel's Kindergarten had three essential parts:

- •creative play, which Froebel called gifts and occupations)
- •singing and dancing for healthy activity
- •observing and nurturing plants in a garden for stimulating awareness of the natural world

https://www.youtube.com/watch?v=6au1rzHvlRk

According to Piaget, a 20th century Swiss Psychologist and one of the most influential Child Psychologists of our time, cognitive growth, specifically conceptual development, is primarily achieved by acting on the world. Piaget believed that people learn about their natural environment through a trial and error. http://prezi.com/rkticr8-i4xc/development-in-play-project/ Puzzles were critical to this development according to Piaget.
https://www.youtube.com/watch?v=TRF27F2bn-A

Susan M. Landau, et. al., in *Association of Lifetime Cognitive Engagement and Low β-Amyloid Deposition* Archives of Neurology May 2012, Vol 69, No. 5 found that greater participation in cognitively stimulating activities such as reading writing and puzzle games across the lifespan, but particularly in early and middle life, was associated with reduced β-amyloid uptake. β-amyloid is the main component of the amyloid plaques found in the brains of Alzheimer patients.

Required

Prepare a pictorial freehand sketch of a proposed puzzle, game, or toy, which is an original design that challenges or fascinates a person at any cognitive level you choose. Crossword puzzles, Sudoku, and computer games are not acceptable. Build the puzzle, which must be an electrical, mechanical, fluidic, or structural device. Prior instructor approval is required. Determine pricing for said product.

Evaluation:

Sketch	20	Due Date: ___________________
High- fidelity prototype. Heirloom quality Functional, finished, void of burrs and sharp edges, not fragile.	70	Due Date: ____________________
Price estimates	10	Due Date: ____________________
Mastery TOTAL POSSIBLE	100	

Appendix F: Instrument

For use by Kevin Dietsche only. Received from Mind Garden, Inc. on April 12, 2018

mind garden

www.mindgarden.com

To Whom It May Concern,

The above-named person has made a license purchase from Mind Garden, Inc. and has permission to administer the following copyrighted instrument up to that quantity purchased:

Alternate Uses

The one sample item only from this instrument as specified below may be included in your thesis or dissertation. Any other use must receive prior written permission from Mind Garden. The entire instrument may not be included or reproduced at any time in any other published material. Please understand that disclosing more than we have authorized will compromise the integrity and value of the test.

Citation of the instrument must include the applicable copyright statement listed below.

Sample Item:

5. BRICK (used for building)
a. ______________________(example: to hit someone on the head)
b. ______________________(example: a paperweight)
c. ______________________(example: to save water in a toilet tank)
d. ______________________(example: a doorstop)
e. ______________________(example: to build a house)
f. ______________________(example: throw through a window)

Sincerely,

Robert Most
Mind Garden, Inc. www.mindgarden.com

Appendix G: Lesson Plan Example For Design Build Projects

Utilizing the adapted CPS framework, an instructor teaching the Design Build Process can utilize the phases to develop a framework to teach a given project and develop a Unit lesson plan. An example framework may look like the following which has been adapted from Berkemer (1989).

I. Problem finding. Familiarization with the specifics of the problem. Initial questions to ask might be:
   A. What solutions already exist that attempt to solve this problem?
   B. How will the solution be novel?
   C. How can the solution be designed to best solve the problem utilizing the equipment and available material?

II. Research and Analyze.
   A. Check information sources: library, engineering and physics instructors
   B. Observe present solutions.
   C. Consider the concept of triangulation

III. Ideation
   A. Brainstorm, etc.
   B. List apparent attributes and weaknesses of ideas.
   C. Sketch a number of ideas and discuss with the instructor.

IV. Experiment and refine. Select the most promising ideas and construct sample components.
   A. Test samples for strength.
   B. Consider the manner and difficulty of fabrication.
   C. Consider and test methods of joining components.
   D. Test joined components for strength.
   E. Determine the most efficient use of materials for each design.

V. Final Solution.
   A. Construct and test.
   B. Modify after testing.
   C. Boast.

VI. Presentation
   A. Test solution in class.
   B. Submit drawings and project notes to instructor.

Appendix H: Student Survey Questions

1. Please rate your perceived level of creativity prior to taking part in this study. One being low four being high.

1 2 3 4

2. Please rate your perceived level of creativity now that you have taken part in this study. One being low, four being high.

1 2 3 4

3. What observations have you made about yourself and your ability to be creative after the completion of this study?

4. What observations did you make regarding creativity in your classmates after the completion of the study?

5. What during the last 8 weeks did you find most useful in enhancing your ability to think creatively?

Appendix I: Teacher Survey

1. Please rate how you perceived your student's creative ability at the beginning of this study. One being low and four being high.

   1 2 3 4

2. Please rate how you perceived your student's creative ability at the end of this study. One being low and four being high.

   1 2 3 4

3. What observations did you make regarding student creativity as you went through the 8 weeks of the Design Build Process?

4. What did you find most useful while teaching creativity using the Design Build Process?

5. What did you find most challenging while teaching creativity using the Design Build Process?

6. Are there any other additional comments/recommendations you would like to make regarding teaching creativity using the Design Build Process?

Appendix J: Teacher Instruction Outline

Instruction Agenda

I. Welcome teachers

   a. Thank you for participating in this study

II. Part 1

   a. Overview of the study

   b. Risks and Benefits Associated with the Study

   c. Review letter for parental consent, student consent

   d. Questions?

III. Part 2

   a. Project handouts, timelines for each project, material associated with each project.

   b. Explain Design Build Process and how to infuse into projects

Materials needed for training:

- Consent form for instructors
-Ppt. giving overview of study
-Parent Notification Letter (Appendix K)
-Alternative Uses Manual
-Outline of delivery for Design Build Process
-Lesson Plan Example for Design Build Projects (Appendix G)

Appendix K: Parent Notification Letter

Dear Parent or Guardian,

My name is Kevin Dietsche, a graduate student in the Ed.D. program at the University of Wisconsin-Stout. I am completing a project entitled: ***Measuring Creativity Employing the Design Build Process within a PK12 Fabrication Laboratory***. As we have a growing number of Fab Labs in the state of Wisconsin, I am working to develop a methodology to help support teachers that work within those Fab Labs. The curriculum is based on existing tooling and equipment and uses proven methods that promote creativity and problem-solving methods utilizing a project-based method.

To determine the effectiveness of the methodology that I am developing your student will be asked to complete a pre-test and a posttest regarding their creativity skills with the methodology and projects being delivered between these two tests. These efforts are the focus of my doctoral dissertation research under the supervision of Dr. Deanna Schultz. Student participation in the study is voluntary and results will be reported in aggregate so no student participant can be identified. Participation in this research does not involve risks above and beyond that which would be found within a normal Fab Lab/Tech Ed Lab environment. Your student is expected to benefit by growing their creativity and problem-solving skills.

As your student is a minor, informed consent is a requirement. As the parent/guardian of your son/daughter I am asking for your consent to use the data gathered in determining the results of this study.

Should you or your student feel uncomfortable at any point during this project, participation is voluntary and you or your student may choose to withdraw without any adverse consequences to either of you.

The study results will be analyzed during the Fall 2018 semester and will be shared with the public. Results of the research will be beneficial to teachers within Fab Labs across the country, and potentially across the world. Copies of the research results will be available upon request.

This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator Elizabeth Buchanan at: 715-232-2477 or by email at Buchanane@uwstout.edu.

Please turn paper over.

Sincerely,

Investigator: Kevin Dietsche
715-232-2274
dietschek@uwstout.edu

Advisor: Dr. Deanna Schultz
715-232-5449
schultzd@uwstout.edu

Statement of Consent:
By signing this consent form you agree to allow your child to participate in the project entitled: ***Evaluating the Effectiveness of the Fabrication Laboratory in Teaching Creative Problem Solving***."

____
Signature of student Date

____
Signature of parent or guardian Date

Appendix L: Teacher Consent Form

Consent to Participate In UW-Stout Approved Research

Title: *Measuring Creativity Employing the Design Build Process within a PK12 Fabrication Laboratory*

Research Sponsor: *Dr. Deanna Schultz*
715-232-5449
schultzd@uwstout.edu

Investigator:
Kevin Dietsche
715-232-2274
dietschek@uwstout.edu

Description:
My name is Kevin Dietsche, a graduate student in the Ed.D. program at the University of Wisconsin-Stout. I am completing a project entitled: ***Measuring Creativity Employing the Design Build Process within a PK12 Fabrication Laboratory***. As we have a growing number of Fab Labs in the state of Wisconsin, I am working to develop a methodology to help support teachers that work within those Fab Labs. The curriculum is based on existing tooling and equipment and uses proven methods used at UW-Stout that promote creativity and problem-solving methods utilizing a project based method.

To aid in determining the effects of this study, I am requesting that you would take part by administering a pre and posttest to your students. If part of the experimental group, this will also include implementing the Design Build Process in your classroom for 8 weeks during the semester within a class that utilizes the Fab Lab and at the end of the 8 weeks take a survey regarding your opinions of your students' creativity and the teaching of creativity through the Design Build Process. These efforts are the focus of my doctoral dissertation research under the supervision of Dr. Deanna Schultz. Your participation in the study is voluntary and your name and school district will be known only to the researcher.

Risks and Benefits:
Participation in this research does not involve risks above and beyond that which would be found within a normal Fab Lab/Tech Ed Lab environment. You may benefit by learning a method in which to teach and assess creativity utilizing a project-based method known as the Design Build Process. The process may also fit with your districts policies in showing educator effectiveness.

Time Commitment and Payment:
The study will begin for the Fall of 2018 semester and is expected to run eight weeks. An instruction day will take place within two weeks prior to the start of the study. There is no payment associated with this study.

Confidentiality:
Your name will not be included on any documents. We do not believe that you can be identified from any of this information. This informed consent will not be kept with any of the other documents completed with this project.

Right to Withdraw:
Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. Should you choose to participate and later wish to withdraw from the study, you may discontinue your participation at this time without incurring adverse consequences. Should you choose to withdraw, any student data collected up to the point of your withdrawal will be collected and destroyed.

IRB Approval:
This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

Investigator: *Kevin Dietsche, 715-232-2274, dietschek@uwstout.edu*

Advisor: *Dr. Deanna Schultz, 715-232-5449, schultzd@uwstout.edu*

IRB Administrator
Elizabeth Buchanan
Office of Research and Sponsored Programs
152 Vocational Rehabilitation Bldg.
UW-Stout
Menomonie, WI 54751
715.232.2477
Buchanane@uwstout.edu

Statement of Consent:
By signing this consent form you agree to participate in the project entitled, ***Measuring Creativity Employing the Design Build Process within a PK12 Fabrication Laboratory.***

____

Signature Date