ABSTRACT

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This study compared the creative outcomes in student work resulting from two pedagogical approaches to creative problem solving activities. A secondary goal was to validate the Consensual Assessment Technique (CAT) as a means of assessing creativity.

Linear models for problem solving and design processes serve as the current paradigm in classroom practice. However, the need for alternative pedagogies has been identified in the research literature, as has the need for nurturing creativity and innovation. The choice-based approach, a method practiced in the field of visual art education, offers potential for transferability to the field of technology education.

Six groups of students in sixth through eighth grade visual arts classes were taught an instructional unit on game art and design, a topic applicable to both art and technology curricula. Either the choice-based approach, borrowed from art education, or the DEAL method (Define/Explore/Anticipate/Look back), currently part of the North Carolina K-12 curriculum for Technology Education, was used to guide the unit of study. Following either of these methods, students completed the problem-solving task using a variety of fabrication materials and techniques including video game design software. The unit culminated in a class gaming session, presentation and critique during which students completed self- and peer- product evaluations. The consensual assessment technique was then employed using seven adult raters to compare outcomes of student work resulting from the contrasting pedagogies.
Creativity, technical strength and aesthetic appeal were the three major dimensions measured on the consensual assessment form. Nine additional items were measured. Comparisons of means determined no significant difference in creativity scores between the choice-based and DEAL groups. Factor analysis suggested the existence of a creativity cluster comprising creativity and the three associated items, novel idea, novel use of materials, and complexity. Inter-rater reliability was high for all 12 items measured.

The results of this research are consistent with those of earlier studies in determining that creativity can reliably be assessed in classroom problem-solving activities.
Fostering and Assessing Creativity in Technology Education

by
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BIOGRAPHY

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# TABLE OF CONTENTS

LIST OF TABLES ............................................................................................................................viii

LIST OF FIGURES ...........................................................................................................................ix

CHAPTER 1: INTRODUCTION .................................................................................................1

CHAPTER 2: LITERATURE REVIEW .........................................................................................9

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>9</td>
</tr>
<tr>
<td>Creativity Definitions</td>
<td>10</td>
</tr>
<tr>
<td>Fundamental Principles</td>
<td>11</td>
</tr>
<tr>
<td>Creativity Research</td>
<td>12</td>
</tr>
<tr>
<td>Guilford’s Call to Action</td>
<td>12</td>
</tr>
<tr>
<td>Stages of Creative Thought</td>
<td>13</td>
</tr>
<tr>
<td>Defining Creativity Apart From Intelligence</td>
<td>15</td>
</tr>
<tr>
<td>Creativity in the Evolution of Technology Education</td>
<td>17</td>
</tr>
<tr>
<td>Significance of the Research Problem</td>
<td>22</td>
</tr>
<tr>
<td>A Globally Competitive Workforce</td>
<td>23</td>
</tr>
<tr>
<td>Defense Against Malevolent Innovation</td>
<td>23</td>
</tr>
<tr>
<td>Increased Student Engagement and Rates of Graduation</td>
<td>24</td>
</tr>
<tr>
<td>Theoretical Considerations</td>
<td>26</td>
</tr>
<tr>
<td>Vertical and Lateral Thinking</td>
<td>27</td>
</tr>
<tr>
<td>The Choice-Based Method</td>
<td>29</td>
</tr>
<tr>
<td>Twenty-first Century Skills</td>
<td>31</td>
</tr>
<tr>
<td>The DEAL Problem-Solving Method</td>
<td>36</td>
</tr>
</tbody>
</table>
Correlations Among the Three Major Dimensions ........................................67
Hypothesis #2 .........................................................................................67
Inter-rater Reliability ............................................................................69
Hypothesis #3 .........................................................................................69
Hypothesis #4 .........................................................................................69
Systematic Bias in Individual Raters ......................................................71
Discriminant Validity ...........................................................................73
Hypothesis #5 .........................................................................................73
Chapter Summary .................................................................................75
CHAPTER 5: DISCUSSION ........................................................................76
Introduction ..........................................................................................76
Reliability and Validity of the Consensual Assessment Technique ..........81
The DEAL and Choice-Based Methods ..................................................84
Additional Limitations ..........................................................................85
Moving Forward with Fostering and Measuring Creativity in STEM Education ...86
Conclusion ............................................................................................91
REFERENCES .......................................................................................92
APPENDICES .........................................................................................108
APPENDIX A: RATER BACKGROUND SURVEY ...................................109
APPENDIX B: CONSENT FORMS .........................................................111
Informed Consent Form for Raters .......................................................112
Informed Consent Form for Students ....................................................114
APPENDIX C: DESIGN BRIEF: CHOICE-BASED METHOD…………………………..117
APPENDIX D: DESIGN BRIEF: DEAL METHOD………………………………..120
APPENDIX E: DEAL HANDOUTS…………………………………………………123
APPENDIX F: SELF/PEER EVALUATION FORM……………………………..128
APPENDIX I: CONSENSUAL ASSESSMENT FORMS…………………………..130
LIST OF TABLES

Table 2.1 21st Century Skills and the Technology Laboratory ................................................34
Table 2.2 Benchmark Scale for Valuation of Inter-rater Reliability Coefficients ........44
Table 3.1 Course Details and Enrollment by Method .................................................................53
Table 3.2 Daily Process by Method .........................................................................................56
Table 3.3 Rating Instruments by Population and Scores Produced .................................58
Table 4.1 Variables of Interest for Research Hypotheses ......................................................64
Table 4.2 Descriptive Statistics for All Rated Items .................................................................66
Table 4.3 Tests of Independence of Means: DEAL vs. Choice-Based for Adult CAT Scores .................................................................................................................................67
Table 4.4 Correlations for Three Dimensions by Method .......................................................68
Table 4.5 Correlations for Three Dimensions .......................................................................68
Table 4.6 Inter-rater Reliabilities for Seven Adult Raters .......................................................70
Table 4.7 Inter-rater Reliabilities for All Raters ...................................................................70
Table 4.8 Pairwise Correlations between Rater Types ...........................................................70
Table 4.9 Correlation Coefficients and Bland Altman Plots of Creativity by Rater ........72
Table 4.10 Factor Loading of 12 Items, Promax Rotation .....................................................75
LIST OF FIGURES

Figure 2.1  Industrial Arts, 1929 .................................................................19

Figure 2.2  21st Century Student Outcomes and Support Systems........................33
CHAPTER 1: INTRODUCTION

American public education places heavy emphasis on a limited range of skill sets that are simple to assess using standardized multiple-choice testing formats. In order for American students to remain globally competitive, however, a paradigm shift is needed, such that creativity, innovation, problem-solving abilities and intrinsic motivation are qualities fostered and valued in public education. The National Center on Education and the Economy (2010) has identified Applied Learning as a relatively new focus of study for which it has developed standards centering on problem solving. The center’s discussion and recommendations explicitly call for the inclusion of creativity throughout these applied activities.

Creativity is gaining recognition as a necessary component of K-12 education, but some contend that education is instead currently stifling children’s creativity. As Ken Robinson said in his 2006 TED talk, we are systematically educating the creativity out of American children and it is doing them a great disservice (TED, 2006). He explained, employers “want people who can think intuitively, who are imaginative and innovative, who can communicate well, work in teams and are flexible, adaptable and self-confident. The traditional academic curriculum is simply not designed to produce such people” (2001, p. 52). What schools are producing, said Richard Florida (2007), are students unprepared for the 21st century, more suited to the needs of the Industrial Age and equipped to take on jobs as assembly line workers. Florida insisted that the cultivation of human creativity lies at the core of what education reform must accomplish. This is essential to the sustainability of not only the American workforce, but to ensure that American students will become functioning...
members of a global economy, whatever that might look like a generation or more into the future. Howard Gardner advised parents to help their children prepare for working for modern companies by pursuing activities and hobbies outside of school that do not require a single right answer (Bryant, 2010).

Nurturing students’ creativity is not just about teaching an employable skill, however. John Dewey was an advocate for creativity in the classroom because, said Lewis (2009), he saw the importance of the subject for children, not so much as an interpreter of industry, but as a means of providing them with self knowledge of their own impulses, gained by seeing the external results of their motor activities. (p. 256)

The development of creativity is associated with increased resourcefulness, self-sufficiency and adaptation to the rapid change characteristic of the transition from the Information Age to the Conceptual Age (Pink, 2006). Teaching children creative problem-solving skills helps them become successful adults who can question the accuracy of information and put what they learn to constructive use (Todd & Shinzato, 1999). Csikszentmihalyi (1997) called creativity a “central source of meaning in our lives” and said that without it:

There would be no speech, no songs, no tools, no ideas such as love, freedom or democracy. It would be an existence so mechanical and impoverished that none of us would want any part of it. [. . .] Scientists will have to come up with new solutions to overpopulation, the depletion of nonrenewable resources, and the pollution of the environment [. . .] Whether we like it or not, our species has become dependent on creativity. (p. 317)
Economist Richard Florida (2007) described a global transition to a creative economy in which human creative capital is a near limitless resource. He said that for the United States to ensure an open, economically secure society, creativity must be thought of as a common good not unlike liberty or security, something “essential that belongs to all of us, and that must always be nourished, renewed, and maintained” (pp. 262-269).

Fostering creativity and creative problem-solving skills is easier said than done within the current goal framework of the average public school classroom. Teachers may view creative students as “inattentive and disruptive,” tending to “wander away from the regular paths of thought” (Lau & Li, 1996, p. 348). Westby and Dawson (1995) found significant negative correlations between teachers’ favorite students and their creative students. According to Strom and Strom (2002), Torrance gave a list of 62 characteristics of students to 1,000 expert teachers and asked them to rate desirable qualities. “Low correlations were found between the behaviors teachers wanted students to demonstrate and behaviors commonly demonstrated by creative persons,” undermining creativity by discouraging students from asking questions, guessing, becoming preoccupied with tasks, risk taking and acting like visionaries (Strom & Strom, 2002, p. 184).

Teresa Amabile (1998) has extensively studied social, psychological and instructional factors influencing creative outcomes in educational and business settings. She identified ways creativity is routinely undermined (1998) by focusing too heavily on extrinsic, rather than intrinsic, motivation, providing an inappropriate level of challenge, limiting freedom regarding the means to achieving a prescribed solution or goal, unnecessarily limiting resources such as time, supplies, and money with arbitrary deadlines or policies, ignoring the
importance of team dynamics and neglecting to provide praise. The experience of many students and teachers, including myself, mirror both Torrence’s and Amabile’s results. For many reasons – time constraints, demands of standardized testing, teacher discomfort, classroom management concerns, ease of assessment – creative behaviors are often discouraged. Thus, creativity is stifled in classrooms.

Technology education offers a potentially fertile environment for developing students’ creative problem-solving abilities and creative behaviors. Creativity and innovation are explicitly stated goals for the field, potentially fostering an instructional environment supportive of creative expression. At the core of the discipline are the Standards for Technological Literacy (2007), which heavily emphasize design processes, problem solving, invention, innovation, troubleshooting and experimentation. According to Lewis (2009), technology education allows for the expression of students’ multiple intelligences because it “broadens the range of domains within which talents can be uncovered” (p. 256). Lewis identified examples of curricular approaches to teaching technology courses that could encourage creative thinking including a focus on inventiveness, divergent thinking, combination thinking and analogical thinking (2009).

While the publication of the Standards for Technological Literacy – with four of its twenty standards explicitly dealing directly with design – marks a step towards greater focus on fostering students’ creativity, there is work to be done in establishing successful pedagogical strategies for fostering creativity in technology labs (Lewis, 2005). Technology teachers must, said Lewis (2009), “become more fully grounded in the ways of inventors — their modes of thought, cognitive strategies, and the kinds of knowledge on which they draw”
Unfortunately, attempts to create uniform curriculum have hampered these courses with linearity and standardization. Often products come to be valued and focused upon to a far greater degree than the experience of the creative problem solving process (McCormick, 2004). Alternately, the process itself can become so methodical as to stamp out the creativity for students. Reeder (2001) emphasized the value in teaching somewhat methodical steps to a design process, but warned about doing it so overtly. Lewis (2005) explained:

Teaching design as a linear stage process is akin to arriving at a pedagogy of art by mere narration of the observable routines of the artist. It simply misses the point that design, like art, proceeds from deep recesses of the human mind . . . The key is to recognize design as a creative rather than a rationalistic enterprise. (para. 35)

Flowers (2010) took issue with the widespread “dogmatic” use of the word the in the field of technology education to imply singularity, uniqueness or supremacy of one design or problem-solving process over any other:

It is likely a comfort for teachers and teacher educators to become attached to only one of many approaches, as it protects us from having to question our assumptions and our knowledge. Even though our beliefs can provide comfort, we are not there for teacher or student comfort. (p. 18)

A similar explanation from Mawson (2003) was that perhaps a “principle motive for the development of models of the design process was to make possible the teaching and assessing of technology education by imposing order on what is an essentially confused interactive process,” the acceptance of which also avoids “problems schools would have faced with management, assessment, and resourcing if students were allowed to engage in
open-ended problem solving” (p. 119). Teachers are generally expected to align the goals and objectives of lessons with measurable outcomes, but for reasons of simplicity, speed, and, arguably, accuracy, many teachers avoid explicitly including creativity in their lessons. Lewis (2005) attributed the fledgling state of creative problem-solving assessment in technology education to the lack of work the field has done on helping teachers to identify and assess inherent creativity in students’ design work.

An approach to managing challenges very similar to those described by Mawson has been developed in the field of visual art education. Teaching for Artistic Behaviors, also called the choice-based approach, is student-centered and focused on independent decision-making. Practitioners of choice-based art education have developed strategies for classroom management, assessment, and resource allocation that support students’ pursuit of independent work and creative behaviors (Douglas & Jaquith, 2009). Therefore the choice-based approach is a promising model for promoting creativity in the technology education laboratory.

Game design is a topic of study covered in the North Carolina technology education curriculum that shows promise as a fertile ground for nurturing creativity. Eow, Mahmud and Baki, (2010) found that video game design supported the development of secondary school children’s creativity. Li (2010) reported high levels of creativity and engagement resulting from a digital game building project with elementary students. In an effort to explore the creative potential for game design in the context of the technology education laboratory, this study used two pedagogical strategies as approaches to a game art and design
project. The DEAL method, currently used in some areas of the North Carolina technology education curriculum, is a somewhat linear approach, requiring that students:

1. *Define* the problem and goals for the problem-solving task;
2. *Explore* possible strategies and new information for accomplishing those goals;
3. *Anticipate* the outcomes of those strategies in order to decide which to *Act* upon; and
4. *Look back* and *Learn*.

In contrast, the choice-based approach is a student-centered, open-ended approach that involves teacher facilitation of student decision-making about many aspects of the learning environment and tasks.

**Research Questions**

The focus here is on exploring the potential for fostering creative problem-solving behaviors in the classroom and in developing quality creativity assessment strategies for classroom teachers. This study was designed to compare measures of creativity of projects produced in two distinctly different problem-solving environments: a linear (DEAL) approach versus a more open-ended, choice-based approach. Questions include:

- Will measures of creativity on students’ game art and design projects be higher after using the choice-based method or the DEAL method?
- How will measures of technical strength correlate with measures of creativity?
- Will the consensual assessment technique yield high levels of inter-rater reliability when applied to middle school children’s game, art and design projects?
• Will discriminant validity be demonstrated with regard to the consensual assessment form’s separate measures of creativity, technical strength and aesthetic appeal?

Chapter Summary

Creativity, innovation, problem-solving abilities and intrinsic motivation are qualities that stand to be more effectively cultivated in public education. They are skills that have been recognized as essential to students embarking on careers in the 21st century and valuable commodities in the global economy. The current classroom paradigm is not structured to easily promote or assess creativity. The DEAL and choice-based methods are two potential ways of fostering students’ creative problem-solving abilities—a vehicle for promoting the above-mentioned aspirations. The consensual assessment technique is one potential way of assessing students’ creativity in technology education. This study was designed to compare measures, acquired via the consensual assessment technique, of the creativity of projects produced in two distinctly different problem-solving environments: a linear (DEAL) approach versus a more open-ended, choice-based approach.
CHAPTER 2: LITERATURE REVIEW

Introduction

Human creativity has, since at least the time of Socrates, often been associated with divine inspiration by Muses and spirits (Treffinger, Isaksen & Dorval, 1994); with insanity (Simonton, 2010; Averill & Nunley, 2010); and with intellectual elitism (McWilliam & Haukka, 2008; Csikszentmihalyi, 1997). The notion of the aha moment is pervasive, though the research literature has shown that the aha moment actually tends to follow many hours of focused attention on a problem as well as many failed attempts at solving it (Kounios & Beeman, 2009; Schilling, 2005).

Creativity is inherently a part of most technology education curricula in the United States, albeit sometimes an unspoken one. The promise of a creative outlet is what draws many students to the hands-on work done in problem-solving based courses. “What many children cherish about technology education,” said Lewis (2009), “is the freedom it allows them to imagine and invent” (p. 260). Creativity and creative design processes are fundamental to the Standards for Technological Literacy (2007) on which these courses are designed, yet due to a variety of factors, creativity is not explicitly stated as a course objective and is often not explicitly taught or assessed. This literature review explores the concept of creativity within the field of technology education, with particular focus on 1) creativity definitions; 2) fundamental principles; 3) creativity research; 4) the significance of the research problem; 5) vertical and lateral thinking; 6) pedagogical strategies for successfully fostering creativity in technology education; and 7) statistical and
methodological concerns surrounding the assessment of creativity in the technology classroom.

This topic of creativity lies at the intersection of several fields of study from which relevant literature was sought:

- the growing field of creativity research
- technology education, and the broader umbrella of STEM (science, technology, engineering and mathematics) education
- visual art education

**Creativity Definitions**

When sorting through the profuse definitions and conceptual frameworks available for discussing the concept of creativity, it is useful to identify those most applicable to the task at hand; in this case the topic of interest is the potential for fostering students’ creativity in hands-on problem-solving activities in technology education. Two types of definitions are useful to this discussion. Henessey, Amabile, and Mueller (in press), whose work in creativity assessment has had tremendous influence upon the design of this study, offered the following:

- *Conceptual definition of creativity*: “A product is considered creative to the extent that it is both a novel and appropriate, useful, correct or valuable response to an open-ended task” (p. 4).

- *Operational definition of creativity*: “A product or response is considered creative to the extent that appropriate observers independently agree that it is creative.”
Appropriate observers are those familiar with the domain in which the product was created or the response articulated” (p. 4).

Hennessey et al.’s conceptual definition is a useful guide for evaluating student products. The definition assimilates many prior conceptual definitions (Cropley, 1999) and can be helpful in clarifying to students what is being asked of them when they are told that creativity is a part of their grades. Young (2009) discussed the importance of teachers’ clear communication about the role of imagination and creativity in assignments so that students are not blindsided by an unexpected grade.

This operational definition establishes the framework and justification for the use of Amabile’s (1983) Consensual Assessment Technique (CAT) for evaluating creativity and other dimensions of student responses to open-ended design and problem-solving activities—if knowledgable raters independently, and with an acceptable level of inter-rater reliability, determine that a student product is creative in its context, then by definition it is.

**Fundamental Principles**

Several fundamental principles, well supported in the literature, substantiate the application of Hennessey, et al.’s definitions to the study of creativity in technology education: a) all people have creative potential (Treffinger, et al., 1994; Florida, 2007); b) creativity happens “in the interaction between a person’s thoughts and a sociocultural context” (Csikszentmihalyi, 1997, p. 23); and c) creativity can manifest in a broad array of topical areas in nearly infinite ways (Torrance & Safter, 1990; Robinson, 2001). The pursuit of a technologically literate society is a driving force for the field of technology education. Technology educators wish to see the next generation of children become innovators and
creative problem-solvers, engaged in the decisions that shape our technological future (ITEA, 2007). Florida (2007) said the single most important element of his economic theory is that every human being is creative, and he insisted that his concept of the creative class “be understood as neither elitist nor exclusionary” (pp. 34-35). Technology education provides a rich landscape for potentially nurturing creativity in all children (ITEA, 1996).

**Creativity Research**

The study of creativity has undergone tremendous growth and change since the mid-20th century, when creativity was viewed as a component of intelligence and measured by IQ instruments (Barlow, 2000). This section of the literature review examines the roots of the theory of creativity that supports the assessment method used in this study, Amabile’s (1983) consensual assessment technique. It also underscores the pedagogical strategies used in this study, the DEAL method and the choice-based method. Topics discussed in this section include a) Guilford’s call to action in creativity research; b) stages of creative thought; c) defining creativity apart from intelligence; and d) creativity and the evolution of technology education.

*Guilford’s call to action*

In 1950, J.P. Guilford, president of the American Psychological Association, called for action in the fledgling field of creativity research (Rhodes, 1961). Guilford “said he had searched *Psychological Abstracts* for a quarter of a century and found that only 186 out of 121,000 entries dealt in any way with creativity, imagination, or any topic closely related” (Rhodes, 1961, p. 306). The field since 1950 has exploded. A search conducted by the author in Google Scholar for *creativity research* yielded over 1,010,000 hits (Buelin-
Biesecker, 2011). Several peer-reviewed publications are devoted exclusively to the topic of creativity including but not limited to:

- *Creativity Research Journal*, published since 1988, five-year impact factor of 1.942 as of 2010
- *Journal of Creative Behavior*, published since 1967, five-year impact factor of 1.384 as of 2010

Additionally, many more publications regularly cover creativity research contextualized in other fields such as art and design, advertising and marketing, psychology, and the performing arts. Neuroscience, in particular, has seen a surge in studies involving creativity since functional magnetic resonance imaging (fMRI) has become available to researchers (Geake, 2011; Haier & Jung, 2008; Mihov, Denzler, & Forster, 2010).

**Stages of creative thought**

In 1926, Wallas published *The Art of Thought*, in which he proposed four stages of creative thought:

1. preparation/problem investigation
2. incubation, or unconscious work during a period of rest
3. illumination, the sudden appearance of a solution
4. verification/validity testing (Mumford, Reiter-Palmon, & Redmond, 1994).

The preparation stage “would include problem identification and problem definition, as well as information gathering and the like” (Runco, 2007, p.19). Incubation “involves the
unconscious processing of information . . . associative processes are at work and are free from the censorship of the conscious mind” (Runco, 2007, p.19). “The period of incubation is considered to be a time when inappropriate responses can be forgotten, allowing more relevant responses to be made available for problem solving” (Smith & Blakenship, 1991, p. 61). Webster, Campbell & Jane (2006) urged technology teachers to give due attention “to the duration of the incubation period, so that creativity in technology designs can be fostered” and suggested that further research be conducted to “investigate the optimal length of a nonfocused thinking period that is required to enhance the creative process and students’ learning in technology” (p. 221). Illumination is trickier, since it suggests that insights are immediate, like flipping a light switch. However, studies show otherwise. Neuroscientists conducting imaging studies using fMRI and electroencephalography (EEG) determined that “although the experience of insight is sudden and can seem disconnected from the immediately preceding thought, these studies show that insight is the culmination of a series of brain states and processes operating at different time scales” (Kounious & Beeman, 2009, p. 210). Verification involves continually refining the product by checking the results of the creative activity (the solutions found) against previous knowledge (Peterson, 1993); it “allows the creative individual to test and tinker” (Runco, 2007, p.19).

Wallas’ framework continues to inform creativity research (Allen, A. P., & Thomas, K. E., 2011; Moore, D.W. et al., 2009) as well as instructional design. These stages are identified in recent creativity studies in mathematics education (Sriraman, 2004), music education (Peterson, 1993), visual art education (Marshall, 2010), and technology education (Webster, Campbell & Jane, 2006). The stages are also referenced in Bransford and Stein’s
The Ideal Problem Solver (1984), the source for the DEAL method of problem solving used in technology education courses as well as this study.

Defining creativity apart from intelligence

In the mid-1950s educational theorist Mel Rhodes sought to find a suitable scholarly definition for creativity and, in doing so, synthesized the nearly sixty definitions of creativity and imagination he found in the literature (Rhodes, 1961). What emerged were four distinct strands of overlapping and intertwining ideas which he would eventually identify as the four P’s of creativity (Rhodes, 1961), a conceptual framework that still guides present day discussion and study of creativity (e.g., Agars & Kaufman, 2005; Drago, Foster, Heilman, Aricò, Williamson, Montagna, & Ferri, 2011; Zeng, Proctor, & Salvendy, 2010). The four P’s, according to Rhodes (1961) are

- the person
- mental processes
- press, i.e., the “influence of the ecological press on the person and upon his mental processes”
- product

Rhodes’ description of the person strand included “information about personality, intellect, temperament, physique, traits, habits, attitudes, self-concept, value systems, defense mechanisms, and behavior” (p. 307). He applied the term process to the actions of motivation, perception, learning, thinking, and communicating. Press refers to “the relationship between human beings and their environment,” attributing successful creative production to “certain kinds of forces playing upon certain kinds of individuals as they grow.
up and as they function” (p.308). Finally, his products strand referred to the embodiment of an idea in tangible form.

Variations on Rhodes’ four P’s are still commonly used to frame new concepts of creativity (Simonton, 1990; Richards, 1999; Runco, 2004). In 1990, Simonton added persuasion, “the idea being that creative people change the way other people think” (Runco, 2007, p.384). In 2003, Runco added potential in “an attempt to redirect research and educational attention back ‘to the people who need us the most,’ namely those with potential but lacking the skills to express themselves” (2007, p. 384). In 2010 Cropley used the four P’s as the basis for an updated framework for conceptualizing a malevolent, “dark side of creativity” (p. 371), which featured six P’s: process, personal motivation, personal properties, personal feelings, product and press. These recent adaptations of Rhodes’ model, particularly Runco’s interest in students’ potential, support goals technology teachers have for developing creativity in American children (ITEA, 1996, 2007).

In 1967, Guilford published his Structure of Intellect Model. Prior to Guilford’s work, the predominant area of focus for psychological research and theory on human differences was in tests of intellectual potential (Houtz, 2003, p. 4). Guilford asserted that creativity went beyond IQ, and that divergent thinking was a measurable factor that could be isolated via factor analysis (Barlow, 2000). His three major factors were content, product and process, and he expected that people could perform well on some tested dimensions of these factors and poorly on others (Barlow, 2000). Guilford’s work was influential in the development of the Consensual Assessment Technique (CAT) (Amabile, 1983, pp. 19-21 &
17

83), the evaluation method used in this study, as well as establishing a precedent for analysis of data collected via the CAT.

*Creativity in the evolution of technology education*

Alongside the twentieth-century evolution of creativity research, the field now known as technology education (TED) has evolved as well. The origins of the field can be traced to the late 1800s, when the Scandinavian *sloyd* method made its way into the American curriculum, leading to what would become the field of manual training (Olson, 1967). Emphasis was placed on making useful articles for the home, usually out of wood, and while the activities may have functioned in some measure as creative processes for students, neither aesthetic design nor the nurturing of creativity was of prominent concern (Olson, 1967). In 1917, amidst the arts and crafts movement happening in visual art, design and architecture, Charles Bennett wrote *The Manual Arts*, in which he proposed a new curriculum that would focus on hand skills and “artistry with materials” as well as the increasingly mechanized “tools of industry” (Olson, 1967, pp. 4-5). Bennett said that two of the direct results of manual arts study were, most importantly, the “power to do,” followed by the “ability to appreciate what is done by others” (1917, p. 35). Students in manual arts courses learned a variety of materials and processes including drawing, painting, woodworking, metalworking, pottery, weaving, lettering and bookmaking (Bennett, 1917, p. 44). Creativity was not an explicit curricular goal; however Bennett did describe a civic responsibility to reach all students, some of whom would become the innovators of the future:

If the schools are to produce American citizens with (a) skill, (b) initiative and (c) power to think for themselves—those who can follow directions efficiently or can
invent a better way, all three of these methods must be employed in teaching the manual arts in the schools. (1917, p. 112)

*Manual arts* took hold, but not for long. By 1923, the term *industrial* arts was gaining popularity, the standing definition of which was “a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes” (Bonser & Mossman, 1923 as cited in Foster, 1994, p. 19). In 1929, a committee headed by William Warner was appointed by the Western Arts Association to look into the appropriateness of the terminology and supporting theory used to describe the field; Figure 2.1 was one product of their work (Barlow, 1967). F.C. Whitcomb explained the diagram this way:

“The boy” is made the center of the picture. It is he rather than subject matter that represents the purpose of the school and of teaching. His needs and interests provide the approach to what shall be taught and how it shall be taught. The chart is an interpretation of Practical Arts as general education. (Barlow, 1967, p.268)

The diagram presented “the conceptual framework in which industrial arts educators viewed the nature of their program” (Barlow, 1967, p. 268) and it included experimentation, creation, art expression and play as essential components of the student-centric approach to education.
By 1937, Bennett, Warner, Bonser and other leaders in the field later had helped facilitate the transition to widespread use of the term *industrial arts*, emphasizing “the all around arts of industry rather than just manipulative or ‘manual’ aspects of artistic construction implied in the term Manual Arts” (Barlow, 1967, p.268).
The Jackson’s Mills (1981) reconceptualization resulted in a new curriculum theory, but maintained a definition more akin the industrial arts of the 1920s than the TED of today, defining *industrial arts* as “a comprehensive educational program concerned with technology, its evolution, utilization, and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their socio-cultural impact.” (Foster, 1994, p.19). Though creativity had not become an explicit curricular objective (Snyder & Hales, 1986), the work done at Jackson’s Mills began to merge the evolution, utilization and significance of *technology* with the techniques, resources, and products of *industry*, likely laying the groundwork for the transition to *technology education* (Lauda, 2002). West Virginia University renamed its industrial arts program to technology education in 1970, and over the next fifteen years many higher education programs did the same, followed later by public and private schools (Lauda & McCrory, 1986). In 1985 the American Industrial Arts Association changed its name to the International Technology Education Association (ITEA), and by the 1990s a shift had occurred, elevating design and problem-solving processes to a place of curricular importance, though creativity was still not being discussed in the literature. In 1993, the International Technology Education Association (ITEA) published *A decision maker’s guide to technology education* (Wright, Israel & Lauda, 1993) which contained this definition for *technology education*: “Technology Education is an educational program that helps people develop an understanding and competence in designing, producing, and using technology products and systems and in assessing the appropriateness of technological actions” (Foster, 1994, p. 18). ITEA’s new *Standards for Technological Literacy* (2000) did explicitly push creativity to the
forefront, mentioning the terms *creative* and *creativity* a total of 60 times. In February, 2010, the International Technology Education Association changed its name to the International Technology and Engineering Educators Association in an effort “to position the association to deal with the ‘T’ & ‘E’ of a strong STEM education (ITEEA, 2010). The most recent definition for *technology education* found in the *Standards for Technological Literacy* is: “A study of technology, which provides an opportunity for students to learn about the processes and knowledge related to technology that are needed so solve problems and extend human capabilities” (p. 242).

Game design, the content covered during the implementation of this study, is one small segment of the technology education curriculum, and it is also a competitive event for middle school and high school students in the Technology Student Association (TSA). Computer game design, one option for students involved in this study, has been shown to increase students’ creative perception (Eow, Mahmud & Baki, 2010). According to Eow, Mahmud and Baki (2010), creative perception is characterized by the following: “self-confidence, inquisitiveness, awareness of others, disciplined imagination, environmental sensitivity, initiative, self-strength, intellectuality, individuality and artistry” (p.149).

Creativity is a topic of interest in technology education research in the United States and internationally (Lewis, 2005 & 2009; Middleton, 2005; Liu, 1998; Howard-Jones, 2002). The Council for Technology Teacher Education (CTTE) is an affiliate organization of the ITEEA. The 2011 CTTE yearbook is titled *Creativity and Design in Technology Education* and it was built on the following themes:

- the properties of, and the relationships between, creativity and design
connections among human development, brain operations, and creative dispositions

- physical and cultural environments along with appropriate pedagogy for enhancing creativity and design in technology education

- implications for promoting creativity and design through the professional development of technology and engineering teachers (Warner, 2011).

Despite the ideological support for fostering creativity in technology education, few empirical studies on the subject have been published in the United States. Public policy is pushing creativity research ahead in other nations. In 1999 in the United Kingdom, the National Advisory Committee on Creative and Cultural Education published a report calling for a focus on creativity to be extended beyond the arts curricula and into areas such as business and technology (Lewis, 2009). *Design and technology*, technology education’s U.K. counterpart, subsequently saw a renewed interest in the promotion of creativity in its curriculum provisions within the National Curriculum (Lewis, 2009; McLellan & Nicholl, 2011; Rutland, 2009). Similar focus on creativity and innovation has also been seen in Australia. Bruton (2011) reported the emergence of national trends and education initiatives in creativity and innovation that “aimed to improve [Australia’s] economic recovery after a global recession and to develop a longer-term plan for a competitive strategy that might keep education and industry at the international technological innovation forefront” (p. 323).

**Significance of the Research Problem**

Many researchers in academia as well as economists, political scientists, and other authors agree that creativity is not currently a priority for public schools in a culture characterized by budget shortages and No Child Left Behind (Friedman, 2007; Robinson,
2001; Sheridan-Rabideau, 2010). But in addition to the benefits that the cultivation of creative behaviors lends to the human condition, a field far too wide to broach in this literature review, there are several specific advantages identified in the research literature that society stands to gain from its support of the creativity-infused technology classroom. Those discussed in the following section include:

- Preparation of a globally competitive workforce
- Defense against malevolent use of innovations
- Increased student engagement and rates of graduation

_A globally competitive workforce._

The development of students’ creative thinking capacities is an essential component of a globally competitive workforce. Creative thinking shapes technological development (ITEA, 2007). Technology courses often emphasize systems thinking which requires the application of “logic and creativity with appropriate compromises in complex, real-life problems” (ITEA, 2007, p. 42). This synthesis and application of cross-curricular knowledge toward creative problem solving is widely called for in the United States (Florida, 2007; Pink, 2006; Robinson, 2001). A better understanding of pedagogical strategies for developing students’ creativity stands to improve problem-solving and systems thinking abilities that are essential in an economy transitioning from one of manual labor to one of knowledge work (Friedman, 2007).

_Defense against malevolent innovation._

Creative thinkers must be cultivated in the defense against those who are creatively but immorally innovative. The Committee on Science and Technology for Countering
Terrorism (2002) identified the need for new technologies to be invented in a national effort to respond “with creativity and effectiveness to a dramatically new kind of threat” (p. 360). Cropley, Kaufman, and Cropley (2008) argued the existence of malevolent creativity, which they described as:

creativity that is deliberately planned to damage others. Such creativity is deemed necessary by some society, group, or individual to fulfill goals they regard as desirable, but has serious negative consequences for some other group, these negative consequences being fully intended by the first group. (p.106)

James and Drown (2008) applied Cropley, et al.’s (2008) analysis to the specific problem of terrorism prevention in hazardous materials trucking, illustrating the pervasive challenge faced by industries of all kinds: “creative (especially convergent) thinking about how to generate dual-use benefits—enhancing security while also improving productivity or reducing other costs” (p. 125).

Cybersecurity is one more example of many contexts addressed in the literature in which the need for creative approaches has been identified. Tovstiga, Tulugurova and Kozlov (2010) reported on creativity and innovation in open, collaborative cyber communities. Their interviews with cyber-security experts advanced understanding of how cyber criminals innovate collaboratively within Peter Gloor’s (2006) conceptual model of swarm creativity.

Increased student engagement and rates of graduation

Archambault, Janosz, Fallu and Pagani (2008) found that students’ engagement level made a significant contribution in the dropout prevention equation. A case study by Doppelt,
Mehalik, Schunn, Silk and Krysinski (2008) suggested that design-based learning in science topics resulted in increased student interest, high levels of student engagement, and unprecedented concept mastery for typically low-achieving students in the class. Stone and Alfeld (2004) said career and technical education (CTE) classes “engage students and keep them in school” because CTE classes present to students the “opportunity to apply school coursework in practical, relevant contexts” (p. 29). They cited a study from the National Research Center for Career and Technical Education (NRCCTE) that pointed to promising improvements when the ratio of CTE and academic courses was well balanced (p. 29). However, Stone and Alfeld, as well as the NRCCTE, were looking at all of CTE and not at technology education exclusively. Clark and Ernst (2008) reported on a curriculum model of companion courses for at-risk students in which technology and graphics education teachers were teamed with algebra and biology teachers. The rationale was that the companion courses would focus on “major topic areas in the ‘end-of-grade’ exam that students have difficulty with as indicated by teachers and statewide statistical data” (p. 23). Though that particular model was not continued beyond the pilot phase, results for at-risk students were promising, and Clark and Ernst contended that technology classes could play a role in keeping students in school.

Technology classes, in particular, offer an appealing creative outlet that can potentially help keep students engaged, thereby possibly decreasing drop-out rates and initiating a trajectory toward higher education. The logical outcome would be not only a more technologically literate society, but a better educated one overall. Evidence to support that line of reasoning is largely anecdotal or postulation; empirical studies directly linking
student engagement in technology education classes with keeping students in school were not found in the literature.

**Theoretical Considerations**

This study was developed around the central question of how educators can nurture creative behaviors in technology education. The choice-based method, from visual art education, offered promising transferability to the technology education laboratory because of the unique opportunity the method affords students for experiencing student-paced cycles of lateral and vertical thinking. The DEAL method, a formulaic approach to problem-solving, is the approach favored in the North Carolina technology education curriculum. The study was designed to compare creative outcomes for students receiving the same content instruction, but using the two different pedagogical methods, DEAL and choice-based. The need to compare some kind of measured score led to a search for creativity assessment in the research literature. The Consensual Assessment Technique (CAT) emerged as a useful model, though researchers who have used the CAT have not published their instruments. The need to appropriately design an instrument and to analyze the data gathered via the CAT led to an investigation of methods for analyzing inter-rater reliability and subsequently drawing conclusions about the CAT’s usefulness in the pursuit of fostering creativity in technology education. The following theoretical considerations are discussed in this section:

- Vertical and lateral thinking
- The choice-based method
- Twenty-first century skills
- The DEAL problem-solving method
- Inter-rater reliability
- Systematic rater bias

*Vertical and lateral thinking.*

We are all familiar with the experience of vertical thinking, the converse of lateral thinking. Sometimes called logical thinking, vertical thinking “is a sequential process in which every single step has to be correct and justified before moving to subsequent stages – it is a hierarchical ordered process” (Waks, 1997, p. 246). Vertical thinking can include clear-cut categorization, rules and techniques. Vertical thinking can be appealing in education because it provides, for both students and teachers, “the ‘right’ direction with its accompanying motivational stimulation, determination and its apparent effectiveness (Waks, 1997, p. 247). It also makes multiple-choice, standardized test questions easy to write and assess, and facilitates the grouping of students into similar age and ability levels.

Lateral thinking, on the other hand, “deals with the generation of ideas and approaches – order and sequence does not matter” (Waks, 1997, p. 246). Lateral thinking is a pattern of using information at which nearly all students can become skilled. “Instead of just hoping for insight and creativity one can use lateral thinking in a deliberate and practical manner” (de Bono, 1973, p. 13). Because we are living in a “knowledge-explosion,” wrote Waks (1997), it is likely that a shift in the emphasis in education will take place, from knowledge to understanding (p. 247). He predicted that teaching patterns will have to likewise move from the transmission of knowledge to enculturation, which “concentrates on
creating an environment that nurtures thinking dispositions—tendencies to carry out thinking activities in certain directions like investigating or being aware of approaches contradicting those one is used to” (p. 247).

In practice, a classroom environment promoting lateral thinking looks different from one promoting vertical thinking. It requires the teacher to turn over to students some degree of control of the pacing and content. Lewis, Petrina and Hill (1998) explained:

> classroom dynamics change, as do roles of students and teachers [. . .] The pedagogical dynamics move away from a systematic process with a predetermined teacher problem and right answer that may or may not capture student interest, to one where there is openness and potential for surprise. (para. 75)

This can be especially difficult when class sizes are large and ability levels vary widely. In such lab situations, students’ prior knowledge will vary greatly but “mastery of prerequisite material is not always mandatory,” said Waks (1997, p. 250). In fact, prior knowledge can hinder the creative process, manifesting as functional fixedness; i.e., the “past experience of seeing a situation in a certain way constrain[s] the heuristics used in the creative process by limiting subjects from generating novel solutions” (Goncalo, Vincent, & Audia, 2010, p. 119). This is a fine line that warrants further investigation, as studies have shown that a certain level of domain mastery is essential before problem solving, creative or otherwise, is likely to occur (Amabile, 1996; Cropley, 1997; Lewis, 2005). According to Lewis, Petrina and Hill, “co-construction” of knowledge occurs in this type of environment: “students’ thinking and prior understandings must be taken seriously in the design and implementation
of instruction. The teacher’s knowledge about teaching and the thinking of her/his students evolve simultaneously with changes in the students’ knowledge” (1998, para. 20).

The natural design tendencies of children involve what can be described as a cycle of lateral and vertical thinking (Lewis, 2005). In lab settings that support this interplay, design alternatives can be tested directly, without a need for translations, analogies or measures (Waks, 1997). Waks said that in “synthesizing followed by acting, one has to consider a variety of options and possibilities through invention whilst in analyzing and describing he/she is mostly aligned to discover an existing direction and target” (p. 251). In TED this might be applied as lateral thinking in most engineering/technology activities and as vertical thinking in memorizing and following established scientific rules. This cycle of synthesis, action and analysis is not unlike the studio behaviors of practicing artists and is at the heart of a movement in art education called Teaching for Artistic Behaviors (TAB), also known as choice-based art education.

*The choice-based method*

The choice-based model is “a learner-centered practice,” in which control is passed “from teacher to student so they can pursue independent work in a carefully planned learning environment” characterized by studio centers that offer many options (Douglas & Jaquith, 2009, p. 3). The choice-based approach is not new to art education, but it does not and has not ever formally dominated classroom practice in American visual art education (Smith, 1996). Teaching for Artistic Behavior, Inc. (2009) defined the method this way:

Choice-based art education regards students as artists and offers them real choices for responding to their own ideas and interests through the making of art. This concept
supports multiple modes of learning and teaching for the diverse needs of students. The learning environment provides resources and opportunities to construct knowledge and meaning in the process of making art. Choice-Based Art Education utilizes multiple forms of assessment to support student and teacher growth. (para. 3)

TAB originated as a rather grassroots phenomenon, and despite a growing online presence and following, still remains outside mainstream educational practice. This is likely because it is far outside of most art teachers’ experience base as either a student or a teacher-in-training, and it is most assuredly outside of the experience of most school administrators who must, at an organizational level, sanction this instructional model. Because it can look so radically different from what students, parents, and administrators expect an orderly classroom to look like, an online community of practitioners have assembled recommendations for teachers embarking on this way of teaching (Douglas & Jaquith, 2009).

The choice-based method enables students to experience the work of the artist through “authentic learning opportunities and responsive teaching” (Teaching for Artistic Behavior, Inc., 2009, para. 7) and can be described in terms of its fundamental characteristics. Roher and Decker (2008) outlined four contexts integral to this approach:

- **The Personal Context** regards students as artists and provides them with real choices for self-expression and personal discovery. Primary pitfalls of this aspect of TAB are that some students will not have any ideas or self-motivation, and some will make inappropriate choices.

- **The Pedagogical Context** can potentially be quite inclusive and therefore adaptable to the demands of various local curricula. However, “the pitfall is students may not
choose assignments that address the local standards and/or curriculum” (Roher & Decker, 2008, para. 12).

- The Classroom Context is one of opportunity: The Teaching for Artistic Behavior Partnership described the ideal learning environment as one that supports student learning through the effective structure of time, the careful arrangement of space, thoughtfully chosen materials, and a method of classroom management that allows teachers to respond to student needs.

- Assessment is multifaceted in a TAB approach: “Assessment is ongoing and continuous with students showing evidence of learning in their daily activities. Multiple, formative assessments inform teaching, resulting in materials and instruction that are closely aligned with student needs” (Teaching for Artistic Behavior Partnership, 2009, para. 9).

The choice-based method was chosen as one of the two pedagogies used in this study because of its capacity to support lateral thinking, and therefore its potential to positively affect the creativity of student projects.

*Twenty-first century skills*

As stated earlier, a student-centered choice-based classroom, and any environment in which lively lateral thinking is taking place, can potentially look very different from one that emphasizes vertical thinking and/or is driven largely by structured teacher planning and decision-making. The twenty-first century skills framework provides a lens through which the choice-based approach can be envisioned, particularly with regard to the technology education laboratory. This study took place in a middle school in North Carolina, where the
recently adopted teacher evaluation instrument for all content areas includes the imperative that all teachers weave 21st century interdisciplinary themes into their lessons (North Carolina Department of Public Instruction, 2009). Among the required skills within those themes are creativity and innovation skills: 1) demonstrating originality and inventiveness in work; 2) developing, implementing and communicating new ideas to others; and 3) being open and responsive to new and diverse perspectives (p. 15).

The work of the Partnership for 21st Century Skills (P21) has begun taking hold on a national level, with many states taking on initiatives to promote critical thinking and problem solving, communication, collaboration, and creativity and innovation (P21, 2004). Curriculum at local and state levels as well as teacher evaluation instruments have been influenced by the themes and standards identified within the Framework for 21st Century Learning. As of October, 2011, sixteen states including North Carolina were P21 Leadership States, meaning:

- a state demonstrates commitment from the governor and chief state school officer, and submits an application to P21 that describes the state’s plan to fuse the three Rs and four Cs (critical thinking and problem solving, communication, collaboration, and creativity and innovation) within standards, assessments and professional development programs (P21, 2004).
Figure 2.2. 21st Century Student Outcomes and Support Systems. Copyright 2011 by Partnership for 21st Century Skills. Used with Permission.

Figure 2.2 is a diagram used by P21 to present “a holistic view of 21st century teaching and learning that combines a discrete focus on 21st century student outcomes [. . .] with innovative support systems to help students master the multi-dimensional abilities required of them in the 21st century” (para 1). Creativity is one of the primary student outcomes sought by P21 and affiliated stakeholders.

Table 2.1, an adaptation of information provided by TAB, Inc. (2009), identifies the alignment of 21st century skills with the choice-based approach and is applicable to the goals and standards in the technology education laboratory.
Table 2.1. 21st Century Skills and the Technology Laboratory (adopted from TAB, Inc. (2009))

<table>
<thead>
<tr>
<th>21st Century Student Outcomes</th>
<th>21st Century Skills</th>
<th>Application in the technology education laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning and Innovation Skills</td>
<td>Critical Thinking/</td>
<td>Learners find and solve problems through inquiry, divergent thinking, play, reflection and evaluation. Students who bring ideas to class plan ahead for their work; others discover ideas by experimenting with media at lab/studio centers.</td>
</tr>
<tr>
<td></td>
<td>Problem Solving</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creativity/Innovation</td>
<td>Students who are intrinsically motivated will respond to problems in original and innovative ways. The predictability of choice-based lab/studio centers allows children to pursue and refine their ideas over weeks, months and even years if they are inclined to do so. This allows learners to “go deep” with their work.</td>
</tr>
<tr>
<td></td>
<td>Communication/Collaboration</td>
<td>Students learn to communicate their ideas and needs clearly because they are motivated to succeed at their self-directed work. Groups of self-selected learners form their own collaborative teams based on common interests and goals. Peer coaches assist with classmates’ challenges.</td>
</tr>
<tr>
<td></td>
<td>Research and Inquiry</td>
<td>Students use technology to research ideas, find visual references and expand concepts. Teachers use technology to present information of relevance to the class.</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Learners document and comment on their progress in electronic portfolios. Teachers maintain assessments of student learning in formats that are compatible with their district expectations.</td>
</tr>
<tr>
<td></td>
<td>Art Making</td>
<td>Digital photography, animation, movies and graphics programs enable students to explore the immediacy of digital art and design. The ability to create and revise without loss to the original work is an incentive for those who fear taking risks with their work.</td>
</tr>
<tr>
<td>Life &amp; Career Skills</td>
<td>Flexibility/Adaptability</td>
<td>Every class brings unexpected discoveries. Students interact with available resources in studio centers; teachers respond to incoming student ideas and artistic processes.</td>
</tr>
<tr>
<td></td>
<td>Initiative/Self-Direction</td>
<td>Learners are intrinsically motivated to engage in meaningful work from personal context. After a brief demo lesson, students begin their work without teacher assistance, setting up materials, pacing themselves and putting materials away.</td>
</tr>
</tbody>
</table>
Table 2.1 Continued

<table>
<thead>
<tr>
<th>Skills</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social/ Cross-Cultural</td>
<td>Students work with friends and classmates at will, sometimes collaborating, sometimes working side-by-side. Negotiations arise over shared materials and space. Peer coaching and discussions about ongoing work are prevalent in the studio centers. Students learn to recognize their own working style and preferences, and to appreciate the same of others. Personal work brings diverse perspectives into the classroom.</td>
</tr>
<tr>
<td>Productivity/ Accountability</td>
<td>Students are expected to come to class with ideas or a willingness to explore materials and techniques. Learners show what they know and can do when they work independently and are held accountable for their progress. The teacher intervenes and modifies content as needed.</td>
</tr>
<tr>
<td>Leadership/ Responsibility</td>
<td>Teachers design the learning environment and students are expected to maintain it, by keeping studio centers tidy and organized. Learners take responsibility for their own learning and behavior. Opportunities for student leadership in the choice-based classroom are plentiful; those who show readiness are encouraged to peer coach, curate exhibits, design new studio centers and help maintain electronic portfolios.</td>
</tr>
</tbody>
</table>

Reasoning parallel to the work in 21st century skills in the fields of visual art and TED makes a strong case for shifting design and problem-solving processes away from the teacher-directed, linear lesson plan and toward a student-driven, open-ended environment more supportive of creativity. According to Lewis, Petrina & Hill, “students find the [formulaic] methods cumbersome to utilize, and if held accountable, merely retrofit methods and their stages to their actual experience” (1998, para. 14). Teachers who embrace choice-based art education are fostering creative thinking and studio/lab/classroom management practices in ways that are potentially transferrable to other disciplines, and especially to TED. Technology education, said Waks (1997) “characterized by reconstructive learning activities of designing, making, using and evaluating of matter, energy and information in real-life
situations is an appropriate environment for developing complementary incorporation of vertical and lateral thinking” (p. 245). Table 2.1 demonstrates that technology education labs offer similar potential to TAB art studios for providing students with opportunities for creative problem solving experiences.

*The DEAL problem-solving method.*

The DEAL method is a prominent example of a highly prescriptive design and problem solving process used in TED instruction and assessed on the Vocational Competency Achievement Tracking System (VoCATS) standardized test used by the North Carolina Department of Public Instruction. It was used as the alternative model to the choice-based method in this study because of its prevalence of use in instruction and somewhat linear and structured nature. The acronym stands for “Define, Explore, Act, and Look Back,” and the four steps involve defining criteria and constraints, brainstorming, modeling and testing and performance monitoring. DEAL is taught in North Carolina’s *Exploring Technology Systems* course for middle school students as well as *Fundamentals of Technology* for high school students (NCDPI, 2002). The course blueprint mandates the use of the DEAL model, explaining that a problem “should be chosen based on its ability to address relevant standards that students need to learn” and that the context “should not be fanciful or farfetched” (pp.169-170). A sample multiple-choice VoCATS question about the DEAL process is, “Why is it important to follow a formal problem solving method?” to which the correct answer is “You deal with problems logically” (p.170). This approach is certainly relevant to some problem-solving scenarios, some learning objectives, and some students; for example, Hollingsworth and Woodward (1993) demonstrated the benefits of
teaching explicit problem-solving strategies to students with learning disabilities. There are dissenting opinions, however, about whether or not it is the best way to foster creative thinking for the general population (de Bono, 1973; Lewis, Petrina & Hill, 1998; Waks, 1997).

DEAL is not unlike a great many other systems developed for organizing design and problem-solving processes; one study identified as many as seventeen systematic approaches to defining ‘the design process’ between 1971 and 1995 in the United Kingdom alone (Mawson, 2003). However, asking students to creatively solve a problem and simultaneously imposing a structured, linear framework on their process may not be the best strategy to support creative behaviors and therefore not the best (or only) approach for all students. Lewis, Petrina and Hill (1998) warned, “control may neutralize the creativity that most teachers intend to nurture” (para. 13). We might better serve students by empowering them, not with formulas for getting a single correct answer to a predetermined question, but with strategies and thinking skills for creative problem solving. An alternative approach to lab-based courses and studio experiences would provide students the physical environment, freedom and confidence to move in and out of a cycle of a linear structure as much as it is useful, but not restrict their unique creative processes unnecessarily. The choice-based method is one such possible approach.

Some evidence in the literature suggests that not only is the current paradigm unsuccessful at fostering creative behaviors and solutions to problems, but that it is actually harmful. Mawson (2003) describes rigid models as having a “detrimental impact on children’s learning in technology” and points to a 1993 British assessment which, while
acknowledging that design and problem solving models can serve as helpful guides, concluded that “such models had been equally dangerous in prescribing ‘stages’ that need to be ‘done’ by pupils,” effectively “turning the process of design and technology into a series of end-on products” (p.119). Based on concerns such as these, say Mawson, Cropley, Lewis and others, an alternative pedagogy is needed.

The news is not all grim. TED teachers likely won’t have to look far for guidance in making a transition because great things are happening in advanced courses and outside of the school day. Among them are game art and design units of study, robotics courses, and events sponsored through the Junior Engineering Technical Society, the Technology Education Collegiate Association (TECA), and the Technology Student Association (TSA). TSA shows promise for its influence on the development of students’ problem-solving and critical thinking skills (Taylor, 2006). Busby’s study (as cited in Taylor, 2006), using Clark’s quality indicators for North Carolina technology education programs, found that “the only quality indicator for which there was a significant difference between low performing schools and high performing schools [defined by the schools overall score on the North Carolina VoCATs test ] was the program's involvement in TSA” (para. 4). Most participants in Taylor’s study “felt the activities motivated them to do their best work” and 92% of the participants said that participation in the TSA activity developed their ability to be creative (para. 31). But for the majority of children in TDE foundational courses the outdated, linear paradigm still prevails.

A point of interest for stakeholders making decisions about which pedagogies to implement is likely to be the trade-offs involved as students traverse the continuum of greater
choice versus tighter structure. According to proponents of choice-based methods, standards for project completion, craftsmanship, behavior, and personal responsibility are tied into the constructivist classroom philosophy, in which work is student-driven and rubrics are developed collaboratively between students and teachers (TAB, Inc., 2009). Nonetheless, this different way of managing a classroom could present challenges for stakeholders looking for consistency and clear evidence of standards mastery. If a benefit of the choice-based method is that students may choose to pursue an idea or technique for a long span of time until mastery is achieved (TAB, Inc., 2009), then it stands to reason that much time could also potentially be wasted, with little or no concept or skill mastery achieved by some students. Therefore the current study considers correlations between students’ creativity scores and technical strength scores, a relationship that could help to describe one trade-off that may be intrinsic to the classroom implementation of a choice-based method.

The Consensual Assessment Technique and Inter-rater Reliability

The current study measured, among other characteristics, the creativity of students’ work. The technique used for deriving meaning from the ratings was Amabile’s (1983) consensual assessment technique (CAT). The application of the CAT for making inferences about students’ work, as well as subsequent inferences about pedagogical strategies used in producing that work, is dependent upon the acceptance of an operational definition of creativity: “a product or response is considered creative to the extent that appropriate observers independently agree that it is creative. Appropriate observers are those familiar with the domain in which the product was created or the response articulated” (Hennessey, Amabile, & Mueller, in press, p.4). Inter-rater reliability “quantifies the closeness of scores
assigned by a pool of raters to the same study participants. The closer the scores, the higher
the reliability of the data collection method” (Gwet, 2008, p. 29). “In the case of the
Consensual Assessment Technique,” explained Hennessey, et al.:

reliability is measured in terms of the degree of agreement among raters as to which
products are more creative, or more technically well done, or more aesthetically
pleasing than others. […] By definition, interjudge reliability […] is equivalent to
construct validity: If appropriate judges independently agree that a given product is
highly creative, then it must be accepted as such (p. 4).

Inter-rater reliability is key to making claims about the usefulness of the consensual
assessment technique in classroom evaluation of student work. If stakeholders believe that
student work cannot be reliably assessed for creativity because the concept is too enigmatic
or inconsistent, then weaving creativity into a curriculum presents problems for goal setting
and measurement. If, however, it can be shown that creativity can be reliably assessed in the
classroom, then curricula and education policy can evolve to meet the changing needs of 21st
century learners.

Also pertinent to inter-rater reliability in the classroom application of the CAT is
consideration of types of raters available to classroom teachers. Three types of raters were
used for this study: self-evaluations were conducted by students; peer-evaluations were
conducted by students within the same classes; and adult ratings were conducted by raters
with experience in the domain. In addition to self-evaluation data being useful for the CAT,
according to Rolheiser and Ross (2011), self-evaluation is a valuable assessment tool for a
variety of student-centered reasons: “(i) self-evaluation will focus student attention on the
objectives measured, (ii) the assessment provides teachers with information they would otherwise lack, (iii) students will pay more attention to the assessment, and (iv) student motivation will be enhanced” (para. 40). Peer assessment has also been recognized as “enhancing student learning if sensitively implemented” and can potentially also be leveraged as a CAT data source (Mok, 2011). Because of the recognized value of self and peer evaluation to students’ learning and achievement, the current study used the rating data from students as well as the seven adult raters with experience in the domain. Further, larger-scale study could be useful in exploring potential benefits of self and peer evaluation to student achievement as well as to creativity assessment. Prior studies by Amabile (1983), Hickey (2001), and others did not use scores provided by children, so the correlations of these rating types with those of adults were of interest.

Agreement among raters has been reported using a number of different coefficients for inter-rater reliability. Debate as to the best coefficient for tests using multiple raters is abundant in the literature. This section comprises a discussion of available coefficients for reporting inter-rater reliability for multiple raters as well as a rationale for the one chosen for this study, Chronbach’s alpha. Systematic bias is also discussed since it can be a factor when interpreting the data produced by multiple raters.

In her early work with the CAT, Amabile (1983) used the Spearman-Brown calculation of reliabilities, a calculation dependent on the number of judges and the average inter-judge correlation in her measures of creativity of children’s collages. In later work she used Cronbach’s alpha (α), calculated by the “reliability analysis” procedure in SPSS (Statistical Package for the Social Sciences) (Hennessey, Amabile & Mueller, in press).
Goldblatt, Elkis-Abuhoff, Gaydos, Rose, and Casey (2011) used Cronbach’s $\alpha$ to calculate inter-rater reliability among three scorers’ responses to students’ line drawing representations of conflict words.

In her application of the CAT for rating children’s musical compositions, Hickey (2001) used Hoyt's analysis, an intraclass correlation technique for rendering a coefficient alpha, to calculate inter-rater reliability. The *intraclass correlation coefficient* (ICC) is defined as “a measure of the homogeneity of observations within the classes of a random factor relative to the variability of such observations between classes” (Babylon.com, 2011). One common use of the ICC in the behavioral sciences has been to demonstrate levels of inter-rater reliability (Cook, 2000).

Another widely used option for reporting inter-rater reliability is kappa ($\kappa$). Fleiss’s $\kappa_j$ is an extension of Cohen’s $\kappa$ and used to account for multiple raters (Springer, Chang, Fields, Beck, Firestone, Rosenstiel, & Christensen, 2011; Schorer, and WeiB, 2007). Fletcher, Mazzi, & Nuebling (2011) compared the results of Cohen’s $\kappa$, Fleiss’s $\kappa_j$, and ICC for a study of agreement in coded doctor/patient communication data. They reported marginal differences between $\kappa$ and ICC and “a very minor difference between $\kappa_j$ and ICC” (p.341). The usefulness of kappa has been debated in the literature because of some well-documented weaknesses (Feinstein & Cicchetti, 1990; Gwet, 2008, 2010; Lantz & Nebenzahl, 1996). There are two paradoxes associated with kappa: (a) at very high levels of agreement, a very low $\kappa$ statistic can be produced; and (b) unbalanced marginal totals have been known to produce higher values of $\kappa$ than balanced ones (Feinstein & Cicchetti, 1990;
Gwet, 2010). Ultimately, Cronbach’s $\alpha$ was chosen for reporting inter-rater reliability for the following reasons:

- The trait of primary interest, creativity, as well as other dimensions to be rated can be viewed as continuous traits (Uebersax, 2010b).
- Raters were instructed to place their X anywhere on the scale between low and high anchors, thus creating as close as possible a continuous rating scale (Uebersax, 2010b).
- Cronbach’s alpha is desirable for direct comparison of these results to those found in earlier, similar studies (Amabile, 1983).
- Cronbach’s alpha is preferable to kappa, because the latter is prone to the paradoxes noted earlier (Gwet, 2010, 2011, Uebersax, 2010a).

According to Hennessey, Amabile & Mueller (in press), who used Cronbach’s coefficient alpha, “in most instances, a reliability figure of .70 or higher can be considered evidence of an acceptable level of agreement between judges” (p.15). Gwet (2010) provided two guiding questions for considering the value of the inter-rater reliability coefficient: (a) “What makes a good extent of agreement good?” and (b) “How high should the inter-rater reliability coefficient be for the extent of agreement as a construct to be considered good?” (p.112).

Several scales have been proposed for the valuation of agreement strength. They are compared in Table 2.2. Researchers have looked to the widely used Landis and Koch (1977) benchmark scale and found it consistently useful. However, results based on any scale can be
invalidated if the model does not account for (a) the number of response categories, (b) the number of raters, and (c) the number of subjects, and this is especially true with smaller sample sizes (Gwet, 2010, pp. 114-120).

Table 2.2. Benchmark Scale for Valuation of Inter-rater Reliability Coefficients

<table>
<thead>
<tr>
<th>Benchmark Scale</th>
<th>Strength range for valuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landis and Koch</td>
<td>0.0  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9  1.0</td>
</tr>
<tr>
<td></td>
<td>poor  slight  fair  moderate  substantial  almost perfect</td>
</tr>
<tr>
<td>Fleiss’s κ</td>
<td>poor  intermediate to good  excellent</td>
</tr>
<tr>
<td>Altman’s κ</td>
<td>poor  fair  moderate  good  very good</td>
</tr>
</tbody>
</table>

As noted above, the number of judges used can impact the value of the inter-reliability coefficient. Amabile’s methods have varied widely on this point. For a study of elementary school children’s art, she used six undergraduate art students (1983). For a similar study she used 12 Stanford University psychology faculty members, 21 art teachers, and seven undergraduate and graduate art students (1983). Analysis of thirteen CAT studies reported by Amabile (1983) revealed that numbers of judges ranged from six to 40, and there appeared to be no correlation between inter-rater reliability levels and numbers of judges. In her more recent work, “10 or so judges have typically been employed” Hennessey, et al., in press, p. 17). Fiske (1977), in a study of ratings made on musical performances using a method similar to the CAT, recommended a minimum of seven raters for stable results. The
available literature, as well as practical limitations such as time and cost, point to an ideal of approximately seven to ten raters.

Another variable in the design of a CAT study is the nature of the scale on the rating form, including the number of response categories and the type of data the scale can produce (continuous, ordinal, discrete, etc). These decisions profoundly impact the nature of the information gleaned from an instrument as well as the types of statistical testing performed. For example, when using Cronbach’s alpha, the items in the scale can be continuous or categorical. The intra-class correlation, however, assumes equal spacing and categories must be assigned numeric values (Uebersax, 2007). This study made use of student scores derived from students working alone or in pairs, with each student giving their own self-evaluation scores. For purposes of inter-rater reliability calculations, means of paired students scores were used; thus calculations based on continuous data were more applicable.

Bauer, Kaufman, and Gentile (2004) used a 1.0-5.0 scale to rate the creativity of stories, personal narratives and poems. Hickey’s (2001) study of children’s musical compositions used two rating forms—one for theorists and composers to use, and one for music teachers to use. The theorists and composers’ form was an 18-item, seven-point Likert-type scale with anchors at low, medium, and high, and the music teachers’ form was a three-item form containing seven-point rating scales for creativity, craftsmanship, and aesthetic appeal (Hickey, 2001). It was Hickey’s study that served as the precedent for the two versions of the CAT form used in the current study: adult raters used a 12-item form, and students used a three-item form. Amabile (1983) did not publish her rating forms and did not respond to a request by this researcher to share them. However, in 1983 Amabile did make a
case for taking the procedural precautions necessary so that the data could arguably be treated as continuous:

The artist-judges were presented with continuous scales for making each judgment. These scales had equally spaced reference points marked, three of which were labeled: high, medium, and low. The judges were told to make each judgment by placing an X anywhere on the scale. They were asked to make their judgments under the assumption that the scale had equal spacing between the five reference points, and they were encouraged to make use of the entire range of the scale. (p. 51)

Uebersax (2000) argued that Likert-type scales can potentially be designed so that the data can be treated as interval-level data rather than ordered-categorical, thus benefitting from the greater statistical power gained when assumptions for parametric testing can be met. The format of the scale is key, and his suggestions include (a) using integer anchors, (b) choosing “categories that represent more or less equal increments,” and (c) choosing, wording, and formatting the rating level anchors in a way that implies the equal spacing of rating levels (para. 7). Although specific details and examples are scant throughout the literature on the CAT as well as in related work in multi-rater assessment, the suggestions from Amabile and Uebersax are useful to the design of a customized consensual assessment instrument. Additional research in the development of rating instruments for use with the CAT is needed.

One final point on the agreement statistic is that it is sometimes appropriate to assign weights to various levels of agreement. For example, if a patient is asked to rate pain on a scale of one to ten, the disagreement between nine and ten is not as serious a disagreement as
the difference between one and 10. In the context of this study, two raters might determine
the creativity level of a project to be very low. When marks on the rating form are coded as
integers, perhaps those two scores would be coded as 1 for the first rater and 2 for the second
rater. Perhaps then a third rater felt the creativity level was very high and that rater’s score
fell into the 7 range. If the assumption is made, as it has been for this study, that the trait
being measured (creativity) is continuous by nature, then it would be inappropriate to
conclude that there was an absence of rater agreement. That is because, so some degree, the
first two raters agreed that the creativity level was low. Standard agreement weights can be
chosen in statistical software, and weights can also be assigned by the researcher, which take
into account the seriousness of the agreements (Gwet, 2010, pp. 53-58). The reporting of
agreement weights is lacking in the literature on the use of the CAT. It is also seldom seen in
related literature on the use of inter-rater reliability for assessment purposes. Cohen (1968)
warned of the dangers of irresponsible handling of agreement weights:

The weights assigned are an integral part of how agreement is defined and therefore
how it is measured . . . the results of significance tests are also dependent upon the
weights. Another way of stating this is that the weights are part of any hypothesis
being investigated. An obvious consequence of this is that the weights, however
determined, must be set prior to the collection of the data. (p. 215)

Gwet offered a similar warning about the option of quadratic weights in particular, because
of the higher sensitivity to partial agreement, saying, “overstating inter-rater reliability by
abusing the use of weights could overstate the reliability of a poor system” (p. 57). Given the
influence that weighting choice has on inter-rater reliability results, further research is needed
so that researchers and practitioners who wish to use the CAT have a clear precedent and baseline for comparison of results.

*Systematic rater bias*

It can be useful to look for systematic bias in studies using multiple raters because a) bias can cause misinterpretation of results and b) patterns of bias can inform the selection of future raters. For example, Hickey (2001) used the CAT to determine the most reliable types of judges for assessing children’s musical compositions from among music teachers, composers, theorists, seventh-grade children, and second-grade children. Researchers may wish to adjust for systematic bias when analyzing CAT data, exclude extreme outliers, or simply use the knowledge of rater-type bias in future selection or calibration of judges (Cicchetti, Aivano & Vitale, 1976; Hennessey, et al., in press). Lowry (2011) explained bias this way:

> The mean of any particular sample can be taken as an unbiased estimate of the mean of the population from which the sample is drawn. In general, a biased estimate is one that will systematically underestimate the true value, or systematically overestimate it [. . .] It is roughly analogous to shooting arrows at a target. The archer who tends to hit below the bull's eye is systematically biased in one direction, while the archer who tends to hit above it is systematically biased in the other. An archer without such a systematic bias will hit below and above the bull's eye in equal measure, and occasionally she will even hit it dead center. (para. 3)

There are several ways to detect rater bias. The correlation coefficient might be used to compare mean scores from individual raters to those of the group; however, the problem with
the correlation coefficient is that the two measures might be highly correlated yet there could be substantial differences in the two measurements across their range of values (Fernandez & Fernandez, 2011). The correlation coefficient is a good place to start, but additional information can be helpful. When there is no true score for a measured trait, such as in the case of measuring creativity, the Bland-Altman method can be useful for plotting differences against averages. It can be used when “we cannot regard either method as giving the true value of the quantity being measured. In this case we want to know whether the methods give answers which are, in some sense, comparable” (Altman & Bland, 1983, p. 307). The Bland-Altman method, widely used by biomedical researchers, plots the differences between the values resulting from the two methods of measurement against the averages of the values (Ludbrook, 2010). Used alongside correlation, this method can give a clearer picture of how the ratings from one rater look against those of the group.

**Discriminant Validity**

In order to claim that creativity is being isolated and measured apart from other characteristics of students’ work, it is desirable to be able to demonstrate an instrument’s discriminant validity. This means that items related to creativity will likely receive consistently different ratings from items related to other, categorically different types of items. Amabile’s (1983) studies served as the source for choosing applicable dimensions of judgment for this study, and her dimensions, as implemented in many studies using the CAT, fell naturally into three clusters: creativity, technical strength and aesthetic appeal. Factor analysis often showed that items within those three clusters tended to consistently load together. For example, neatness and organization consistently loaded on a technical
goodness factor (Amabile, 1983). Ideally, a consensual assessment instrument will display significant discriminant validity through factor analysis so that researchers can make legitimate claims about the CAT and about creativity assessment. Consistent loading together of creativity-related items can substantiate the argument that creativity can be reliably assessed and that it should explicitly be stated in course curricula.

Chapter Summary

This chapter presented conceptual and operational definitions of creativity useful to the assessment of creativity in technology education. Fundamental principles of creativity in education were discussed. The development of relevant creativity research was traced, beginning in the mid-20th century and leading up to the present. A history of creativity in technology education was presented, beginning with the field’s roots in manual training and leading up to present day technology, design and engineering education. The significance of the research problem was viewed in terms of technology education’s role in developing a globally competitive workforce; in educating students who can participate in a defense against malevolent innovation; and in contributing to a better-educated citizenry because of the unique opportunities the technology education laboratory offers for increased student engagement. A theoretical framework was assembled, integrating the concepts of vertical and lateral thinking, the choice-based and DEAL methods, 21st century skills, and the statistical concepts of inter-rater reliability, systematic bias, and discriminant validity.
CHAPTER 3: METHOD

Introduction

This chapter begins with a statement of the research hypotheses tested in this study. Participants are described and study procedures are explained. Materials used by students, the researcher, and the adult raters are listed. Rating procedures followed by students and adult raters are detailed. Testing methods used for data analysis are introduced.

Research Hypotheses

The primary research question for this study is whether the classroom implementation of the choice-based method and the DEAL problem-solving method would result in different levels of creativity in middle school students’ game art and design projects.

The following hypotheses were tested:

1. Projects created using the choice-based method will receive significantly higher mean creativity scores than those created using the DEAL method, as measured by adult raters using the CAT instrument.

2. Students using the choice-based method will show low correlations between mean creativity scores and mean technical strength scores, as measured by adult raters using the CAT instrument.

3. In both choice-based and DEAL conditions, there will be a significant correlation between scores on students’ self- and peer- evaluations for the dimensions creativity, technical strength, and aesthetic appeal.
4. In both choice-based and DEAL conditions, there will be strong (\(\alpha>0.75\)) inter-rater reliability among all adult raters for the 12 items measured on the consensual assessment form.

5. Factor analysis will reveal discriminant validity among the three major dimensions of judgment (creativity, technical strength, and aesthetic appeal), appearing as three distinct factors, each having eigenvalues greater than 1.0.

Participants

The target population for this study consisted of 132 middle school students enrolled in the researcher’s middle school visual art classes. Seventy-two projects were completed. Students were given the option to work alone or in pairs. In the choice-based group, there were 64 students. Eight students worked alone and 56 opted to work in pairs, for a total of 36 choice-based projects. In the DEAL group, there were 58 students. Fourteen students worked alone and 44 opted to work in pairs, for a total of 36 DEAL projects. All projects were used in the rating sample. The children whose work was used in this study attended a suburban public middle school in the largest school system in North Carolina. The school population was 1,186 with 17.5% of students receiving free and reduced lunch. At the time the study was conducted the school system operated under a student assignment policy that promoted socioeconomic diversity. A variety of factors determined students’ placement in visual arts courses:

- Attempts were made to give students either their first or second choices of elective courses. Official statistics were not available, but an informal student survey
determined that approximately 70% of enrolled art students were in electives they had selected.

- All sixth graders at the school were placed on a rotation through elective courses meaning that every sixth grader took art at some time during the year. This resulted in a representative sample for the study since sixth grade enrollment in art was compulsory rather than by choice, as it was for seventh and eighth graders.

The enrollment and course details are provided in Table 3.1.

Table 3.1: Course Details and Enrollment by Method

<table>
<thead>
<tr>
<th></th>
<th>Choice-Based</th>
<th>DEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Projects</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Number of Students</td>
<td>64</td>
<td>58</td>
</tr>
<tr>
<td>Course Title</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pottery &amp; Sculpture</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Visual Composition</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Visual Art Exploratory</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Painting</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Pottery &amp; Sculpture</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Visual Art Exploratory</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Grade Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>26</td>
<td>26</td>
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<tr>
<td>7</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Enrollment</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Number of Males</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>13</td>
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<td>13</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Number of Females</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
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<td>8</td>
</tr>
<tr>
<td>17</td>
<td>17</td>
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<tr>
<td>Age Range</td>
<td>13-16</td>
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<tr>
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<td>12-14</td>
<td>11-13</td>
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<td>12-15</td>
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<tr>
<td></td>
<td>12-15</td>
<td>11-13</td>
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<tr>
<td>Mean Age</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>14</td>
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<td></td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>12</td>
</tr>
</tbody>
</table>

Two students in this population were autistic. The researcher worked with both families and the school’s Special Education staff to develop strategies for the successful completion of modified projects for both of these students. Both projects were part of the data sample used in this study.

Nine students in the population were identified as ESL (English as a Second Language) or LEP (Limited English Proficiency). The researcher worked with these students, their
families, and the school’s ESL/LEEP teacher to develop strategies for these students including peer assistance, cooperative learning, and oral alternatives to written assignments as deemed appropriate (in this case, the DEAL handout was completed with the assistance of the ESL/LEEP teacher as needed). All projects were part of the data sample used in this study.

The seven raters were recruited personally by the researcher and consisted of individuals (e.g., graduate students, teachers in Wake and Durham Counties, North Carolina State University faculty, and professionals) with expertise in creative design processes (Appendix A, Rater Background Survey, and Appendix B, recruitment statement and consent form). The rater survey revealed the following about the seven raters: They ranged in age from 30 to 57, with a mean age of 41.4. Five of the seven indicated their most professional experience was as an educator, with one reporting both artist and educator and the seventh reporting both designer and educator. Four of the seven indicated they had taught middle and/or high school courses emphasizing creative problem-solving methods. Four of the seven indicated they had taught middle or high school courses emphasizing a specific design process.

Raters were asked to commit approximately two to three hours to a rating session during which they would evaluate student projects on dimensions such as creativity, aesthetic value, and technical strength. Eligible raters (six of the seven were allowed by their job position policies) were compensated with a $25 gift card for their participation.
Procedures

All students were required to complete a game art and design project (see Appendix C: Design Brief: Choice-Based Method and Appendix D: Design Brief: DEAL Method), either working alone or in pairs. Students were given the option of making a card game, a video game, a board game, or a game that did not easily fit into one of those categories. Video games were required to be created in GameMaker (YoYo Games, 2011). The unit was conducted over three five-day weeks of daily 45-minute class sessions. Work outside of class was encouraged, especially for the video game designers, but was not required. Before-and after-school open studio sessions were offered 10 times over the three weeks. Nineteen students attended at least one open studio session.

Students began the unit with a day of research in the computer lab. Research was conducted through the school media center’s research website. Students identified and described elements of a variety of game types. On day two they received and discussed their design brief. Students were required to design and construct an original card, board, or video game. Emphasis was placed on making strong and deliberate decisions about the use of the elements of art (such as color, line, and texture) and principles of design (such as contrast, movement, and unity) when designing original games. DEAL classes also discussed the DEAL method and how it would be used to approach this project (see Appendix E: DEAL handouts). On day three students moved around the classroom round-robin style, trying a variety of board, card, and video games. Days four through 13 were designated work days, during which students researched, designed, and constructed their games. (Appendices F and G: Examples of Student Projects.) Days 14 and 15 consisted of critique, assessment, and
game play. Participants turned projects in to their teacher (the researcher). Table 3.2 compares the 15-day process for the two different groups.

Table 3.2: Daily Process by Method

<table>
<thead>
<tr>
<th>Day of Project (15 Days Total)</th>
<th>DEAL Method Classes</th>
<th>Choice-based Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All students to computer lab for project overview and research</td>
<td>All students to computer lab for project overview and research</td>
</tr>
<tr>
<td>2</td>
<td>Distribution/discussion of design brief; Discussion of DEAL process and handouts</td>
<td>Distribution/discussion of design brief</td>
</tr>
<tr>
<td>3</td>
<td>Round-robin game play</td>
<td>Round-robin game play</td>
</tr>
<tr>
<td>4</td>
<td>Recap/discussion of design brief; Students begin work on DEAL handouts</td>
<td>Recap/discussion of design brief; Students begin developing games</td>
</tr>
<tr>
<td>5-13</td>
<td>Students continue game development; Ongoing student/teacher discussions of progress with the DEAL process and completion of handouts</td>
<td>Students continue developing games</td>
</tr>
<tr>
<td>14</td>
<td>Students present and play each others' games</td>
<td>Students present and play each others' games</td>
</tr>
<tr>
<td>15</td>
<td>Continued game play; self and peer evaluations</td>
<td>Continued game play; self and peer evaluations</td>
</tr>
</tbody>
</table>

The researcher replaced personal identifiers with code number stickers prior to taking projects from the classroom. Projects, with the coded ID attached, were taken to the seven rating sessions and then returned to students at the conclusion of the study.
Materials

Students were given multiple media options in the art studio such as markers, tempera and acrylic paint, clay, wood, a variety of papers and canvas, printing materials, wire, and found objects. Some students brought additional materials from home. Techniques for safe use of these materials and of all related equipment were taught earlier in the year in all courses. Both groups, DEAL and choice-based, had the same access to all materials in the classroom.

Additionally, the following materials were used in the study: a) a self/peer evaluation form (Appendix H), completed by participants during the critique session and submitted to the researcher for analysis; b) a background survey (Appendix A), used to collect information from the seven expert raters about their experience in the field of creative problem solving; and c) the Consensual Assessment (CAT) form (Appendix I), used by adult raters in individually assessing student projects. Table 3.3 provides the population and scores produced for each instrument. In accordance with Amabile’s (1983) recommendations, two versions of the CAT form were used. On Form A the set of dimensions of creativity came first, aesthetic appeal second, and technical strength third. The order was reversed on Form B because, Amabile warned, “If all judgments were made in the same order by all judges, high levels of interjudge reliability might reflect method artifacts” (1983, p. 39). That is, that there may be an order effect that arises from the order in which the dimensions are assessed.
Table 3.3: Rating Instruments by Population and Scores Produced

<table>
<thead>
<tr>
<th>Name of Instrument</th>
<th>Population</th>
<th>Scores Produced</th>
</tr>
</thead>
</table>
| Self Evaluation    | Each Individual Student | 3 Dimensions:  
• Creativity  
• Aesthetic Appeal  
• Technical Strength |
| Peer Evaluation    | Small groups of 4-5 students | 3 Dimensions:  
• Creativity  
• Aesthetic Appeal  
• Technical Strength |
| Consensual assessment (CAT) form | Adult Raters | 12 Items:  
3 Dimensions:  
• Creativity  
• Aesthetic Appeal  
• Technical Strength  
9 Items Subjacent to Dimensions:  
• Organization  
• Neatness  
• Effort Evident  
• Pleasing Use of Shape/Form  
• Pleasing Use of Color/Value  
• Liking  
• Novel Use of Materials  
• Novel Idea  
• Complexity |

Rating Procedures

The assessments for this study consisted of 1) a self/peer evaluation (Appendix F), conducted during the critique sessions on days 14-15 with each group; and 2) a series of seven individual assessment sessions, during which individual raters assessed all student projects using the consensual assessment form (Appendix G).
The self and peer evaluations are six-item surveys. Following presentations of projects to the class as well as time for game play, students rated their own projects on 1) creativity, 2) aesthetic value and 3) technical strength. The class was then divided into groups of 3-4 students who came to a consensus rating for each project in the small group on 1) creativity, 2) aesthetic value and 3) technical strength. For reasons of simplicity, age-appropriateness, and time, the student rating form contained only the three major dimensions: creativity, aesthetic appeal, and technical strength; the adult form contained additional items subjacent to the three major categories.

The consensual assessment (CAT) form is a 12-item Likert-type survey. No standardized form for the CAT is available (perhaps appropriate, since contexts will vary), and the Amabile research group does not publish their instruments. Neither have other researchers who have reported the use of the technique (e.g., Baer, Kaufman & Gentile, 2004; Hennessey, et al., in press; Hickey, 2001).

The researcher scheduled individual rating sessions with each of seven raters. For inter-rater reliability to be meaningful, it is essential that ratings be independent (aside from the statistical dependence related to all judges rating the same projects). Raters were told they would be assessing middle school game art and design projects for creativity and other measures, but that they would not be trained in, or otherwise given further rating criteria, related to concept definitions, etc. Based on Amabile’s (1983) advice, projects were spread across tables in a different order for every rating session and raters were given the following instructions for rating:
1. Please view all products before making any ratings

2. Please rate products relative to each other, rather than to some absolute standard

3. Place an X anywhere on the scale from low to high.

One paper copy of the CAT form was provided per rater, per student project. The rating form includes a prompt to write the project code number, which helps the researcher verify that all projects were rated each session, and rated only once per rater. Paper rating forms were provided on a clipboard. As the rater moved around the room, he/she placed rating sheets on top of projects to easily track which projects had been rated. It took approximately two to five minutes to rate each project. Before each rating session ended, the researcher checked the completed rating sheets against a list to ensure that no projects had been missed by the rater.

Once rating sheets were collected from raters, the marks made on the sheets were coded numerically for analysis using a transparent columnar overlay. Marks were translated to integers one through eight. Because no previously published consensual assessment instruments were available to use as guides, the decision to use eight columns was deemed appropriate since it left room for observing what seemed to be a reasonable amount of variability.

**Data Analyses**

Mean creativity, technical strength, and aesthetic appeal scores were calculated for (a) all adult raters, (b) group consensus by peers, and (c) self evaluations. In 22 cases, the self-evaluation score was a single score. For the remaining 50 projects, those cases in which
students worked in pairs, the self-evaluation score used for all statistical analyses was actually the mean of the two students’ self-evaluation scores.

Means were also calculated for each of the nine items that were only rated by adults: overall organization, neatness, effort evident, pleasing use of shape/form, pleasing use of color/value, liking, novel use of materials, novel idea, and complexity. Descriptive statistics were run to test for normality and outliers.

Pedagogical strategies (DEAL versus choice-based) were compared using the Mann-Whitney non-parametric alternative to the independent group t-test.

To test inter-rater reliability, Cronbach’s alpha was calculated using adult raters’ scores for the 12 separate items rated. Additionally, pairwise correlations were run among self-, peer-, and adult ratings of creativity.

Individual raters’ scores were tested for systematic bias using the Pearson (parametric) and Spearman (nonparametric) correlation coefficients. Bland-Altman plots were generated for viewing rating patterns of individual raters against the group mean.

Finally, in order to evaluate discriminant validity, correlations were run between the major three dimensions measured: creativity, technical strength, and aesthetic appeal. Factor analysis was then conducted on all 12 items measured.

**Chapter Summary**

This chapter presented the research hypotheses tested in this study and the methods used to test them. Participants were described and study procedures were explained along with a listing of assessment materials used by students, the researcher, and the adult raters.
For the use of these assessments, rating procedures followed by students and adult raters were detailed. Finally, testing methods used for data analysis were introduced.
CHAPTER 4: RESULTS

Introduction

This chapter provides the results of testing the research hypotheses. It begins with statements of the research hypotheses and variables of interest. Analyses and their results are presented. An alpha level of 0.05 was used as a significance criterion for all statistical tests.

Hypotheses

Projects created using the choice-based method will receive significantly higher mean creativity scores than those created using the DEAL method, as measured by adult raters using the CAT instrument.

1. Students using the choice-based method will show low correlations between mean creativity scores and mean technical strength scores, as measured by adult raters using the CAT instrument.

2. In both choice-based and DEAL conditions, there will be a significant correlation between scores on students’ self- and peer- evaluations for the dimensions creativity, technical strength, and aesthetic appeal.

3. In both choice-based and DEAL conditions, there will be strong ($\alpha>0.75$) inter-rater reliability among all adult raters for the 12 items measured on the consensual assessment form.
4. Factor analysis will reveal discriminant validity among the three major dimensions of judgment (creativity, technical strength, and aesthetic appeal), appearing as three distinct factors, each having eigenvalues greater than 1.0.

Variables

The dependent variable for the research question driving this study was the mean creativity score as measured by seven adult raters using the CAT instrument. The independent variable was the pedagogical strategy for problem-solving: The DEAL method was used in three of the six classes and the choice-based method was used in the alternate three. Table 4.1 describes the variables of interest for hypotheses 1-5.

Table 4.1: Variables of Interest for Research Hypotheses

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Variable of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H1</strong>: Projects created using the choice-based method will receive significantly higher mean creativity scores than those created using the DEAL method, as measured by seven adult raters using the CAT instrument.</td>
<td>Mean adult creativity score</td>
</tr>
<tr>
<td><strong>H2</strong>: Students using the choice-based method will show low correlations between mean creativity scores and mean technical strength scores, as measured by seven adult raters using the CAT instrument.</td>
<td>Correlation between mean adult creativity score and mean adult technical strength score</td>
</tr>
<tr>
<td><strong>H3</strong>: In both choice-based and DEAL conditions, there will be a significant correlation between scores on students’ self- and peer- evaluations for the creativity dimension.</td>
<td>Correlation between self and peer evaluation scores</td>
</tr>
<tr>
<td><strong>H4</strong>: In both choice-based and DEAL conditions, there will be strong ($\alpha &gt; 0.75$) inter-rater reliability among all adult raters for the 12 items measured on the consensual assessment form.</td>
<td>Inter-rater reliability coefficient for adult raters</td>
</tr>
<tr>
<td><strong>H5</strong>: Factor analysis will reveal discriminant validity among the three major dimensions of judgment (creativity, technical strength, and aesthetic appeal), appearing as three distinct factors, each having eigenvalues greater than 1.0</td>
<td>Factor loadings for the twelve CAT items</td>
</tr>
</tbody>
</table>
Preliminary Analyses

Following the collection of the consensual assessment (CAT) forms, a transparent columnar overlay was used to code raters’ pen marks numerically on a scale of one through eight.

**Descriptive statistics.**

Mean creativity, technical strength, and aesthetic appeal scores were calculated per student project for (a) all adult raters, (b) group consensus by peers, and (c) self evaluations. Means were also calculated per student project for all items rated by adults only: novel use of materials, novel idea, complexity, pleasing use of shape/form, pleasing use of color and/or value, liking, overall organization, neatness, and effort evident. Descriptive statistics were run to test for normality and outliers. Table 4.2 contains the results of the preliminary analyses.

All distributions were normal except for adult raters’ mean scores for neatness. Non-parametric tests were, therefore, used as appropriate.

**Tests for Outliers.**

One outlier was detected. The lowest mean score for complexity, $G = 3.68, p = 0.01$, came from a sixth grade project using the choice-based approach. It was determined that (a) the outlier did reflect a low level of complexity for that particular student project (i.e., this was not an instance of data entry error, etc.); (b) the outlier was a legitimate case occurring in the sample population through random chance since it was from a sixth grade class, the strongest of the three grade levels used in the study in terms of random sampling; and (c) the
outlier did not detrimentally affect the overarching goals of the study. Therefore the outlier was not discarded from the data set.

Table 4.2: Descriptive Statistics for All Rated Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Rater Type</th>
<th>Mean±</th>
<th>SD</th>
<th>Median*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>Adult</td>
<td>5.21</td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>Creativity</td>
<td>Student/Self</td>
<td>6.21</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>Creativity</td>
<td>Student/Peer</td>
<td>6.49</td>
<td>1.13</td>
<td></td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>Adult</td>
<td>5.11</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>Student/Self</td>
<td>5.77</td>
<td>1.31</td>
<td></td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>Student/Peer</td>
<td>6.03</td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>Technical Strength</td>
<td>Adult</td>
<td>4.75</td>
<td>1.13</td>
<td></td>
</tr>
<tr>
<td>Technical Strength</td>
<td>Student/Self</td>
<td>5.75</td>
<td>1.19</td>
<td></td>
</tr>
<tr>
<td>Technical Strength</td>
<td>Student/Peer</td>
<td>6.00</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>Color/Value</td>
<td>Adult</td>
<td>5.30</td>
<td>1.23</td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td>Adult</td>
<td>4.65</td>
<td>1.26</td>
<td></td>
</tr>
<tr>
<td>Effort</td>
<td>Adult</td>
<td>5.44</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>Liking</td>
<td>Adult</td>
<td>4.75</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>Neatness</td>
<td>Adult</td>
<td>5.12</td>
<td>1.36</td>
<td>5.43</td>
</tr>
<tr>
<td>Novel Idea</td>
<td>Adult</td>
<td>4.81</td>
<td>1.19</td>
<td></td>
</tr>
<tr>
<td>Novel Materials</td>
<td>Adult</td>
<td>4.80</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>Adult</td>
<td>5.25</td>
<td>1.14</td>
<td></td>
</tr>
<tr>
<td>Shape/Form</td>
<td>Adult</td>
<td>5.18</td>
<td>1.23</td>
<td></td>
</tr>
</tbody>
</table>

Notes. *Median is provided when the distribution is not normal.
+ All items are scored on a scale from 1-8.

Comparison of DEAL Method Versus Choice-based Approach

Hypothesis #1: Projects created using the choice-based method will receive significantly higher mean creativity scores than those created using the DEAL method, as measured by seven adult raters using the CAT instrument.

Pedagogical strategies (DEAL method versus choice-based method) were compared for the 12 measured items on the CAT instrument by adults using the independent group t-
test and its non-parametric alternative, the Mann-Whitney. Adult ratings only were considered for this analysis since student self and peer ratings were conducted only on the three major dimensions, creativity, aesthetic appeal and technical strength.

There were no significant differences found between the outcomes of the DEAL and choice-based methods. This was true for all of the 12 items measured, as shown in Table 4.3.

Table 4.3: Tests of Independence of Means: DEAL vs. Choice-Based for Adult CAT scores

| Dimensions of Judgment      | t ratio | Prob > |t| |
|----------------------------|---------|---------|
| Creativity                 | 0.4609  | 0.6463  |
| Aesthetic Appeal           | 1.0144  | 0.3139  |
| Technical Strength         | 0.4250  | 0.6722  |
| Color/Value                | 0.6142  | 0.5411  |
| Complexity                 | 0.3613  | 0.7189  |
| Effort                     | 0.6223  | 0.5337  |
| Neatness                   | 0.603*  | 0.547   |
| Novel Idea                 | 0.5320  | 0.5964  |
| Novel Materials            | 0.5229  | 0.6027  |
| Organization               | 0.2391  | 0.8117  |
| Shape/Form                 | 0.7555  | 0.4525  |

*Note. Adult raters’ scores only. *A z score is given for the Mann-Whitney non-parametric independent group comparison rather than the t ratio due to the non-normal distribution of the data for neatness.

Correlations Among the Three Major Dimensions

**Hypothesis #2:** Students using the choice-based method will show low correlations between mean creativity scores and mean technical strength scores, as measured by seven adult raters using the CAT instrument.

Adult raters’ scores were used to evaluate the magnitude of correlation between the mean scores of the three major scoring dimensions. Table 4.4 shows all pairwise correlations
among the three major dimensions, creativity, aesthetic appeal, and technical strength.

Contrary to the hypothesis, the correlation between creativity and technical strength scores for the choice-based method was higher \( (r=0.8571, p < .001) \) than for the DEAL method \( (r=0.8119, p < .001) \), and also higher for both methods combined, \( r=0.8359, p < .001 \). It appears that greater freedom did not result in lower measures of technical strength, as expected.

Table 4.4. Correlations for 3 Dimensions by Method

<table>
<thead>
<tr>
<th>Dimensions of Judgment</th>
<th>DEAL</th>
<th>Choice-Based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation with Creativity</td>
<td>Correlation with Aesthetic Appeal</td>
</tr>
<tr>
<td></td>
<td>Correlation with Creativity</td>
<td>Correlation with Aesthetic Appeal</td>
</tr>
<tr>
<td>Creativity</td>
<td>--</td>
<td>0.7758***</td>
</tr>
<tr>
<td>Technical Strength</td>
<td>0.8119***</td>
<td>0.8258***</td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>0.7758***</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Adult raters’ scores only.*

*** \( p < .001 \).

Table 4.5. Correlations for Three Dimensions

<table>
<thead>
<tr>
<th>Dimensions of Judgment</th>
<th>Correlation with Creativity</th>
<th>Correlation with Aesthetic Appeal</th>
<th>Correlation with Technical Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>--</td>
<td>0.7927***</td>
<td>0.8359***</td>
</tr>
<tr>
<td>Technical Strength</td>
<td>0.8359***</td>
<td>0.8845***</td>
<td>--</td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>0.7927***</td>
<td>--</td>
<td>0.8845***</td>
</tr>
</tbody>
</table>

*Note. Adult raters’ scores only.*

*** \( p < .001 \).
Inter-rater Reliability

**Hypothesis #3:** In both choice-based and DEAL conditions, there will be a significant correlation between scores on students’ self- and peer- evaluations for the creativity dimension.

**Hypothesis #4:** In both choice-based and DEAL conditions, there will be strong \((\alpha>0.75)\) inter-rater reliability among all adult raters for the 12 items measured on the consensual assessment form.

To test inter-rater reliability, Cronbach’s alpha was calculated using adult raters’ scores for the 12 separate items rated.

Additionally, pairwise correlations were run among self-, peer-, and adult ratings of creativity to inform the discussion of rater types and their usefulness in classroom rating activities. It can be seen in Table 4.6 that, for adult ratings, all items have reliabilities greater than .70, and that nine of the 12 have reliabilities greater than .80. This includes creativity, with an inter-rater reliability of 0.82. According to the Landis and Koch (1977) scale, a reliability coefficient between 0.6 and 0.8 is “substantial” and agreement beyond 0.8 is “almost perfect.” Agreement coefficients among adults, peer consensus ratings, and students’ self-evaluation ratings for creativity, however, were lower, with an overall reliability across all raters of only 0.66 (Table 4.7). This is consistent with the findings of Amabile (1996), Moneta, Amabile, Schatzel, & Kramer (2010), and Heidmeier & Moser (2009), all of whom have noted only moderate correlations between self-assessments of creativity and ratings made by external observers. Inter-rater reliabilities were also low
among the three rater types (self, peer, and adult) for aesthetic appeal, $\alpha=0.66$, and for technical strength, $\alpha=0.50$.

Table 4.6. Inter-rater Reliabilities for Seven Adult Raters

<table>
<thead>
<tr>
<th>Dimensions of Judgment</th>
<th>Cronbach’s $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>0.8233</td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>0.8610</td>
</tr>
<tr>
<td>Technical Strength</td>
<td>0.7729</td>
</tr>
<tr>
<td>Color/Value</td>
<td>0.8138</td>
</tr>
<tr>
<td>Complexity</td>
<td>0.8171</td>
</tr>
<tr>
<td>Effort</td>
<td>0.8266</td>
</tr>
<tr>
<td>Liking</td>
<td>0.8193</td>
</tr>
<tr>
<td>Neatness</td>
<td>0.8545</td>
</tr>
<tr>
<td>Novel Idea</td>
<td>0.7383</td>
</tr>
<tr>
<td>Novel Materials</td>
<td>0.8483</td>
</tr>
<tr>
<td>Organization</td>
<td>0.7983</td>
</tr>
<tr>
<td>Shape/Form</td>
<td>0.8331</td>
</tr>
</tbody>
</table>

*Note.* Seven adult raters’ scores.

Table 4.7: Inter-rater Reliabilities for All Raters

<table>
<thead>
<tr>
<th>Dimensions of Judgment</th>
<th>Cronbach’s $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>0.66</td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>0.66</td>
</tr>
<tr>
<td>Technical Strength</td>
<td>0.50</td>
</tr>
</tbody>
</table>

*Note.* Nine raters total, comprising seven adult raters plus the peer consensus score and the self evaluation score.

Table 4.8. Pairwise Correlations between Rater Types

<table>
<thead>
<tr>
<th>Rater Type</th>
<th>Correlation with Student Self-Evaluations of Creativity</th>
<th>Correlation with Student Peer Consensus on Creativity</th>
<th>Correlation with Adult Creativity Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Self Evaluations of Creativity</td>
<td>--</td>
<td>0.4635***</td>
<td>0.3052*</td>
</tr>
<tr>
<td>Student Peer Consensus on Creativity</td>
<td>0.4635***</td>
<td>--</td>
<td>0.4215***</td>
</tr>
<tr>
<td>Adult Creativity Scores</td>
<td>0.3052*</td>
<td>0.4215***</td>
<td>--</td>
</tr>
</tbody>
</table>

*Note.* *p < .05. ***p < .001.
**Systematic bias in individual raters.**

Individual adult raters’ creativity scores were tested for systematic bias against the adult group mean using Pearson’s \( r \) and Spearman’s \( r_s \), non-parametric correlation coefficients. A low coefficient of correlation between a rater’s scores and the group means would suggest possible systematic bias, although this is not a powerful stand-alone measure of bias (Hunt, 1986). To further inform the assessment of possible bias, Bland-Altman plots were generated for viewing rating patterns of individual raters against groups.

The Bland-Altman plot is a graphical display of agreement between measurement types (Liao & Capen, 2011). The x-axis is the mean of the two measurements (in this case, individual rater’s score and group mean across all adult raters), and the y-axis is the difference between the two measurements. The horizontal lines on either side of the x-axis represent the 95% limits of agreement and their placement is one standard deviation above and below the x-axis. If a rater were showing systematic bias, the points would fall consistently on one side of the x-axis. Extreme differences between the mean adult raters’ scores and the individual rater’s scores would be visible if many (i.e., more than 5%) of the points fell outside the 95% limits of agreement lines. Table 4.9 is organized as a side-by-side display of correlation coefficients and Bland-Altman plots. Used together, these two measures can assist a researcher in determining whether or not a rater’s scores are contributing to the goals of a study. Since the investigation of rater agreement is of central importance to this study’s operational definition of creativity, slight rater bias is important to recognize and to consider in terms of future rater selection, but it does not exclude the use of that rater’s data (Hickey, 2001). Table 4.9 shows that Rater 4 shows slight positive bias and
a rather low correlation with the group mean creativity scores. The Bland-Altman plots do not suggest systematic bias for any of the other six raters.

**Table 4.9: Correlation Coefficients and Bland-Altman Plots of Creativity by Rater**

<table>
<thead>
<tr>
<th>Rater</th>
<th>Correlation</th>
<th>Bland-Altman Plot: Individual Rater versus Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rater versus Group For Creativity</td>
<td></td>
</tr>
<tr>
<td>Rater 1</td>
<td>( r_s = 0.5654^{***} )</td>
<td><img src="image1.png" alt="Bland-Altman Plot Rater 1" /></td>
</tr>
<tr>
<td>Rater 2</td>
<td>( r_s = 0.7478^{***} )</td>
<td><img src="image2.png" alt="Bland-Altman Plot Rater 2" /></td>
</tr>
<tr>
<td>Rater 3</td>
<td>( r_s = 0.7386^{***} )</td>
<td><img src="image3.png" alt="Bland-Altman Plot Rater 3" /></td>
</tr>
<tr>
<td>Rater 4</td>
<td>( r = 0.5541^{***} )</td>
<td><img src="image4.png" alt="Bland-Altman Plot Rater 4" /></td>
</tr>
</tbody>
</table>
Table 4.9 Continued

<table>
<thead>
<tr>
<th>Rater 5</th>
<th>Rater 6</th>
<th>Rater 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

Note. Adult raters’ scores only. ***p < .001.

**Discriminant Validity**

*Hypothesis #5:* Factor analysis will reveal discriminant validity among the three major dimensions of judgment (creativity, technical strength, and aesthetic appeal), appearing as three distinct factors, each having eigenvalues greater than 1.0.

In order to evaluate the discriminant validity for this version of the consensual assessment (CAT) form, correlations were run between the major dimensions measured: creativity, technical strength, and aesthetic appeal. Correlations were rather high among all pairings of the three major dimensions. This could be an indication that the instrument did
not measure the three major dimensions independently; e.g., ratings of creativity-related characteristics such as novelty of ideas were very similar to ratings of technical characteristics such as neatness. Factor analysis conducted on the mean ratings of the 12 dimensions of judgment (promax rotation) suggested two factors, as shown in Table 4.10, though only one true factor emerged with an eigenvalue higher than 1.0. Factor 1 includes overall aesthetic appeal and its subjacent items: pleasing use of shape/form, pleasing use of color and/or value, and liking; as well as technical strength and its subjacent items: overall organization, neatness, and effort evident. Factor 2 comprises creativity and its three subjacent items as categorized on the consensual assessment form: novel idea, novel materials, and complexity. This suggests that raters did distinguish between creativity characteristics and all other characteristics of the students’ game designs. It should be noted, however, that factor analysis is far more stable with larger sample sizes than that of this study and therefore further testing would be necessary in order to make claims about this instrument’s discriminant validity.
Table 4.10: Factor Loading of 12 Items, Promax Rotation

<table>
<thead>
<tr>
<th>Dimensions of Judgment</th>
<th>Factor 1: Technical Strength &amp; Aesthetic Appeal</th>
<th>Factor 2: Creativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>0.17</td>
<td>0.80</td>
</tr>
<tr>
<td>Aesthetic Appeal</td>
<td>0.91</td>
<td>0.11</td>
</tr>
<tr>
<td>Technical Strength</td>
<td>0.49</td>
<td>0.29</td>
</tr>
<tr>
<td>Color/Value</td>
<td>1.00</td>
<td>0.09</td>
</tr>
<tr>
<td>Complexity</td>
<td>0.17</td>
<td>0.76</td>
</tr>
<tr>
<td>Effort</td>
<td>0.43</td>
<td>0.25</td>
</tr>
<tr>
<td>Liking</td>
<td>0.66</td>
<td>0.28</td>
</tr>
<tr>
<td>Neatness</td>
<td>0.83</td>
<td>0.06</td>
</tr>
<tr>
<td>Novel Idea</td>
<td>0.06</td>
<td>1.00</td>
</tr>
<tr>
<td>Novel Materials</td>
<td>0.11</td>
<td>0.82</td>
</tr>
<tr>
<td>Organization</td>
<td>0.58</td>
<td>0.17</td>
</tr>
<tr>
<td>Shape/Form</td>
<td>0.79</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Note. Adult raters’ scores only.

Chapter Summary

This chapter provided the results of testing the research hypotheses. It began with statements of the research hypotheses and identification of the variables of interest. Analyses and their results were presented.

Projects created using the choice-based method did not receive significantly different mean creativity scores than those created using the DEAL method. Students using the choice-based method showed strong correlations between mean creativity scores and mean technical strength scores. In both choice-based and DEAL conditions, there were not significant correlations between scores on students’ self- and peer- evaluations for the creativity dimension. In both choice-based and DEAL conditions, there was strong ($\alpha>0.75$) inter-rater reliability among all adult raters for 11 of the 12 items measured on the consensual assessment form. Factor analysis, though unstable at this sample size, suggested two factors rather than the desired three for the consensual assessment instrument.
CHAPTER 5: DISCUSSION

Introduction

The American education system deemphasizes creativity and innovation in favor of a particular skill set that is more easily and cheaply measured using standardized tests (Florida, 2007). A need for the promotion of creative thinking and innovative problem-solving has been identified in the research literature (Todd & Shinzato, 1999; National Center on Education and the Economy, 2010), while the field of technology education has identified creativity as a core piece of its mission (ITEA, 2007). Unfortunately, creativity has not always explicitly been part of the goals, objectives and measured results in technology classrooms for a variety of reasons, including the perceived difficulty in assessing it (Lau & Li, 1996; Westby & Dawson, 1995; Lewis, 2005). However, studies have shown that the reliable assessment of creativity in students’ work is possible (Amabile, 1983, 1998; Hennessey, et al., in press; Hickey, 2001). Many models for creative problem-solving have been developed, but there is still work to be done in determining effective pedagogical strategies for fostering creativity in the classroom. To that end, this research looked at both the DEAL problem-solving method (Define/Explore/Anticipate/Look back) and the choice-based approach, borrowed from visual art education, as approaches that have potential for fostering creativity in technology classrooms. To address the issue of assessment, the Consensual Assessment Technique (CAT) was used both to assess the efficacy of these two pedagogical approaches in enhancing creativity instruction in the technology education classroom and to, at a meta-level, evaluate its efficacy as an assessment instrument. This study compared the creative outcomes of the DEAL and choice-based methods and examined
the reliability and validity of the CAT in the context of middle school game art and design projects.

The major research question driving this study was, *will measures of creativity on students’ game art and design projects be higher after using the choice-based method or the DEAL method?* The guiding question led to several related inquiries about pedagogy and assessment that further shaped the study. The most immediate that arose was, if one pedagogical strategy does a better job of supporting creativity in the classroom, how will we recognize it and how will we measure it? Amabile’s consensual assessment technique emerged in the literature as a viable option. Amabile’s recommendations regarding appropriate open-ended projects led to the choice of the middle school game art and design unit as the study’s setting. Her research group’s early work in the 1980s involved the evaluation of children’s collages, but in recent years their studies branched out to other project types such as poetry, prose, and computer line drawings. Other researchers have extended the CAT to music and even to mixed project types within a single creativity assessment. The question emerged, *will the consensual assessment technique yield high levels of inter-rater reliability when applied to middle school children’s game art and design projects?* Questions of inter-rater reliability become particularly important when we think about scaling this assessment technique to real-world classrooms where there may be a range of individuals being used for rating, including students in the classroom.

There was no significant difference between mean creativity scores on game art and design projects produced by students in the choice-based environment and students using the DEAL method. However, consistent with the findings of Amabile (1983), Hickey (2001)
and others, inter-rater reliability among the seven adult raters was consistently high for all 12 items of judgment measured in this study: creativity, novel use of materials, novel idea, complexity, overall aesthetic appeal, pleasing use of shape/form, pleasing use of color and/or value, liking, technical strength, overall organization, neatness, and effort evident. Creativity, the dimension of judgment central to this study, had a reliability of $\alpha = 0.82$, deemed by the widely used Landis & Koch (1977) scale, “almost perfect.”

As decisions pertaining to the details of the instructional design of the game art and design unit were made, likely trade-offs emerged for consideration. Often an instructional design will include a demonstration followed by an allotment of time during which students practice the demonstrated skill or technique. If in the choice-based environment, less time is spent on specific lessons of technical skill – i.e., blocks of instructional time in which all students were required to practice a skill in a particular medium – would the result be greater creativity at the expense of technical strength?

An additional research question arose, *how will measures of technical strength correlate with measures of creativity?* On one hand, highly creative students are often the same students whose work also shows outstanding craftsmanship. Keitel, Kopala & Schroder (2003) explained that for gifted and creative individuals, the work they do is a significant source of their self-expression and life satisfaction (p. 245). Therefore, for some gifted and creative students, there would likely be a high correlation between technical strength and creativity. On the other hand, a classroom environment in which time is not sufficiently devoted to technical skill building may be expected to result in products with low measures of technical strength. Students, and particularly younger and less experienced ones, might
not possess the skills to physically model their creative ideas with high levels of
craftsmanship. Therefore creative ideas might be both stymied by students’ lack of technical
skill and underrepresented in measures of creativity since the final product could not
communicate the creative idea effectively. Poor craftsmanship might also negatively skew
creativity scores if judges were to inadvertently associate technical weakness with low
creativity, though the inverse could occur in the case of strong craftsmanship.

Additionally, issues of motivation, work ethic, and social context might be expected to
manifest for some students as influential toward measures of technical strength. This is
because a necessary component of creativity is task motivation, which is “comprised of the
individual’s attitude toward the task and perceptions of the reason for engaging in the task”
(Tighe, Picariello & Amabile, 2003, p.201). Highly creative and/or gifted students might
underachieve as a result of boredom (Keitel et al., 2003, p.250). This might be seen as
laziness or disinterest in attention to craftsmanship-related details such as the use of a
straight-edge to draw lines, the application of a second or third coat of paint as needed, or the
sharp scoring of folded edges, despite the student’s having a highly creative idea.

Alternately, a disparity between creativity and technical strength scores might take the form
of a well crafted but unoriginal attempt at meeting the minimum standards required for an
acceptable grade. Students’ motivational attitudes and perceptions fell outside of the scope
of this study, and further research could be beneficial in exploring the interplay of creativity,
technical strength and motivation. Contrary to the hypothesis, in this situation fewer
constraints on the students’ creative processes did not result in lower measures of technical
strength, due to less emphasis and instructional time placed on developing technical skill with any single material.

Correlations among the items measured speak to more than just the results of classroom pedagogy. In the case of the CAT, for which instruments are adjusted depending on the specifics of the participants’ creative task, Amabile (1983) has discussed the importance of ensuring that raters are, in fact, rating creativity as a characteristic distinct from other qualities such as technical strength and aesthetic appeal. Therefore, in addition to looking at correlations among items rated as functions of pedagogical strategy, the following research question also surfaced as essential to the discussion of the validity of the CAT in this context: will discriminant validity be demonstrated with regard to the consensual assessment form’s separate measures of creativity, technical strength, and aesthetic appeal?

Discriminant validity for the measured dimensions of judgment could not be claimed for this consensual assessment instrument. Correlation coefficients for each pairing of the major three dimensions—creativity, aesthetic appeal, and technical strength—were consistently high. This suggested that, for example, ratings did not successfully distinguish between a project’s creativity and its aesthetic appeal because the scores were similar for both dimensions. There is also, however, the likelihood that a project displaying a high level of creativity also legitimately did display a high level of aesthetic appeal. Amabile (1983) describes it this way:

It appears that although it may be possible for some types of products to obtain creativity judgments that are clearly uncontaminated by assessments of liking, for
other types of products, creativity judgments may be more tightly bound up with assessments of aesthetic appeal. (p.58)

The sample size was too small to produce stable factor analysis results; however, two factors did seem to emerge as meaningful clusters (Amabile, 1983, p. 53). All dimensions that were classified as creativity dimensions (creativity, novel idea, novel use of materials, and complexity) emerged together as a factor apart from the eight others (overall aesthetic appeal, pleasing use of shape/form, pleasing use of color and/or value, liking, technical strength, overall organization, neatness, and effort evident).

**Reliability and Validity of the Consensual Assessment Technique**

Teachers’ schedules do not routinely allow for devoting large blocks of time to spreading dozens of projects around the room and bringing in rater after rater to conduct individual assessment sessions. However, the Consensual Assessment Technique offers benefits to classroom teachers as a viable, adaptable alternative to other types of assessments. Some teachers may be able to recruit knowledgeable adults from the community, such as parents, members of the school’s business alliance, and university students and faculty to serve as raters. Meetings of Professional Learning Communities (PLCs) could function as assessment sessions. More often, and for smaller projects, various combinations of students may serve as CAT raters. The use of the CAT for this study did provide beneficial insights into the value of self-evaluations, peer-evaluations, and judges’ evaluations of creative products, though not as anticipated. Higher correlations among the three rater types (self, peer and adult raters) were expected. Systematic bias was also expected to be seen, elevating
the students’ self-evaluation ratings. Self-evaluation ratings were also expected to correlate more highly with peer consensus ratings. For this study, students were not trained in self-evaluation and peer-evaluation beyond a brief introduction to the evaluation form on the day it was used. It is likely that with deliberate discussion, explanation and practice, students’ ratings would become more reliable and more useful to teachers. While calibration of rater “definitions” is discouraged for adult raters, student raters are not assumed to have expertise, and therefore strict adherence to the recommendations given for adult raters would not make sense. Further study of training students for CAT participation could prove beneficial.

The valuable observations that did emerge regarding the potential benefits of self and peer assessments were qualitative in nature and beyond the scope of this study, but they are fodder for future study. Students were generally quite engaged, and occasionally heated, in their peer consensus discussions. For the most part students stayed on task and were surprisingly thorough in their consideration of other students’ games. Many students were seen reading game instruction inserts and referring back to them for comment, testing games for functionality, thoughtfully critiquing their classmates’ designs and decision-making, as well as pulling game pieces out of the packaging a second and third time to justify their opinions. Although the resulting students’ scores were inconsistent with each other and with the adult raters, the assessment process for the game design project was a rich experience unto itself and should be studied further.

Seventy-two projects were rated for this study. A larger sample size would be desirable in further studies so that highly stable results regarding the consensual assessment form’s discriminant validity could be obtained through factor analysis. A larger sample
would also allow for meaningful objective measures to be taken and inferences drawn about variables such as students’ choices of game type and medium. Gender tendencies might also be of interest in similar future studies of larger samples, as prior studies have intermittently shown girls receiving significantly higher creativity scores than boys (Amabile, 1983; Hennessey, et al. in press).

The theoretical possibility existed of the differential selection threat to validity because the DEAL and choice-based groups were not exactly alike. The DEAL group comprised an eighth-grade painting class, a seventh-grade pottery and sculpture class, and a sixth-grade introductory visual art class. The choice-based group comprised an eighth grade pottery and sculpture class, a seventh grade visual composition class, and a sixth grade introductory visual art class. Some student groups were therefore more accustomed to particular media available in the classroom, as well as to an emphasis on working in two versus three dimensions. It is likely, for example, that more experienced painters would have achieved higher scores for the dimension of technical strength if their game design featured a painted game board. One student in the pottery and sculpture class, having developed her clay sculpture skills over the semester, used the project as an opportunity to make an entire ceramic chess set. Her class used the DEAL method. The idea of making a chess set was perhaps not especially novel or creative, but the craftsmanship was strong, particularly compared with students enrolled in other types of art classes and less experienced with clay. On the other hand, if raters were, as instructed, comparing the projects only to each other rather than to some absolute standard, then perhaps such a novel use of clay, based on the skills developed earlier in the specialized class—relative to other student projects—would
have resulted in a higher creativity score. The sample was not sufficiently large to test for the effects of those variables.

There was also a theoretical possibility of the resentful demoralization threat to validity (Rubin & Babbie, 2011) because some DEAL students were aware that other classes were not required to complete the DEAL handouts. To a middle school child, handouts viewed as extra can seem unfair. Similarly, the requirement of the DEAL handout might have functioned as a disruptor, resulting in an external threat to validity because such work, beyond the usual thumbnail sketches in students’ sketchbooks, was typically not required in art class.

The DEAL and Choice-Based Methods

Both the DEAL and choice-based methods offer potential for fostering students’ creativity through scaffolded instruction that guides and supports creative expression. For example, students with a variety of disabilities have been shown to thrive in more structured environments in which instructions are explicit. This can manifest itself in a variety of ways, from simply a higher rate of completion of assignments to the demonstration of more creative, innovative thinking. Some students, alternately, are turned off by the idea of doing creative work under strict process constraints. When gifted students are given a DEAL handout, they might see potential for greater clarity of goals and processes. They might also see a built-in map for the minimum effort required to obtain an “A” on the assignment.

Perhaps there is no best pedagogy for fostering creativity, but at its best this kind of research
can help teachers better serve individual students through differentiated instructional strategies.

A greater distinction between pedagogical strategies’ creative outcomes might have been seen had this study not taken place in the researcher’s own classroom. It is difficult to know in this situation how much of the prior classroom culture—most likely biasing the entire sample slightly toward the choice-based approach—was brought into the game art and design activity. On the other hand, any implementation hinging on students’ perceptions of openness brings with it control challenges, and other types of classroom settings could bring unexpected complications. Ideally, the treatment would be given to multiple groups with randomly assigned teachers administering it. Such a treatment would also deem any results more directly generalizable to the larger population.

Additional Limitations

A noteworthy limitation of this study was the number of computers available to students who might have preferred to create video games. A 14-unit laptop cart was kept in the classroom for the duration of the study, with 5 computers set up full-time. Computer lab time throughout the semester was limited, so there was not time to adequately teach the game design software to all students prior to the project. The video game design option was described on the design brief as follows:

Video games should be created in Game Maker, a free software that you can download at home. Because we have limited access to computers during class time, you would need to do most of the work on a video game outside of class.
Ms. Buelin can help, but this choice would mean a lot of independent work. No one is required to make a video game. It is simply one option.

Video game design required that students (a) feel and be computer literate enough to try the tutorial provided in class and to work somewhat independently; (b) take the initiative to try an unfamiliar and unrequired challenge; and (c) have access to either a computer and Internet access at home, and/or have reliable transportation to and from before- and after-school open studio sessions. It is likely that more students would have chosen the digital medium had they felt more confident in their abilities to fully realize their ideas. It is possible that raters’ perceptions of the video games were therefore biased because of the novelty of the relative few video games (n= 5) compared with board games, etc. (n= 67 for all others). This may be likely in part because of the instructions given to raters, “Please rate products relative to each other, rather than to some absolute standard.” Results for items such as creativity, novel idea, and complexity might have been skewed higher for video games since they comprised only 7% of the games. However, raters were also instructed to view all games before making any ratings. It is possible that the diversity of ideas and levels of quality among the video games became clear during the first phase of each rating session, as all games were initially surveyed.

Moving Forward with Fostering and Measuring Creativity in STEM Education

Since these findings add to a research base that continues to show creativity can reliably be assessed, technology teachers should not hesitate to include creativity as an explicit objective in classroom activities. A combination of self-evaluations, peer-evaluations and
teacher evaluations can be used toward the determination of creativity scores as appropriate in a wide range of classroom applications and disciplines. Members of teachers’ professional learning communities (PLC), in person and virtually, can potentially collaborate in adaptations of the consensual assessment technique (CAT).

One instance of change already in motion in North Carolina and some 16 other states is the alignment of education policy goals with those of the Partnership for 21st Century Skills (Route 21, 2007). To various degrees and depending on local policy, teachers are being held accountable for including creativity and innovation in their lessons, and some, though arguably not enough, professional development is being made available to teachers. Accountability is built into some school systems’ teacher evaluation instruments (NCDPI, 2009 & 2011). Because of the considerable resources being allocated to teachers’ participation in PLCs, and because teachers in smaller disciplines like technology are often isolated as the only members of their field on a given campus, further study should be conducted on the usefulness and reliability of the technique in virtual PLC scenarios. Additionally, the usefulness of the CAT should be investigated in summative portfolio assessment contexts in technology education, visual art education, and the emerging field of STEM (integrated science, technology, engineering and mathematics) education.

Limited research in component STEM fields has recently identified the importance of teaching using creative problem-solving techniques, as well as teaching students to independently do so. Kandemir and Gur (2007) explored attitudes and barriers affecting creativity in prospective mathematics teachers’ approaches to problem-solving. They found that negative attitudes toward the notion of teaching creativity, fixation issues, and closed
mindedness were all barriers for prospective mathematics teachers. They argued that divergent thinking capabilities and the development of positive attitudes toward teaching for creativity can be attained through appropriate teacher training. Based on prospective teachers’ remarks during and following training, they concluded that creativity training should begin in university mathematics education courses, and that practicing mathematics teachers must be granted time and incentives for the practice of, and reflection on, creativity in mathematics education.

Time might be the least available resource available to mathematics teachers in the United States, even if attitude and experience are not barriers to fostering creative thinking. Standardized math testing serves many functions, including the determination of students’ grade level promotion and college admission, as well as an indication of teachers’ job performance. However, mathematics courses governed by rigid daily pacing guides leave little to no flexibility for open-ended questioning. As mathematics curricula evolve to meet the demands of 21st century learning, the Consensual Assessment Technique could provide a valuable means of traversing unfamiliar ground in more creative mathematics classrooms.

A different set of problems was addressed by Milne (2010), who identified major challenges to science education including the very low status of science in a crowded curriculum, as well as students’ lack of interest in science. He proposed Creative Exploration, an inquiry based model for primary science education. Milne explained the premise of the model:

Children naturally seek explanations for experiences that have some effect on their feelings, attitudes, and the manner in which they think about, or view natural
phenomena. Children will often construct creative explanations when seeking to understand and explain the phenomena involved in their aesthetic experiences [. . . which] can lead to the development of a sense of fascination that, in turn leads to a greater degree of engagement in the learning process [. . . and] a greater depth of understanding. (p. 111)

Children’s unique, personal creative explanations of natural phenomena, and their subsequent use of scientific inquiry, are at the heart of Milne’s model. Such creative exploration and individualized instruction are time consuming, however, and reports have noted a decline in instructional time spent on science, often due to efforts at improving standardized test scores in math and language arts. Integrated STEM units of study offer promise in efficiently covering content from multiple disciplines as well as fostering students’ creativity. The CAT, for its flexibility and its reliability, could prove a useful tool for groups of teachers working collaboratively to develop, implement and assess integrated STEM units of study.

A pilot project at the University of Georgia in 2009 (Constantino, Kellam, Cramond, & Crowder, 2010) paired art education graduate students and second-year undergraduate engineering students in an effort to investigate the following questions:

How may creative thinking and problem-solving skills used in addressing environmental engineering problems affect visual art students’ learning experiences?

Likewise, how may the cognitive capacity of artistic, creative thinking inform development of creative problem finding and solving in environmental engineering, which is increasingly called upon to devise mechanisms for complex human and environmental systems? (p. 49)
The art students taught a series of lessons to the engineering students on observation in diverse contexts, multiple perspectives and the use of metaphor, and synthesis (p. 51). Collaboration with the engineering students was reported to have given the art education students opportunities for practical application of content from their art and cognition course, such as applying creative thinking, metaphoric thinking, and imagination (p. 51). The students worked together to create visual metaphors of food sustainability, and the engineering students developed design plans for an open-ended design problem related to sustainability and food within the local community. Similarly, engineering students reported benefits from working on their creativity with the art students. One said, “I never once thought that art and engineering would go hand in hand . . . but seeing the problem in a different light led to multiple solutions, whereas, without this perspective there may have only been one solution or no solutions” (p. 52).

This collaboration is an example of the kind of integration that has been called for by the Partnership for 21st Century Skills (2004), by economists, and by education reformers. Creativity was an explicit objective and more creative thinking, by all counts, was achieved. Juried assessments are common in art and design courses, and that process shares commonalities with the underlying theory of the Consensual Assessment Technique. It stands to reason that K-12 teachers of science, mathematics, pre-engineering and technology who wish to make creativity an explicit goal that can be reliably assessed stand to gain from adapting the CAT to their unique needs.

An integrated approach to engagement and achievement through STEM education could potentially address some of the issues of time constraints and lack of student
engagement. Science, technology, engineering and mathematics have all been shown to be fertile ground for fostering students’ creative thinking.

**Conclusion**

This study builds upon past work by Amabile (1983), Hennessey, et al. (in press), Hickey (2001), and others in confirming that (a) creativity can be recognized by raters who are knowledgeable in a domain, and (b) that it can be reliably assessed in the classroom. Inter-rater reliability among the seven adult raters was consistently high for all 12 items of judgment measured in this study. Strong correlations between technical strength and creativity scores support a more student-driven, choice-based classroom environment in which students are not required to work at the same pace on a teacher-directed assignment. A number of factors were discussed which could prove useful in future instructional design.

These findings are important to discussions of how curricula and assessment methods might evolve in technology education and in STEM education. Further study is needed to develop practical classroom projects and assessments for technology students and teachers that will spur students toward meeting their creative potential. Parallels were drawn between the challenges involved in promoting creativity and the challenges of creating integrated STEM units of study. It is likely that these challenges can successfully be addressed simultaneously. Although neither of the two strategies for fostering creativity emerged as a “best way” to foster creativity in the classroom, creativity was shown to be a successful student outcome of the game art and design project, and the Consensual Assessment Technique shows promise as a method for measuring creativity in technology education laboratory activities as well as the integrated STEM learning environment.
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Norwood, NJ: Ablex


APPENDICES
APPENDIX A

RATER BACKGROUND SURVEY
Expert Rater Background Survey

1. What is your age?

2. In what capacity do you have the most professional experience?
   a. educator
   b. designer
   c. engineer
   d. artist
   e. none of these

3. Have you ever taught middle school or high school courses that emphasize creative problem solving methods?

3. If so, for how many years?

4. Have you ever taught middle school or high school courses that emphasize the use of a specific design process?

5. If so, for how many years?
APPENDIX B

CONSENT FORMS
A Comparison of Pedagogical Strategies for Fostering Creative Problem Solving

Informed Consent Form for Expert Raters

Jennifer Buelin  Faculty Sponsor: Dr. Eric Wiebe

You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

What is the purpose of this study?
The purpose of this study is to compare the creative outcomes in student work resulting from two different instructional approaches to creative problem solving activities.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to evaluate design/problem-solving projects on dimensions such as creativity, aesthetic value, and technical strength. You will be asked to record your responses on a Likert-type survey.

Approximately sixty student projects will be rated. Each project will likely take 2-4 minutes to assess. The rating session is expected to take approximately 2 ½ to 4 hours. You will be compensated with a $25 gift card for your participation.

Risks
There are no expected risks or discomforts associated with your participation in this study.

Benefits
The results of this research should help educators to identify successful methods for fostering greater creativity in problem solving activities.
Confidentiality
The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely on the researcher’s password protected computer until the conclusion of the study, at which point it will be destroyed (deleted). No reference will be made in oral or written reports which could link you to the study.

Compensation
For participating in this study you will receive a $25 gift card.

What if you are a NCSU student?
Participation in this study is not a course requirement and your participation or lack thereof, will not affect your class standing or grades at NC State.

What if you are a NCSU employee?
Participation in this study is not a requirement of your employment at NCSU, and your participation or lack thereof, will not affect your job.

What if you have questions about this study?
If you have questions at any time about the study or the procedures, you may contact the researcher, Jennifer Buelin, at jkbuelin@ncsu.edu, or 919-824-5850. Alternately, you can also contact the researcher’s faculty sponsor, Eric Wiebe, at eric_wiebe@ncsu.edu.

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator, Box 7514, NCSU Campus (919/515-4514).

Consent To Participate
“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose not to participate or to stop participating at any time without penalty or loss of benefits to which I am otherwise entitled.”

Subject’s signature ___________________________________________ Date ________________
Investigator’s signature __________________________________________
Student Release Form
(to be completed by the parent(s)/legal guardian(s)
of minor students involved in this project)

Dear Parent/Guardian:

I am completing a research study to fulfill the requirements for my Ed.D. (Doctor of Education) at North Carolina State University. My dissertation research is in finding ways that teachers can help students to produce more creative work.

Your child's Game Art and Design project has been completed, and grades have been entered. At this time I would like to borrow the games for approximately 1-2 weeks so they can be assessed by outside design teachers and professionals. Your child’s name will be removed and replaced by a code number, so all ratings will be anonymous. Games will be returned to students immediately after ratings are complete.

The back of this form contains further information about the study. If you are willing to allow me to use your child's work for this research, please indicate your permission by signing at the bottom of the form and having your child return it to me as soon as possible. If you have any questions I am happy to speak further with you about the study now or later, after the data has been analyzed.

Sincerely,

Jennifer Buelin
jbuelin@wcpss.net
North Carolina State University
INFORMED CONSENT FORM for RESEARCH

A Comparison of Pedagogical Strategies for Fostering Creative Problem Solving

Jennifer Buelin NCSU Faculty Sponsor: Dr. Eric Wiebe

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

What is the purpose of this study?
The purpose of this research is to learn about how teachers can help students to produce more creative work. This study will compare the creative outcomes in student work resulting from two classroom approaches to creative problem solving activities.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to allow Jennifer Buelin to borrow your Game Art & Design project for approximately two weeks. Other design teachers and professionals will rate the projects in a way very similar to the evaluations that are done during class critiques. Ratings will be anonymous: your name will not be on the project. At the conclusion of the rating sessions, your project will be returned to you.

Risks
There are no expected risks or discomforts associated with your participation in this study.

Benefits
The results of this research should help teachers to identify successful methods for fostering greater creativity in problem solving activities.

Confidentiality
The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely on the researcher’s password protected computer until the conclusion of the study, at which point it will be destroyed (deleted). No reference will be made in oral or written reports that could link you to the study. Your name will be removed from any study materials prior to their being removed from the classroom so that no one can match your identity to your work.

Compensation
You will not receive anything for participating.
Participation in this study is not a course requirement. Your participation or lack thereof will not affect your class standing or grades in art class.

What if you have questions about this study?
If you have questions at any time about the study or the procedures, you may contact the researcher, Jennifer Buelin, at jbuelin@wcpss.net.

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator, Box 7514, NCSU Campus (919/515-4514).

Consent To Participate
“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose not to participate or to stop participating at any time without penalty or loss of benefits to which I am otherwise entitled.”

Student Name________________________________________________ Date _________________
Parent/Legal Guardian Signature ____________________________
Investigator's signature________________________________________
APPENDIX C

DESIGN BRIEF: CHOICE-BASED METHOD
Game Art and Design Project

During the month of May you will design and make an original game.

You will first spend some time learning about games and playing a few games. You'll pay special attention to the basic parts of a game, what most games have in common, and what makes games fun to play.

You may work with a partner, or you may work alone.

Your game may be a card game, a board game, a video game*, or another type of game if you first clear it with Ms. Buelin.

*Video games should be created in Game Maker, a free software that you can download at home. Because we have limited access to computers during class time, you would need to do most of the work on a video game outside of class. Ms. Buelin can help, but this choice would mean a lot of independent work. No one is required to make a video game. It is simply one option.

1. Some game elements to consider:
   - Players: How many? What age range? Do players have special roles?
   - Objectives: What's the game's objective?
   - Procedures: What are the required actions for play?
   - Rules: Any limits on player actions? Rules about behavior?
   - Conflict: What causes conflict in the game?
   - Boundaries: What sorts of boundaries are in the game?
   - Outcome: What are the potential outcomes of the game (both good and bad)?
Challenge: What makes the game challenging?

Play: Is it fun to play?

Story: What is the game's story?

Character: Does the game have characters?

Title: What will you name the game?

2. What you need to do:

✓ Play each of the following types of games: card, board, video. Think about the kind of game you want to make.

✓ On a blank sheet of paper in your sketchbook, develop your game idea by answering the following questions:

  o My game is (title), a (card/board/video/other) game.
  o The competition is:
  o It's fun because:
  o Obstacles include:
  o The story of the game is:
  o Write out clear game directions.
  o Draw ALL the objects before you make them.

✓ Make your game. Use good craftsmanship skills (like cutting clean edges, drawing and painting neatly, etc.), be creative and original, and make your game aesthetically appealing (remember... this is an ART/DESIGN project). If you think of materials you need but haven't seen in the art room before, ask Ms. Buelin. It's possible we have what you need or can get it for you.

✓ Play your game before turning it in for the critique. Ask other people to proofread the directions to make sure they are understandable. Ask friends or family members to use the directions and play the game. This will help catch problems or things you forgot to include in the directions.
APPENDIX D

DESIGN BRIEF: DEAL METHOD
Game Art and Design Project

During the month of May you will design and make an original game.

You will first spend some time learning about games and playing a few games. You’ll pay special attention to the basic parts of a game, what most games have in common, and what makes games fun to play.

You may work with a partner, or you may work alone.

You will use a problem-solving strategy, the DEAL method, to help with your design and problem-solving process.

Your game may be a card game, a board game, a video game*, or another type of game if you first clear it with Ms. Buelin.

*Video games should be created in Game Maker, a free software that you can download at home. Because we have limited access to computers during class time, you would need to do most of the work on a video game outside of class. Ms. Buelin can help, but this choice would mean a lot of independent work. No one is required to make a video game. It is simply one option.

1. Some game elements to consider:
   
   Players: How many? What age range? Do players have special roles?

   Objectives: What’s the game’s objective?

   Procedures: What are the required actions for play?

   Rules: Any limits on player actions? Rules about behavior?

   Conflict: What causes conflict in the game?

   Boundaries: What sorts of boundaries are in the game?
Outcome: What are the potential outcomes of the game (both good and bad)?

Challenge: What makes the game challenging?

Play: Is it fun to play?

Story: What is the game's story?

Character: Does the game have characters?

Title: What will you name the game?
APPENDIX E

DEAL HANDOUTS
DEAL Problem Solving

1. Define at least three different goals for your problem-solving task.

   Goal 1:
   
   Goal 2:
   
   Goal 3:

2. Explore possible strategies and new information that could help you accomplish each of the important goals listed above.

   Strategies and information to accomplish Goal 1:
   
   Strategies and information to accomplish Goal 2:
   
   Strategies and information to accomplish Goal 3:
Strategies and information to accomplish Goal 2:


Strategies and information to accomplish Goal 3:


3. **Anticipate the outcomes of different strategies to help you decide which ones you will act on.**

   Strategy: 

<table>
<thead>
<tr>
<th>Possible Positive Outcomes</th>
<th>Possible Negative Outcomes</th>
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<tbody>
<tr>
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   Sketches; additional notes:

   Strategy: 

<table>
<thead>
<tr>
<th>Possible Positive Outcomes</th>
<th>Possible Negative Outcomes</th>
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   Sketches; additional notes:
<table>
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<tr>
<th>Possible Positive Outcomes</th>
<th>Possible Negative Outcomes</th>
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</table>

**Sketches: additional notes:**

4. **Look back and learn.**

- After acting on your strategies, what did you notice about the problem you identified?

- After acting on your strategies, what did you notice about the goals you defined?

- After acting on your strategies, what did you notice about the strategies you explored?

- After acting on your strategies, what did you notice about your ability to anticipate their effects?
Project Checklist

✓ Play each of the following types of games: card, board, video. Think about the kind of game you want to make.

✓ On a blank page in your sketchbook, answer the following questions:

  - My game is (title), a (card/board/video/other) game.
  - The competition is:
  - It's fun because:
  - Obstacles include:
  - The story of the game is:
  - Write out clear game directions.
  - Draw ALL the objects before you make them.

✓ Make your game. Use good craftsmanship skills (like cutting clean edges, drawing and painting neatly, etc.), be creative and original, and make your game aesthetically appealing (remember . . . this is an ART/DESIGN project!). If you think of materials you need but haven’t seen in the art room before, ask Ms. Buelin. It’s possible we have what you need or can get it for you.

✓ Play your game before turning it in for the critique. Ask other people to proofread these directions to make sure they are understandable. Ask friends or family members to use the directions and play the game. This will help catch problems or things you forgot to include in the directions.
APPENDIX F

SELF/PEER EVALUATION FORM
Self/Peer Evaluation

<table>
<thead>
<tr>
<th>RATE YOUR OWN WORK</th>
<th>low</th>
<th>high</th>
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<tbody>
<tr>
<td>Creativity [using your own subjective definition of creativity, the degree to which the design is creative]</td>
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<tr>
<td>2 Overall aesthetic appeal [In general, the degree to which the design is aesthetically appealing]</td>
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<tr>
<td>3 Technical strength [The degree to which the work is good technically]</td>
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</tbody>
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<tr>
<th>GROUP CONSENSUS</th>
<th>low</th>
<th>high</th>
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<tr>
<td>1 Creativity [using your own subjective definition of creativity, the degree to which the design is creative]</td>
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<tr>
<td>2 Overall aesthetic appeal [In general, the degree to which the design is aesthetically appealing]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Technical strength [The degree to which the work is good technically]</td>
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Project ID # __________________________

Student Name __________________________
APPENDIX G

CONSENSUAL ASSESSMENT FORMS
### Convivial Assessment Form (Form A)

*Please view all products before making any ratings.*

*Please rate products relative to each other, rather than to some absolute standard.*

<table>
<thead>
<tr>
<th></th>
<th>Creativity</th>
<th>Novel use of materials</th>
<th>Novel idea</th>
<th>Complexity</th>
<th>Overall aesthetic appeal</th>
<th>Pleasing use of shape/form</th>
<th>Pleasing use of color and/or value</th>
<th>Liking</th>
<th>Technical strength</th>
<th>Overall organization</th>
<th>Neatness</th>
<th>Effort evident</th>
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</table>
Consensual Assessment Form (Form B)

*Please view all products before making any ratings.
*Please rate products relative to each other, rather than to some absolute standard.

<table>
<thead>
<tr>
<th></th>
<th>Technical strength [The degree to which the work is good technically.]</th>
<th>lower</th>
<th>higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Overall organization [The degree to which the work shows good organization.]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Neatness [The amount of neatness shown in the work.]</td>
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</tr>
<tr>
<td>4</td>
<td>Effort evident [The amount of effort that is evident in the product.]</td>
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<tr>
<td>5</td>
<td>Overall aesthetic appeal [In general, the degree to which the design is aesthetically appealing.]</td>
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<tr>
<td>6</td>
<td>Pleasing use of shape/form [The degree to which there is a pleasing use of shape/form in the design.]</td>
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<tr>
<td>7</td>
<td>Pleasing use of color and/or value [The degree to which the design shows a pleasing use of color and/or value.]</td>
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<tr>
<td>8</td>
<td>Liking [Your own subjective reaction to the design; the degree to which you like it.]</td>
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<tr>
<td>9</td>
<td>Creativity [Using your own subjective definition of creativity, the degree to which the design is creative.]</td>
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<tr>
<td>10</td>
<td>Novel use of materials [Degree to which the artist's use of materials is unique and interesting.]</td>
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<tr>
<td>11</td>
<td>Novel idea [Degree to which the design explores a unique and interesting idea.]</td>
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</tr>
<tr>
<td>12</td>
<td>Complexity [The level of complexity of the design.]</td>
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