A COMPARISON OF STUDENTS' PRODUCT CREATIVITY USING A COMPUTER SIMULATION ACTIVITY VERSUS A HANDS-ON ACTIVITY IN TECHNOLOGY EDUCATION

Kurt Y. Michael

Dissertation submitted to the faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY
in
Curriculum and Instruction

E. Allen Bame, Chair
Jane L. Abraham
Sharon A. Brusic
Richard F. Hirsh
James E. LaPorte

May 10, 2000
Blacksburg, Virginia

Keywords: Creativity, Creative Product, Computer Simulation, Technology Education

Copyright 2000, Kurt Y. Michael

Comparison of Students' Product Creativity Using a Computer Simulation Activity versus a Hands-on Activity in Technology Education

Kurt Y. Michael

(ABSTRACT)

The purpose of this study was to compare the effect of a computer simulation activity versus a hands-on activity on students' product creativity, originality, and usefulness. Fifty-eight middle school technology education students from Northern Virginia participated in the study. Subjects were randomly assigned to either a computer simulation or hands-on treatment group. The computer simulation group used a Lego-type brick simulator to construct creative products on the computer; whereas, the hands-on treatment group used real LEGO® bricks to construct their creative products. The hands-on groups' products were collected by the researcher and copied into the computer simulation program. Both groups' products were printed using a color printer. The printed products were evaluated by expert judges using a creative product semantic differential scale.

This study showed that there was no significant difference in product creativity scores among the computer simulation and the hands-on treatment group. The null hypothesis was accepted. Findings suggested that it was possible to use a computer simulation activity in place of a hands-on activity and still maintain product creativity, originality, and usefulness.

DEDICATION

This dissertation is dedicated to my family who have given me continuous support in this endeavor. To my wife Pam, and my daughter Julia, whom I am forever grateful for their love, patience, and sacrifice. And to my mother who has instilled in me the importance of an education and the determination to pursue my goals. To my Aunt, Dr. Ruth Simpkins, whose encouragement and support has made this process possible. To each of you, I offer my love and deepest gratitude.

ACKNOWLEDGEMENTS

I thank my committee chair, Dr. Allen Bame, for patiently listening and offering valuable advice throughout the dissertation process. To my research advisor, Dr. Jane Abraham, for her guidance, wisdom and encouragement during this study; for keeping me focused while navigating through numerous obstacles, and for her optimistic attitude. I owe special thanks to Dr. Sharon Brusic, Dr. Richard Hirsh and Dr. Jim LaPorte who have all graciously served as committee members, and each of whom have offered valuable insight to this study.

I thank Dr. Marvin Lentner from the University's Statistical Consulting Center for his consultations and Dr. Gabriella Belli for her assistance while I was taking courses at Virginia Tech's Northern Virginia Center. I also wish to thank Pam Michael for serving as an invaluable proof reader and Gary Foveaux, County Coordinator for Industrial Technology Education, for sponsoring the study.

Finally, I would like to give special thanks to the following faculty and staff members who participated in this study. Without their help this study would not be possible:

Mike Cichocki	Gary McCoy	Kent Schweitzer	Audra Sydnor
Dave Freeland	Ann Monday	Keith Sheriden	Jon Utin
Janice Loyde	Carl Pauli	Steve Snyder	Lee Worley

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

Introduction

> Technology is in essence a manifestation of human creativity. Thus, an important way in which students can come to understand it would be by engaging in acts of technological creation. Technology as a context for creativity is an important area of research (Lewis, 1999, p. 46).

Background

At present, most educational systems do little to foster creative thinking. Instead, schools are more concerned with preparing students to memorize facts and learn procedures (DeVore, 1980; Gallini, 1983; Henderson & Minner, 1991). In order to prepare students for a technological society, schools must engage in methods that will nurture creative thinking. Olson (1974), a highly respected leader in the field of technology education, stated: "If the school has a responsibility for reconstruction of society, its main thrust must be to teach students to think, especially to think creatively" (p. 35).

Technology education has often been interested with the development of the student's creativity. Most recently, the *Technology for All Americans Project* identified creativity as a characteristic of a technologically literate person (International Technology Education Association, 1996). In trying to promote the creative aspect of technological literacy, technology educators may want to consider the use of computer simulations.

Computer simulations are becoming a popular method of instruction for many technology educators. This may be due to the increase of commercially available software that can be purchased directly and cheaply from local retail stores and catalogs. Many commercially developed simulation programs are based on scientific and technological models that replicate natural phenomena. These software programs are allowing students to learn about events, processes, and activities that otherwise may not be available to them (Bilan, 1992). Some researchers speculate that computer simulation technology may have a positive effect on creativity (e.g., Betz, 1996; Gokhale, 1996; Harkow, 1996). However, these researchers offer no empirical evidence to support their claim.

Thus, as simulators become increasingly popular in the classroom, technology educators must examine the effectiveness of such technology. Due to a lack of empirical evidence related to the effectiveness of simulation technology on creativity, especially in relationship to creative products, research pertaining to this topic is needed.

Purpose of Study

The purpose of this study was to compare the effect of a computer simulation activity versus a hands-on activity on students' product creativity.

Significance of the Problem

As discussed previously, computer simulators are becoming increasingly popular in classrooms. This study was conceived in order to investigate the effectiveness of a computer simulation activity versus a hands-on activity on enhancing the creative products produced by middle school technology education students. This study is significant for the following three reasons.

First, there is a lack of literature related to the nurturing and development of creativity in technology education. In an issue of *The Journal of Technology Education*, Lewis (1999) asked two important questions, "What tends to inhibit or enhance problem solving and creativity? What do we know about those children who are successful in producing creative products?" (p. 47). This study is significant in that it will help answer questions pertaining to instructional methods used in the technology classroom and their effectiveness in helping students improve the creativeness of their products.

Second, this study will continue the work of Moss (1966) in establishing a theoretical model for evaluating the creative products of industrial arts and/or technology education students. Moss (1966) concluded that unusualness (or originality) and usefulness are the defining characteristics of the creative product. This study is significant in that it will further establish a theoretical model for evaluating the creative products of technology education students.

Third, after an extensive review of literature, no significant studies related to the effects of computer simulation on creativity as measured by the creative product were found. Despite the lack of evidence, it is believed that computer simulators may aid in enhancing student creativity. This study is significant in that it will add to a limited body of knowledge related to the effects of simulation technology on enhancing the creative product.

By exploring the above issues, technology educators may better assist students in reaching their creative potential. In doing so, students may better meet the demands of a technological society.

Hypotheses

It was hypothesized that the use of a computer simulator would improve the *creativity* of students' products versus those products produced by students during a traditional hands-on instructional activity.

It was hypothesized that the use of a computer simulator would improve the *originality* of students' products versus those products produced by students during a traditional hands-on instructional activity.

Finally, the use of a computer simulator would improve the *usefulness* of students' products versus those products produced by students during a traditional hands-on instructional activity.

Assumptions

This study was based on the following assumptions:

1. The students used in this study were representative of seventh grade technology education students in Northern Virginia.

2. The participating teachers in this study followed the procedure as laid out in this experiment.

3. Uncontrollable variables (i.e., socioeconomic status, intelligence, creativity, and computer literacy) were equally distributed across all groups and had equal effect on treatment group scores.

Limitations

This study was conducted in view of the following limitations:

1. The result of this study should not be generalized beyond the geographical area of Northern Virginia.

2. The computer simulator's virtual environment does not realistically replicate earth's gravity. The software allows bricks to be suspended in space and unbalanced structures do not fall over.

CHAPTER II

Review of Literature

Introduction

Our technological society is surrounded by products that artisans, inventors, engineers, and scientists create. The American Association for the Advancement of Science (1989) stated in the *Project 2061 Panel Report* that, "Technology is best described as a process, but is most commonly known by its products and their effects on society" (p. 1). The product is a physical object, article, patent, theoretical system, an equation or new technique (Brogden & Sprecher, 1964). The product is the material result of the creative process and embodies the very essence of technology.

When teaching about technology, technology educators often have their students engage in the process of product creation rather than just studying about existing products. This approach to studying technology requires a high degree of creativity. Olson (1973), in recognizing the importance of allowing students to create new products, stated:

> Technology was born of creativity.... The creative imagination is the highest level of the intellect.... Emphasis on intellectual development, to think creatively, is the great imperative of industrial arts [technology education]. It draws out the individuality, discovers idiosyncrasy, establishes identity, and demonstrates potential, all essential to realization of self.... Designing with materials, tools, machines, energies, ideas is the way of technology and the way for industrial arts [technology education]. (p. 22)

By using materials, tools, and machines to create products, students engage in the creative act and learn to experience technology first-hand. However, computer simulators are slowly replacing traditional methods of teaching technology. For example, the LEGO® company's educational division introduced a computer simulator called *LegoCAD* to supplement its traditional hands-on *Lego Technic* physical science series. Yet, there is no empirical evidence on what effects these computer-simulated activities have on the production of creative products as compared to hands-on activities. It is for this reason that technology educators must examine the use of computer simulators in the classroom. This investigation begins by reviewing the literature on creativity theory and exploring research related to computers and product creativity.

Creativity Theory

The literature on creativity may be divided into three major categories: the creative person, the creative process, and the creative product. Investigating these three areas will help educators gain a deeper understanding of creativity in general.

The Creative Person

As stated earlier, the development of technology is dependent upon creative processes, the results of which are new products. For this reason, inventors such as Edison and Ford are recognized as being highly creative. Why some people reach a level of creative genius while others do not is still unknown. Psychologist Abraham Maslow (1962), after studying several of his subjects, determined that all people are creative, not in the sense of creating great works, but rather, creative in a universal sense that attributes a portion of creative talent to every person.

Most educators do not expect students to produce new products characteristic of creative genius. It is sufficient if the work is appropriate to the task at hand and original within the student's ability (Dodge, 1991). In trying to understand and predict a person's creative ability, two factors have often been considered: intelligence and personality.

Intelligence. A frequently asked question among educators is “What is the relationship between creativity and intelligence?” Research has shown that there is no direct correlation between creativity and intelligence quotient (I.Q.) (Edmunds; 1990, Hayes, 1990; Moss, 1966; Torrance, 1963). Edmunds (1990) conducted a study determining whether there was a relationship between creativity and I.Q. Two hundred and eighty-one randomly selected students, grades eight to eleven, from three different schools in New Brunswick, Canada participated in the study. The instruments used to collect data were the *Torrance Test of Creative Thinking* and the *Otis-Lennon School Ability Test*, which was used to test intellectual ability. Based on a Pearson product moment analysis, results showed that I.Q. scores did not significantly correlate with creativity scores. The findings were consistent with the literature dealing with creativity and intelligence.

On a practical level, findings similar to the one above may explain why I.Q. measures have proven to be unsuccessful in predicting creative performance. Creative performance may be better predicted by isolating and investigating personality traits (Hayes, 1990).

Personality Traits. Researchers have shown that there are certain personality traits associated with creative people (e.g., Hayes, 1990; Runco, Nemiro, & Walberg, 1998; Stein, 1974). One such list of traits was comprised by technology educators DeVore, Horton, and Lawson (1989) and is summarized below:

Creative people have:

1. The ability to change undesirable habits into desirable ones
2. A positive curiosity of the unknown
3. A positive attitude towards new experiences
4. The ability to take negative criticism and turn it into constructive action
5. The ability to take risks fully knowing that his or her ideas may be attacked by others
6. A good sense of humor
7. The ability to make complex relationships between unrelated items
8. The motivation to solve problems on their own
9. High self-esteem and self-confidence in their abilities
10. The ability to focus their full attention on a particular problem for an appropriate length of time

The above list is only a guide to help identify a person's creative potential. Because all people are creative (Maslow, 1962), it is reasonable to expect that each possess some measure of these characteristics. Nevertheless, highly creative people tend to exhibit more of these traits and to a greater degree of intensity (Stein, 1974).

More recently, Runco, Nemiro, and Walberg (1998) conducted a survey investigating personality traits associated with the creative person. The survey was mailed to 400 individuals who had submitted papers and/or published articles related to creativity. The researchers asked participants to rate, in order of importance, various traits that they believed affected creative achievement. The survey contained 16 creative achievement clusters consisting of 141 items. One hundred and forty-three surveys were returned reflecting a 35.8% response rate. Results demonstrated that intrinsic motivation, problem finding, and questioning skills were considered the most important traits in predicting and identifying creative achievement. Though personality traits play an important part in understanding creative ability, an equally important area of creativity theory lies in the identification of the creative process itself.

The Creative Process

Creativity is a process (Hayes, 1990; Stein, 1974; Taylor, 1959; Torrance, 1963) that has been represented using various models. Graham Wallas (1926) offered one of the earliest explanations of the creative process. His model consisted of four stages that are briefly described below:

1. Preparation: This is the first stage in which an individual identifies then investigates a problem from many different angles.

2. Incubation: At this stage the individual stops all conscious work related to the problem.

3. Illumination: This stage is characterized by a sudden or immediate solution to the problem.

4. Verification: This is the last stage at which time the solution is tested.

Wallas' model has served as a foundation upon which other models have been built. However, some researchers have added the communication stage to the creative process (e.g. Stein, 1974; Taylor, 1959; Torrance, 1966). The communication stage is the final stage of the creative process. At this stage, the new idea confined to one's mind is transformed into a verbal or non-verbal product. The product is then shared within a social context in order that others may react to and possibly accept or reject it. A more comprehensive description of the creative process is captured within a definition offered by Torrance (1966):

> Creativity is a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficult; searching for solutions, making guesses or formulating hypotheses about the deficiencies, testing and re-testing these hypotheses and possibly modifying and re-testing them, and finally communicating the results. (p. 8)

Torrance's definition resembles what some have referred to as problem solving. For example, technology educators Savage and Sterry (1990), generalizing from the work of several scholars, identified six steps to the problem-solving process:

> 1. Defining the problem: Analyzing, gathering information, and establishing limitations that will isolate and identify the need or opportunity.
>
> 2. Developing alternative solutions: Using principles, ideation, and brainstorming to develop alternate ways to meet the opportunity or solve the problem.

3. Selecting a solution: Selecting the most plausible solution by identifying, modifying, and/or combining ideas from the group of possible solutions.

4. Implementing and evaluating the solution: Modeling, operating, and assessing the effectiveness of the selected solution.

5. Redesigning the solution: Incorporating improvements into the design of the solution that address needs identified during the evaluation phase.

6. Interpreting the solution: Synthesizing and communicating the characteristics and operating parameters of the solution. (p. 15)

By closely comparing Torrance's (1966) definition of creativity with that of Savage and Sterry's (1990) problem solving process, one can easily see similarities between the descriptions. Guilford (1976), a leading expert in the study of creativity, made a similar comparison between steps of the creative process offered by Graham Wallas with those of the problem solving process proposed by the educational philosopher John Dewey. In doing so, Guilford simply concluded that, "Problem-solving is creative; there is no other kind" (p.98). Nevertheless, Stein (1973) would argue that creativity is more than problem solving and points out that creativity is different from problem-solving in that creativity involves a mystical phenomenon. This phenomenon is characterized by inspiration, intuition, and aesthetic feeling that is evoked by the "Eureka" or "Aha" experiences. He maintains that creativity is dependent more on the emotional and irrational, whereas problem solving is best seen as depending more on intellectual processes.

Hinton (1968) combined the creative process and problem solving process into what is now known as creative problem-solving. He believed that creativity would be better understood if placed within a problem solving structure. Creative problem solving is a subset of problem-solving based on the assumption that not all problems require a creative solution. He surmised that when a problem is solved with a learned response, then no creativity has been expressed. However, when a simple problem is solved with an insightful response, then a small measure of creativity has been expressed, when a complex problem is solved with a novel solution, then genuine creativity has occurred.

Genuine creativity is the result of the creative process that manifests itself into a creative product. Understanding the creative process plays an important role in enhancing the production of creative products produced within the technology classroom.

The Creative Product

As discussed earlier, technology is a process most commonly known by its products (American Association for the Advancement of Science, 1989). The product may be a physical object, article, patent, theoretical system, equation or new technique (Brogden & Specher, 1964). Historically, technology educators have chosen the creation of products or projects as a means to teach technological concepts (Knoll, 1997). Olson (1973), in describing the important role projects play in the technology classroom, remarks:

> The project represents human creative achievement with materials and ideas and results in an experience of self-fulfillment. The continuing student input causes immediate, real, and meaningful feedback enabling him [or her] to assess his [or her] achievement at any one time or point in the project. (p. 21)

A student's project is nothing less than a creative product. Besemer and O'Quin (1993) believe that the creative product is unique in that it combines both the creative person and process into a tangible object representing the "true" measure of a person's creative ability. For example, Leonardo da Vinci is deemed creative because of his products, and not due to the results of clinical observations or a battery of psychological tests. Yet, researchers still cannot agree on what creativity truly is nor what attributes make up the creative product (Besemer & Treffinger, 1981; Joram, Woodruff, Bryson, & Lindsay, 1992; Stein, 1974). It is for the above reason that researchers have developed various theories used to help identify criteria for evaluating the creative product.

Criteria for evaluating the creative product. Most research on creativity has focused on the creative person and process, not the creative product. This lack of interest in the product has resulted in little progress toward defining attributes of the creative product. To date the most extensive review of literature establishing criteria for evaluating the creative product was conducted by Besemer and Treffinger (1981). In a review of more than 90 substantial literary sources, the researchers investigated over 125 specific criteria used for evaluating creativity. After distinguishing similarities among these attributes with respect to the names and definitions, the researchers grouped the criteria into 14 general categories or sub-scales that were placed under three general dimensions. The researchers' work resulted in the establishment of the *Creative Product Analysis Matrix* or *CPAM* (Besemer & Treffinger, 1981), a theoretical model by which the creative product could be identified and measured. Below is a summary of the model's three general dimensions and sub-categories:

1. The Novelty Dimension: This dimension defines the extent of newness a product possesses in terms of the number of new processes, new techniques, new materials, and new concepts. It also includes the influence the product has on future creative products. Associated with this dimension are the following sub-categories and their definitions:

a. Germinal: The product is likely to suggest additional future creative products.

b. Original: The product is unusual or infrequently seen in a universe of products made by people with similar experience and training.

c. Transformational: The product is so revolutionary that it forces a shift in the way that reality is perceived by users, listeners or viewers. (p. 164)

2. The Resolution Dimension: This dimension defines the degree to which the product fits or meets the needs of the problematic situation. Associated with this dimension are the following sub-categories and their definitions:

a. Adequate: The product answers enough of the needs of the problematic situation.

b. Appropriate: The solution fits or applies to the problematic situation.

c. Logical: The product or solution follows accepted and understood rules for the discipline.

d. Useful: The product has a clear and practical application.

e. Valuable: The product is judged worthy by users, listeners, or viewers because it fills a financial, physical, social or psychological need. (p. 164)

3. Elaboration & Synthesis Dimension: This dimension defines the degree to which the product combines unlike elements into a refined, developed, coherent whole, statement or unit. Associated with this dimension are the following sub-categories and their definitions:

a. Attractive: The product commands the attention of viewer, listener or user.

b. Complex: The product or solution contains many elements at one or more levels.

c. Elegant: The solution is expressed in a refined, understated way.

d. Expressive: The product is presented in a communicative, understandable manner.

e. Organic: The product has a sense of wholeness or completeness about it.

f. Well-crafted: The product has been worked and reworked with care to develop it to its highest possible level for that point in time. (p. 164)

To date, the *CPAM* (Besemer & Treffinger, 1981) is one of the most comprehensive works addressing the creative product. However, another less noted work on the criterion problem can be found within the discipline of industrial arts.

Criteria for evaluating the creative product in the industrial arts. Establishing criteria for evaluating the creative products of industrial arts (now referred to as technology education) has been addressed by only a few researchers (e.g., Moss, 1966; Duenk, 1966) within the discipline. Moss (1966), in examining the criterion problem, concluded that unusualness and usefulness were the defining characteristics of the creative product produced by industrial arts students. A description of his model is presented below:

> 1. <u>Unusualness:</u> To be creative a product must possess some degree of unusualness. The quality of unusualness may, theoretically, be measured in terms of probability of occurrence; the less the probability of its occurrence, the more unusual the product (Moss, 1966, p. 7).
>
> 2. <u>Usefulness:</u> While some degree of unusualness is a necessary requirement for creative products, it is not a sufficient condition. To be creative, an industrial arts student's product must also satisfy the minimal principle requirements of the problem situation; to some degree it must "work" or be potentially "workable." Completely ineffective, irrelevant solutions to teacher-imposed or student-initiated problems are not creative (Moss, 1966, p. 7).
>
> 3**.** <u>Combining Unusualness and Usefulness:</u> When a product possesses some degree of both unusualness and usefulness, it is creative. But, because these two criterion qualities are considered variables, the degree of creativity among products will also vary. The extent of each product's departure from the typical and its value as a problem solution will, in combination, determine the degree of creativity of each product. Giving the two qualities equal weight, as the unusualness and/or usefulness of a product increases so does its rated creativity; similarly, as the product approaches the conventional and/or uselessness its rated creativity decreases (Moss, 1966, p. 8).

In establishing the construct validity of his theoretical model, Moss (1966) submitted his work for review to 57 industrial arts educators, two measurement specialists, and six educational psychologists. Results of the review found the proposed model was compatible with existing theory and practice of both creativity and industrial arts. No one disagreed with the major premise of using unusualness and usefulness as defining characteristics for evaluating the creative products of industrial arts students.

To date little additional research has been conducted to establish criteria for evaluating the creative products of industrial arts and/or technology education students. If technology is best known by its creative products, then technology educators are obligated to identify characteristics that make a product more or less creative. Furthermore, educators must find ways to objectively measure these attributes, then train students so that they can enhance the creativity of their products. Another possible approach to enhancing product creativity is by incorporating computer simulation technology into the classroom.

Computers and Creativity

As discussed earlier, there is no substantial research directly measuring the effects of computer simulation technology on creativity. For that matter, there are relatively few empirical studies on the effects of computers on creativity in general. For this reason, this section will briefly examine instructional computing in the context of creativity and current theories related to computer simulation technology.

Instructional Computing and Creativity

In the early 1990s, computer use accelerated in the classroom. With the introduction of the graphical user interface (e.g., pull down menu, scroll bars, icons, and command lines), increase in processing speed, and affordability, educational computing had finally come of age. Software designers today are now able to design multidimensional educational programs that include high quality graphics, stereo sound, and real time interaction (Bilan, 1992).

Computer programs have advanced beyond the early days of drill and practice instruction, and are now addressing higher order thinking skills, including creativity. However, researchers warn that computers alone do not provide students with the opportunities to be creative, the classroom teacher is still responsible for choosing appropriate software and effectively implementing it in the classroom (Gallini, 1983; Henderson & Minner, 1991).

Implementing computers into the classroom may hold many advantages for students. It is theorized that computers can offer students a variety of opportunities in which to foster their creativity. For example, Dodge (1991) suggests that creative computing can offer students:

1. Flexibility, mobility: the ability to shift perspectives...to redefine a problem in the direction of greater or lesser abstractness.

2. Fluency: the ability to generate many ideas, knowing that only a few will be valuable.

3. Association: the ability to put disparate elements together to make new combinations.

4. Testing: the ability to quickly try out ideas, discarding those that don't work. (p. 5)

Because of its educational potential, computers are becoming more abundant in the classroom. If implemented correctly, the computer may be an effective method in developing student creativity, however more research is needed to measure the computer's true effect.

Empirical Research on Computers and the Creative Product

As stated earlier, there are relatively few empirical studies on the effects of computers on creativity. The lack of research may be because instructional computing has only thrived over the last decade. The following are the only two empirical studies found to date that address computers and creativity as measured by the creative product.

Study one. A study conducted by Joram, Woodruff, Bryson, & Lindsay (1992) found that average students produced their most creative work using word processors as compared to students using pencil and paper. The researchers hypothesized that word-processing would hinder creativity due to constant evaluation and editing of their work. To test the hypotheses, 31 average and above average eighth grade writers were randomly assigned to two groups. The first group was asked to compose using word processors while the second group was asked to compose using pencil and paper. After collecting the compositions, both the word-processed and handwritten texts were typed so that they would be in the same format when presented to a panel of raters. Using a five-point rating scale, the raters evaluated the products for creativity. In order to assess the effects of the experimental factors, a univariate analysis of variance was carried out. Results showed that there was a significant three-way interaction between skill, medium of production and composing instructions on creativity, $F(1,15) = 4.69$, $p < .05$. Based on these results the researchers concluded that word-processing enhances the creative abilities of average writers. A reason for this result may be that word-processing helps average writers generate a number of ideas knowing that only a few of them will be usable and the rest can be easily erased. However, the researchers also found that word-processing had a negative effect on the creativity of above average writers. These mixed results suggest that the use of word-processing may not be appropriate for all students. However, due to the small number of subjects used in the study, results should be generalized with caution.

Study two. Similar to word processing, computer graphic programs may also help students improve the creativeness of their products. In a study conducted by Howe (1992), two advanced classes in graphic design, consisting of 28 undergraduate students, were randomly assigned to one of two treatments. The first treatment group was instructed to use a computer graphic program to complete a design project whereas the other group was asked to use conventional graphic design methods to design their product. Upon completion of the assignment, both groups' projects were collected and photocopied so that they would be in the same format when presented to a panel of raters. Using the C*reative Product Semantic Scale* (Besemer & O'Quin, 1989), the raters evaluated the products for creativity. Results showed that students using computer graphics technology surpassed the conventional method in all sub-scales of creativity with organic (F (2,28) = 4.90, $p < .02$) and well-crafted (F (2,28) = 4.60, $p < .02$) posing significant means. Howe concluded that computer graphics technology may enable graphic designers to generate an abundance of ideas, then capture the most creative ones and incorporate them into their designs. However, due to the small sample size and a lack of random assignment, results of the study should be generalized with caution.

Much like word processing and computer graphics technology, simulation technology is another type of computer application that allows users to freely manipulate and edit virtual objects. However, due to a lack of research, the true effect of simulation technology on creativity is still unknown and can only be surmised.

Computer Simulation

Computer simulation technology is becoming a popular method of instruction for many educators. Simulation programs with titles like *Electronic Workbench, LegoCAD,* and *Car Builder,* are helping students learn about events, processes, and activities that either replicate or mimic the real world. Gokhale (1996) believes that these virtual experiences can provide the learner with an opportunity to learn by doing as opposed to straight lecture. This statement was supported by Menn (1993) who found that students retain 90% of what they learn if they do the job themselves, even if it is a simulation.

Though it is believed that most educators prefer real-life laboratory activities to simulations, simulation technology can provide the learner with numerous advantages. For example, computer simulators can:

1. *Provide the students with the opportunity to engage in activities that may otherwise be unattainable.* Consider the use of flight simulators in the classroom. Simulators of this type can allow students to experience flight when real opportunities (due to cost, feasibility and safety) are unavailable.

2. *Enhance academic performance and learning achievement levels of students.* In a study conducted by Betz (1996), it was found that students who supplemented their class readings with the use of a computer simulator, performed better on their examination. In the study, two freshman engineering technology Material and Methods Construction classes at SUNY Farmingdale, NY, were assigned to one of two treatment groups. Twenty-four students participated in the study. The experimental group learned about urban design concepts through assigned readings and by using a computer simulator called *Sim City 2000*, a complex city system planning and management software program. The control group learned about urban design concepts through the assigned readings only. Upon completion of the treatments, an exam was administered and results showed that the experimental group performed significantly better on the exam as compared to the control group, $p < .05$. Based on these results the researchers concluded that the reading assignments supplemented with computer simulation tend to help students better understand the readings and learn more. However, due to the small sample size and a lack of random assignment, results of the study should be generalized with caution.

3. *Be equally as effective as real life hands-on laboratory experiences.* In a study conducted by Choi and Gennaro (1987), it was found that a computer-simulated activity was as effective as a hands-on laboratory activity in teaching the volume displacement concept. In the study, 128 eighth-grade students from five different science classes at a middle school in Minnesota, were randomly assigned to one of two treatment groups: the microcomputer-simulated experience (experimental group) and the hands-on laboratory experience (control group). The experimental group was taught the volume displacement concept using a series of five simulated experiments on the computer. The control group was taught the same concepts using five parallel hands-on laboratory experiments. Upon completion of the treatments, a posttest was administered and results showed that there was no significant between the two

groups in the learning of the volume displacement concept. Based on these results the researchers concluded that computer simulated experiences were as effective as hands-on experiences. However, because the sample population was limited to one school, results of the study should be generalized with caution.

4. *Foster peer interaction.* In a qualitative study conducted by Bilan (1992), middle and high school students from surrounding school systems in Calgary, Canada volunteered to come one night a week to the University of Calgary. The exact number of participants was not specified in the report. The students spent an average of sixty hours with various computer simulators and reported their experiences in a log. In their finding, the researchers noted that simulators were able to keep students of various abilities challenged and interested. The researchers also reported that students participating in the study often sought out peers to discuss problems, lend help, and share their experiences.

5. *Provide students with immediate and reliable feedback*. Simulators like *SimFoil* can aid students in the design and testing of airfoils. By manipulating certain variables in the simulator, students can quickly obtain reliable data pertaining to lift and drag. Simulators of this type can also save students' time and money by avoiding the need to construct and test physical models in real wind tunnels.

Though the advantages of computer simulation are encouraging, after an extensive review of literature, no studies have been found addressing the effects of simulation technology on creativity. Yet, even with this lack of evidence, some researchers have theorized that computer simulation may in fact enhance creativity (e.g., Betz, 1996; Gokhale, 1996; Harkow, 1996). However, further investigation must be conducted to substantiate this claim.

Summary

This review of literature has dealt with the various aspects of creativity and computer simulation technology. Described in this chapter was theory related to the creative person, process, and product. In addition, the effect of computer technology on developing the creative abilities of students was also explored. Though it is theorized that using computer simulations may enhance students' creativity, due to a lack of research, the true effectiveness of computer simulation technology on enhancing creativity is still unknown. For this reason, this study is proposed.

CHAPTER III

Method

Introduction

This chapter contains a general discussion of the method used in this study. Included are the following sections: description of the subjects, description of the materials and test instrument, the experimental procedure, and the collection and statistical analysis of data.

Subjects

The subjects selected for this study were seventh-grade technology education students from three different middle schools located in Northern Virginia during the spring semester 1999-2000 school year. Northern Virginia is a middle-to-upper income suburb outside of Washington, D.C. The three participating schools were chosen because of the teachers' willingness to participate in the study. One class from each of the three schools was selected and randomly divided into the two treatments.

Fifty-eight subjects participated in this study. Each subject was randomly assigned to either the hands-on treatment group or the computer simulation treatment group. The study included a total of 21 females and 37 males with an average age of 12.4 years old.

Permission to conduct research at these schools was obtained from the individual technology teachers, the schools' principals, the school division's Research Screening Committee, students and their parents. Further permission was obtained from the Department of Teaching and Learning Human Subjects Committee, and the Institutional Review Board for Research Involving Human Subjects at Virginia Tech. See Appendix A, B, C, D, and E for permission letters and forms used to conduct this research.

Materials and Test Instrument

Materials

The materials used in this study were *Classic LEGO Bricks* ™ and the demo version of *Gryphon Bricks* ™ software.

Classic LEGO Bricks ^{TM}. Each subject in the hands-on treatment group received a container with 214 mixed colored (red, white, blue, black and yellow) LEGO® bricks and a 16x16 green base plate. Contents of each container are described below:

Quantity	Brick type
45	2x4
22	2x3
48	2x2
92	1x1

Gryphon Bricks ^{TM} *Demo Version for Macintosh.* Each subject in the computer simulation group was assigned to a Macintosh computer on which a demo version of *Gryphon Bricks* ™ for Macintosh was installed (Gryphon Software Corporation, 1996). *Gryphon Bricks* ™ are computer generated Lego-type bricks that can be assembled and disassembled like real LEGO® bricks. The *Gryphon Bricks* ™ demo version was chosen because of the quickness and ease in which the students could learn the software and its free availability. The demo version of *Gryphon Bricks* ™ features four basic brick types:

2X4
2X3
2X2
1X1

The user is supplied with an unlimited number of virtual bricks that can be put together to create three-dimensional objects. The simulator allows the user to easily change brick color as well as inspect their objects from various perspectives. The simulator behaves much like its physical counterparts except that the virtual environment lacks gravity. The software is recommended for ages five to adult. See Appendix F for software modeling environment.

Test Instrument

The evaluation of creative products was based on the theoretical model proposed by Moss (1966). As discussed in chapter two, Moss (1966) is one of few researchers who has conducted significant research related to the evaluation of creative products produced by industrial arts students (i.e., technology education students). His model was based on the combination of two attributes of the creative product, unusualness (or *originality*) and *usefulness.* The combination of these two attributes was used to evaluate the creativeness of products produced by subjects participating in this study.

The researcher chose to use two sub-scales from the *Creative Product Semantic Scale* or *CPSS* (Besemer & O'Quin, 1989) to determine creativity. See Appendix G for test instrument and Appendix H for the permission to use the test instrument. The sub-scales used in this study were *original* and *useful*. These two sub-scales were chosen to keep in alignment with the theoretical model proposed by Moss (1966). The researcher decided not to use Moss's (1966) instrument because of its reported low reliability.

The *CPSS* has proven to be a reliable instrument in evaluating a variety of creative products based on objective, analytical measures of creativity rather than intuition (Besemer & O'Quin, 1986, 1987, 1989, 1993). The analytical measure is accomplished by the use of a bipolar semantic differential scale.

In general, semantic differential scales are good for measuring concepts or mental images. Information is obtained by asking the evaluators to rate a concept based on a continuum of polar opposites and placing a mark where he or she feels the concept lies (Dawes, 1972). Since semantic differential scales use a series of bipolar adjectives or profiles, images can clearly and effectively be portrayed by comparing various profiles against one another (Alreck, 1995). Because creativity is a mental concept, the semantic differential naturally lends itself to measuring the creative product.

As addressed in chapter two, the *CPSS* is based on a theoretical model called the *Creative Product Analysis Matrix* or *CPAM* (Besemer & Treffinger, 1981). The authors of the *CPAM,* and later the *CPSS,* cite a number of substantial research studies which helped establish the construct validity of their instrument. The *CPSS* is organized around three general dimensions, containing 14 sub-scales. The authors believe that the dimensions and sub-scales conceptualize all attributes of a creative product. The general dimensions established are Novelty (newness of processes, materials, and design), Resolution (functionality, usefulness, workability of the product), and Elaboration and Syntheses (the stylistic attributes of the finished product) (Besemer & Treffinger, 1981).

In establishing the reliability and validity of the *CPSS*, the authors conducted several studies (Besemer & O'Quin, 1986, 1987, 1989). The studies:

1. Confirmed that the instrument could differentiate between creative products.

2. Established the independence of each dimension and sub-scale.

3. Deleted items that did not contribute to each dimension and sub-scale.

4. Established high inter-rater correlation for each dimension and sub-scale.

Prior to this study, the *CPSS* was used in a study conducted by Howe (1992). His reliability analysis, based on Cronbach's alpha coefficient, yielded good to high reliability across all sub-scales of the *CPSS*. Important to this study are the reliability results for sub-scales original (.93) and useful (.92). These two sub-scales have consistently shown high reliability, which is in keeping with earlier studies conducted by Besemer and O'Quin (1986, 1987, 1989).

To date the *CPSS* remains one of the most ambitious projects in pursuit of measuring attributes of the creative product. Currently, the *CPSS* can be obtained from Susan Besemer at State University New York College at Fredonia.

One weakness of the CPSS is "...the scale is rather long for repeated administration" (Besemer & O'Quin, 1986, p.125). Alreck (1995) recommends not using more than 20 profiles when using a semantic differential scale. As mentioned earlier, this study will use only two sub-scales consisting of ten profiles. Using only ten profiles will help protect against rater fatigue.

On the other hand, the strength of the *CPSS* is its adaptability. As discussed earlier, there is no real consensus among scholars as to what combination of attributes truly make up the creative product. However, the *CPSS* is flexible enough to allow researchers to pick various sub-scales based on the theoretical construct being investigated; for example, this study will use only *original* and *useful* as defining attributes. In support of this, Besemer and O'Quin (1986) state, "... the sub-scale structure of the total scale lends itself to administration of relevant portions of the instrument rather than the whole" (p. 125). This adaptability makes the *CPSS* a powerful tool in evaluating the creative products of all types from various disciplines.

Procedure

Overview

Three technology education classes from three different schools in the same school system were used in this study. One class at each school was selected for the study. Participants in each class were given a student identification number, then randomly assigned to either a hands-on or computer simulation treatment group using a random-number table (Howell, 1995).

The independent variable in this study was the instructional activity consisting of two categories: traditional hands-on and computer simulation. The dependent variable was the subjects' creative product scores as determined by the combination of the original and useful sub-scales from the *Creative Product Semantic Scale* (Besemer & O'Quin, 1989).

Treatments used in this study consisted of a hands-on activity using LEGO® bricks (Treatment Group A) and the use of a computer simulation program called *Gryphon Bricks* ™ (Treatment Group B). Subjects in both treatment groups were asked to construct a "Creature" that they believed would be found on a LEGO® planet. The "Creature" scenario was chosen because it was an open-ended problem and possessed the greatest potential for imaginative student expression. The only major difference in treatment between groups A and groups B is that group A used a traditional hands-on approach using LEGO® bricks in constructing their creative product whereas group B used the computer simulator.

The treatments were administered at the same time and overall treatment time was the same for both groups. Group A met in its regular classroom whereas group B met in the computer lab. The technology teacher at each school proctored treatment groups A and the researcher proctored treatment groups B. See Appendix I for proctors' instructions. The activities used in this study were found grade level appropriate as determined by the three technology teachers participating in this study. The teachers had a combined total of 24 years of teaching experience.

Because LEGO® bricks are used in the technology classroom and creative problem-solving is part of the technology education curriculum, students who chose not to take part in the research study were still expected to do the LEGO® activity. Six students chose not to participate in the study. These students stayed in the classroom with the rest of the class and worked at their own pace.

Upon completion of the activity, the non-participating students' projects were separated from the data collection process. Refusal to be part of the study did not affect the student's grade in any way.

Hands-on treatment (Group A)

Subjects in treatment group A were asked to construct an *original* and *useful* object using LEGO® bricks. Each subject was given a container having a sufficient quantity of LEGO®

bricks for the assembly of his or her objects and a written copy of the student instructions. The materials section of this chapter lists the contents of each container. Subjects were given five-minutes to sort their bricks by color, into five piles. At the end of five minutes, the following student instructions were read to the subjects:

> Each of you will be using LEGO® bricks to complete the following activity. Pretend you are a toy designer working for the LEGO® Company. Your job is to create a "creature" using LEGO® bricks that will be used in a toy set called *Lego Planet*. What types of creatures might be found on a LEGO® planet? Use your creativity and make a creature that is *original* in appearance yet *useful* to the toy manufacturer.
>
> One more thing, the creature you construct must be able to fit within a five-inch cubed box, that means you must stay within the limits of your green base plate and make your creature no higher than 13 bricks.
>
> You will have 25 minutes to complete this activity. If you finish early, spend more time thinking about how you can make your creature more creative. You must remain in your seat the whole time. If there are no questions, you may begin.

Upon completion of the instructions, subjects were allowed only 25 minutes to construct their creative products. Subjects were given 10 minute and 5 minute warnings as to how much time was left to finish. When the time was up, the subjects were asked to stop working.

The researcher ensured that each product was properly labeled with the student identification number, collected from the subject, copied into the Gryphon® computer program, and printed using an inkjet color printer.

Computer simulator treatment (Group B)

Subjects in treatment group B were asked to construct an *original* and *useful* object using the demo version of the *Gryphon Bricks* ™ simulator. Each subject was assigned to a Macintosh computer containing the software and given a written copy of the student instructions. A description of the software is available in the materials section of this chapter. Subjects watched a five-minute video created by the researcher explaining how to use the Gryphon® software. After watching the video, the following student instructions were read to the subjects:

> Each of you will be using the Lego- type simulator to complete the following activity. Pretend you are a toy designer working for the LEGO® Company. Your job is to

create a "creature" using LEGO® bricks that will be used in a toy set called *Lego Planet*. What types of creatures might be found on a LEGO® planet? Use your creativity and make a creature that is *original* in appearance yet *useful* to the toy manufacturer.

One more thing, the creature you construct must be able to fit within a five inch cubed box, that means you must stay within the limits of your green base plate and make your creature no higher than 13 bricks. In addition, you may only use the following five colors: red, white, blue, black, and yellow.

You will have 25 minutes to complete this activity. If you finish early, spend more time thinking about how you can make your creature more creative. You must remain in your seat the whole time. If there are no questions, you may begin.

Upon the completion of the instructions, subjects were allowed 25 minutes to construct their creative products. Subjects were given 10 minute and 5 minute warnings about how much time was left to finish. When the time was up, the subjects were asked to stop working. The researcher ensured that each product was properly saved to a diskette labeled with the student identification number. The diskettes were then collected and the products were printed out using an inkjet color printer.

Evaluation of the Products

Evaluation of the products was conducted by two teacher-raters, a middle school art teacher and a middle school science teacher. The teachers had a combined total of 36 years of teaching experience. The raters used the o*riginal* and *useful* sub-scales of the *Creative Product Semantic Scale* (Besemer & O'Quin, 1989) to rate the products. The teacher-raters were given a package of all 58 inkjet colored printed products. See Appendix K for a sample product. As mentioned before, the hands-on treatment groups' objects were copied into *Gryphon Bricks* ™ program, then printed. This was done to assure that the raters were blind to which products were constructed by the hands-on treatment groups and which were constructed by the computer simulation groups. The teacher-raters were instructed to rate each printed product separately over a three-week period. At the end of three-weeks, the products and evaluations forms were collected. To verify inter-rater reliability, a correlation matrix based on Cronbach's alpha coefficient was conducted across the two raters.

Pilot Study

A pilot study was conducted on December 17, 1999 to evaluate the procedures described in this chapter. A seventh-grade technology education class from a Southwest Virginia middle school was selected as part of the pilot study. The pilot study consisted of 16 subjects who were randomly assigned to either a hands-on treatment group or a computer simulation treatment group. Subjects received the same set of instructions and experimental procedures as described in this chapter. However, the pilot study revealed that the initial time allocated for the students to assemble their creative product needed to be decreased from 30 minutes to 25 minutes. This change was made because the majority of students finished their assigned task early.

To help establish inter-rater reliability, a rater training session was conducted during the pilot study. The same teacher-raters used in the pilot study were used in the final study. The training session provided the teacher-raters with instructions on how to use the instrument and allowed them to practice rating sample products. During the session, disagreements on product ratings were discussed and rules deciding what score to give specific profiles were developed. See Appendix J for raters' instructions. The pilot study confirmed good inter-rater reliability across all the scales and ensured that the experimental procedures could proceed as designed. No significant difference in product *creativity*, *originality*, or *usefulness* was found during the pilot study.

Summary

This chapter contained the method used in this study. The sample for this study consisted of seventh-grade technology education students from three different schools located in Northern Virginia. The subjects were randomly assigned to either a hands-on or computer simulation treatment group. The computer simulation group used a program called *Gryphon Bricks* ™ for Macintosh whereas the hands-on treatment group used *Classic LEGO Bricks* ™ to construct their creative products. After the students completed their assigned task, the products were collected and printed. The printed products were evaluated by expert judges using a creative product semantic differential scale. Results of this study will help educators determine the effectiveness of computer simulation technology on enhancing the creative products of technology education students.

CHAPTER IV

Results

Introduction

This chapter contains a discussion of the data collected and the statistical treatment of them. Included are the following sections: Null Hypotheses, Data Analysis, and Summary.

Null Hypothesis

The following null hypotheses were tested in this study:

HO_1: There is no difference in product *creativity* scores among computer simulation and traditional hands-on groups.

HO_2: There is no difference in product *originality* scores among computer simulation and traditional hands-on groups.

HO_3: There is no difference in product *usefulness* scores among computer simulation and traditional hands-on groups.

Data Analysis

A one-way analysis of variance (ANOVA) was applied in order to test $HO_{1,}$ HO_2 and HO_3. This procedure allowed for the comparison of product scores among the computer simulation and the traditional hands-on groups. Significance levels were set at $\underline{p} < .05$ and $\underline{F}$ values were obtained using *NCSS v.6.0* statistical software (Hintze, 1996). Before product creativity scores were analyzed, an inter-rater reliability analysis based on Cronbach's alpha coefficient was conducted. This was done in order to verify the reliability of all judgments between the two raters. However, initial results yielded low inter-rater reliability (.17) to (.57) across all the scales. This low reliability may be attributed to the ten-week time delay between the initial training session that took place during the pilot study and the actual rating of the final products. This assumption can be supported by Ivancevich (1979) who demonstrated that the benefits of rater training can dissipate over a short period of time and refresher training is often needed in order to achieve good inter-rater reliability. Ivancevich further remarked that experienced and quality raters play an important role in achieving good reliability. For these reasons, the existing teacher-raters, who were the most experienced raters, were re-trained and asked to re-evaluate the products. As a result, the evaluation process yielded moderate to good inter-rater reliability across all the scales. Rater reliability and statistical analysis for each null hypothesis are presented below:

Hypothesis Number One: Creativity

Rater Reliability. The inter-rater reliability for product *creativity* was (.88). The results demonstrated good reliability for the overall scale.

Analysis of Variance. HO_1 , that there is no difference in mean product *creativity* scores among computer simulation and traditional hands-on groups, was accepted. No statistical significance was found F (5,52) = 0.54, p = 0.75. Results are presented in Tables 1 and 2.

Table 1

Analysis of Variance for Product Creativity

Source	df	SS	MS	F	p
Groups	5	123.31	24.66	0.54	0.75
Error	52	2396.97	46.09		
Total	57	2520.28			

Table 2

Aggregated Product Creativity Scores

Treatment	n	M	SD
Computer	29	41.74	7.93
Hands-on	29	42.00	5.58

Hypothesis Number Two: Originality

Rater Reliability. The inter-rater reliability for product *originality* was (.86). The results demonstrated good reliability for the sub-scale.

Analysis of Variance. HO_2, that there is no difference in mean product *originality* scores among computer simulation and traditional hands-on groups, was accepted. No statistical significance was found F (5,52) = 1.07, p = 0.39. Results are presented in Tables 3 and 4.

Table 3

Analysis of Variance for Product Originality

Source	df	SS	MS	F	p
Groups	5	77.24	15.45	1.07	0.39
Error	52	749.36	14.41		
Total	57	826.60			

Table 4

Aggregated Product Originality Scores

Treatment	n	M	SD
Computer	29	20.59	4.44
Hands-on	29	21.10	3.10

Hypothesis Number Three: Usefulness

Rater Reliability. The inter-rater reliability for product *usefulness* was (.74). The results demonstrated moderate reliability for the sub-scale.

Analysis of Variance. HO_3, that there is no difference in mean product *usefulness* scores among computer simulation and traditional hands-on groups, was accepted. No statistical significance was found F (5,52) = 0.49, p = 0.78. Results are presented in Tables 5 and 6.

Table 5

Analysis of Variance for Product Usefulness

Source	df	SS	MS	F	p
Groups	5	34.72	6.94	0.49	0.78
Error	52	740.99	14.25		
Total	57	775.71			

Table 6

Aggregated Product Usefulness Scores

Treatment	n	M	SD
Computer	29	21.16	4.17
Hands-on	29	20.90	3.20

Summary

A one-way analysis of variance (ANOVA) was used to test all three null hypotheses. This procedure allowed for the comparison of product scores among the computer simulation and the hands-on groups. However, before product creativity scores were analyzed, an inter-rater reliability analysis, based on Cronbach's alpha coefficient, was conducted. Rater reliability for the overall creativity scale and the two sub-scales ranged from (.74) to (.88). After confirming rater reliability, an F ratio was obtained for each of the null hypotheses. The analyses led to the acceptance of all the hypotheses.

CHAPTER V

Summary, Conclusions, and Recommendations

Introduction

This chapter contains a brief summary of this study. Also presented in this chapter are conclusions based on the research findings and recommendations for future research.

Summary

The purpose of this study was to compare the effect of a computer simulation activity versus a hands-on activity on students' product creativity. Fifty-eight middle school technology education students from three different schools in Northern Virginia participated in the study. Subjects were randomly assigned to either a computer simulation or hands-on treatment group. The computer simulation group used a Lego-type brick simulator call *Gryphon Bricks* ™ to construct creative products on the computer; whereas, the hands-on treatment group used classic LEGO® bricks to construct their products. Both treatment groups were given the same types of bricks and an equal amount of time to construct their products. Upon completion of the experiment, the computer simulation groups saved their products to diskettes. The hands-on groups' products were collected by the researcher, copied into the computer simulation program and saved to diskettes. Both groups' products were printed out using an inkjet color printer. This printed format was chosen to keep the judges blind as to which products were constructed by hand and which products were constructed on the computer. The printed products were evaluated by two expert judges using a creative product semantic differential scale. The scale measured overall *creativity*, by use of two sub-scales *originality* and *usefulness*. To verify inter-rater reliability, a correlation matrix based on Cronbach's Alpha coefficient was conducted across the two raters. A one-way analysis of variance (ANOVA) was applied to the data in order to test three hypotheses. This statistical procedure allowed for the comparison of product scores among the computer simulation and the traditional hands-on groups. Results showed that that there was no significant difference in mean product *creativity* scores among computer simulation and traditional hands-on groups $\underline{F}$ (5,52) = 0.54, $\underline{p}$ = 0.75. Furthermore, it was found that there was no significant difference in mean product *originality* scores $\underline{F}$ (5,52) = 1.07, $\underline{p}$ = 0.39, and mean product *usefulness* scores F (5,52) = 0.49, p = 0.78, among computer simulation and traditional hands-on groups.

Conclusions

The conclusions for this study were supported by the acceptance of all three null hypotheses. Based upon the results, the following conclusions were derived:

1. HO_1 dealt with the effectiveness of a computer simulation versus a hands-on activity on improving the *creativity* of products produced by middle school technology education students. Since there was no significant difference between treatments, the computer simulation activity was equally as effective as the hands-on activity in product *creativity* of middle school technology education students in Northern Virginia.

2. HO_2 dealt with the effectiveness of a computer simulation versus a hands-on activity on improving the *originality* of products produced by middle school technology education students. Since there was no significant difference between treatments, the computer simulation activity was equally as effective as the hands-on activity in product *originality* of middle school technology education students in Northern Virginia.

3. HO_3 dealt with the effectiveness of a computer simulation versus a hands-on activity on improving the *usefulness* of products produced by middle school technology education students. Since there was no significant difference between treatments, the computer simulation activity was equally as effective as the hands-on activity in product *usefulness* of middle school technology education students in Northern Virginia. However, due to the moderate inter-rater reliability of the usefulness sub-scale, results pertaining to product *usefulness* should be interpreted with caution.

Implications

In certain situations, educators may not be able to provide students the opportunity to engage in hands-on activities due to cost, feasibility, and/or safety. However, research has shown that computer simulation activities can be used as an alternative for reaching educational goals. For example, Choi and Gennaro (1987) demonstrated that a computer simulation is equally as effective as real life hands-on laboratory experiences in enhancing learning achievement. This study may indirectly supports the above findings by demonstrating that it is possible to use a computer simulation activity in place of a hands-on activity in promoting product *creativity* while at the same time maintaining comparable results. This statement can be equally applied to the *originality* and *usefulness* of the product as well.

Specifically addressing the needs of technology educators, this study has helped answer a question posed by Lewis (1999). Lewis asked, "What tends to inhibit or enhance problem solving and creativity?" Based on the results of this study, a computer simulation activity neither inhibits nor enhances the creative problem solving of students as compared with a similar hands-on activity.

On a practical level, computer simulations can provide the technology educator with the flexibility to meet the ever-demanding needs of the classroom. For example, if under budget constraints, the technology educator may want to consider using computer simulation activities in lieu of expensive hands-on activities that require large amounts of consumable materials and costly equipment. Likewise, the educator may also want to consider the time saved not having to organize, distribute, and clean-up those materials. If laboratory space is at a premium, computer simulation activities may help the technology educator eliminate the need for a room to store equipment, materials, and bulky student projects. Computer simulation activities can also allow students who are absent from school to easily make-up missed laboratory activities. Finally, computer simulations may provide a means by which to help physically disabled students participate in laboratory activities that are otherwise inaccessible. The practical applications and the results of this study can further help technology educators justify the use of computer simulations in the classroom.

Though the benefits of computer simulations are encouraging, it is the personal opinion of this researcher, that whenever possible, real life experiences should always supersede simulated experiences. Yet, computer simulation holds promise in allowing students to engage in a variety of creative problem-solving activities that otherwise may be unattainable. For this reason, computer simulations should be considered as an alternative to hands-on activities in meeting educational goals.

Recommendations for Further Study

Based on the results of this study and the cited literature, the following recommendations are made:

1. Research similar to this study should be conducted to validate and generalize the results found in this study. Other populations outside the geographical area of Northern Virginia should be considered. Furthermore, factors targeting socioeconomic status, age group, educational level, and gender should also be explored.

2. Research similar to this study using a different type of computer simulation program should be conducted to verify the findings reported in this study.

3. Research similar to this study should be conducted that incorporates a different theoretical model and instrument for measuring the creative product. For example, rather than using only the two sub-scales *original* and *useful* of the *Creative Product Semantic Scale* (Besemer & O'Quin, 1989), the complete instrument should be used.

4. The continued development of a theoretical model and instrument for measuring the creative product must ensue. The *Creative Product Semantic Scale* (Besemer & O'Quin, 1989), though beneficial to this study, was truly designed to rate a few number of products using multiple raters. This study adapted the instrument using only two raters and many products. Though an acceptable inter-rater correlation was eventually achieved, rater fatigue was an issue throughout the rating process. Therefore, the development of a valid and reliable instrument that uses only a few raters capable of rating many products is needed.

REFERENCES

Alreck, T.L., & Settle, B.R. (1995). *The survey research handbook* (2nd Ed.). Chicago: Irwin Inc.

American Association for the Advancement of Science. (1989). *Project 2061:Technology* (AAAS Publication 89-06S). Washington, DC: J. Johnson.

Besemer, S.P., & O'Quin, K. (1993). Assessing creative products: Progress and potentials. In S.G. Isaksen (Ed.), *Nurturing and developing creativity: The emergence of a discipline* (pp. 331-349). Norwood, New Jersey: Ablex Publishing Corp.

Besemer, S.P., & O'Quin, K. (1989). The development, reliability and validity of the revised creative product semantic scale. *Creativity Research Journal, 2*, 268-279.

Besemer, S.P., & O'Quin, K. (1987). Creative product analysis: Testing a model by developing a judging instrument. In S.G. Isaksen, *Frontiers of creativity research: Beyond the basics*. (pp. 341-357). Buffalo, NY: Bearly Ltd.

Besemer, S.P., & O'Quin, K. (1986). Analysis of creative products: Refinement and test of a judging instrument. *Journal of Creative Behavior, 20* (2), 115-126.

Besemer, S.P., & Treffingger, D. (1981). Analysis of creative products: Review and synthesis. *Journal of creative behavior, 15*, 158-178.

Betz, J.A. (1996). Computer games: Increase learning in an interactive multidisciplinary environment. *Journal of Technology Systems, 24* (2), 195-205.

Bilan, B. (1992). *Computer simulations: An Integrated tool.* Paper presented at the SAGE / 6th Canadian Symposium, The University of Calgary.

Brogden, H., & Sprecher, T. (1964). Criteria of creativity, In Taylor, C.W., *Creativity, progress and potential*. NY: McGraw Hill.

Choi, B., & Gennaro, E. (1987). The effectiveness of using computer simulated experiments on junior high students' understanding of the volume displacement concept. *Journal of Research in Science Teaching, 24* (6), 539-552.

Dawes, R.M. (1972). *Fundamentals of attitude measurement*. New York: John Wiley & Sons, Inc.

DeVore, P. (1980). *Technology: An introduction.* Worcester, Massachusetts: Davis Publications, Inc.

DeVore, P., Horton, A., & Lawson, A. (1989). *Creativity, design and technology*. Worcester, Massachusetts: Davis Publications, Inc.

Dodge, B. (1991). Computers and creativity: Tools, tasks, and possibilities. *Communicator: The Journal of the California Association for the Gifted, 21* (1), 5-8.

Duenk, L.G. (1966). *A study of the concurrent validity of the Minnesota Test of Creative Thinking, Abbr. Form VII, for eighth grade industrial arts student.* Minneapolis: Minnesota University. (Report No. BR-5-0113).

Edmunds, A.L. (1990), Relationships among adolescent creativity, cognitive development, intelligence, and age. *Canadian Journal of Special Education*, *6* (1), 61-71.

Gallini, J. (1983). What computer-assisted instruction can offer towards the encouragement of creative thinking. *Educational Technology, 28* (4), 7-11.

Gokhale, A.A. (1996). Effectiveness of computer simulation for enhancing higher order thinking. *Journal of Industrial Teacher Education, 33* (4), 36-46.

Gryphon Software Corporation (1996). Gryphon Bricks Demo (Version 1.0) [Computer Software]. Glendale, CA: Knowledge Adventure. [On-line] Available: http://www.kidsdomain.com/down/mac/bricksdemo.html

Guilford, J. (1976). *Intellectual factors in productive thinking*. In R. Mooney & T. Rayik (Eds.), *Explorations in creativity*. New York: Harper & Row Publishers.

Harkow, R.M. (1996). *Increasing creative thinking skills in second and third grade gifted students using imagery, computers, and creative problem solving.* Unpublished master's thesis, NOVA Southeastern University.

Hayes, J.R. (1990). *Cognitive processes in creativity.* Berkeley: University of California. (Paper No. 18).

Henderson, A., & Minner, S. (1991). Computing for creativity. *Intervention in School & Clinic*, *27* (1), 43-46.

Hinton, B.L. (1968, Spring). A model for the study of creative problem solving. *Journal of Creative Behavior, 2* (2), 133-142.

Hintze, J.L. (1996). NCSS 6.0.21 Statistical System for Windows [Computer Software]. Kaysville, Utah: Number Cruncher Statistical Systems.

Howell, D.C. (1995). *Fundamental statistics for the behavioral sciences* (3rd Ed.). Belmount, CA: Duxbury Press.

Howe, R. (1992). Uncovering the creative dimensions of computer-graphic design products. *Creativity Research Journal, 5* (3), 233-243.

International Technology Education Association. (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: Dugger, W.

Ivancevich, J.M. (1979). Longitudinal study of the effects of rater training on psychometric error in ratings. *Journal of Applied Psychology, 64,* 502-508.

Joram, E., Woodruff, E., Bryson, M., & Lindsay, P. (1992). The effects of revising with a word processor on writing composition. *Research in the Teaching of English, 26* (2), 167-192.

Knoll, M. (1997). The project method: Its vocational education origin and international development. *Journal of Industrial Teacher Education*, *34* (3), 59-80.

Lewis, T. (1999). Research in technology education: Some areas of need. *Journal of Technology Education, 10* (2), 41-56.

Maslow, A. (1962). *Toward a psychology of being*. Prinston, NJ: Van Nostrand.

Menn, D. (1993, October). Multimedia in education. *PC World*, M52-M60.

Moss, J. (1966). *Measuring creative abilities in junior high school industrial arts*. Washington, DC: American Council on Industrial Arts Teacher Education.

Olson, D.W. (1974, March). Interpreting a technological society. *School Shop*, 35-36.

Olson, D.W. (1973). *Tecnol-o-gee*. Raleigh: North Carolina University School of Education, Office of Publications.

Runco, R.A., Nemiro, J., & Walberg, H.J., (1998). Personal explicit theories of creativity. *Journal of Creative Behavior*, *32*(1), 1-17.

Savage, E., & Sterry, L. (1990). *A conceptual framework for technology education.* Reston, VA: International Technology Education Association.

Stein, M. (1974). *Stimulating creativity: Vol. 1. Individual procedures.* New York: Academic Press.

Taylor, I.A. (1959). The nature of the creative process. In P. Smith (Ed.), *Creativity: An examination of the creative process* (pp. 51-82). New York, NY: Hastings House Publishers.

Torrance, E. P. (1966). *Torrance test on creative thinking: Norms-technical manual* (Research Ed). Lexington, Mass: Personal Press.

Torrance, E.P. (1963). Creativity. In F. W. Hubbard (Ed.), *What research says to the teacher* (Number 28). Washington, DC: Department of Classroom Teachers American Educational Research Association of the National Education Association.

Wallas, G. (1926). *The art of thought*. New York: Harcourt, Bruce and Company.

Appendix A: Teacher/Administrator Permission Letter

TO:	Kurt Michael Virginia Polytechnic Institute and State University Department of Teaching and Learning
FROM:	(Insert Teacher/Administrator's Name)
DATE:	(Insert Date)
SUBJECT:	Permission to Conduct Research

Dear Mr. Michael,

As per our conversations, I agree to allow you to conduct research using my seventh grade technology education classes/school. It is my understanding that the study is designed to determine the effectiveness of computer simulation versus a traditional hands-on activity in promoting the creative abilities of technology education students.

By choosing to participate, I understand that you will need to randomly choose one of my seventh grade technology education classes for your study. Students in the selected class will be moved to the Macintosh computer Lab where they will be assigned to either a computer simulation or hands-on group. Students in the computer group will use a Lego-type simulator to construct a creative product whereas the hands-on group will use real LEGO® bricks to construct their creative product. Upon completion, student products will be collected and evaluated by expert judges. The experiment will take one class period.

I also agree that the results of this project may be used for scientific and/or educational purposes, presented at meetings, and/or published in a scientific, educational journal, or dissertations. However, all information gathered in this study will be kept confidential. A coded number will be used to identify the students' creative products during analysis and reporting of data. Student names will not be used in any way.

I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent to have my classes participate in this study. I understand I have the right to withdraw from this study at any time without penalty. If I have any questions regarding this study, I should contact one of the persons named below. Given these procedures and conditions, I agree to allow my classes to participate in this study.

Kurt Michael, Principal Investigator	(540) 231-8169
Dr. Jane Abraham, Research Advisor	(540) 231-8337
Dr. Jan Nespor, Chair, Human Subjects Committee	(540) 231-8327
Dr. Tom Hurd, Chair, Institutional Review Board	(540) 231-5281

Sincerely,

____

Appendix B: School Divisions Permission to Conduct Research

[redacted] COUNTY
PUBLIC SCHOOLS

Office of Planning, Testing, and Evaluation
Walnut Hill Center
7423 Camp Alger Avenue
[redacted], Virginia [redacted]

February 8, 2000

Kurt Michael
395 Silver Leaf Drive
Christiansburg, VA 24073

Dear Mr. Michael:

The Research Screening Committee has reviewed your proposal to conduct a study of the effectiveness of computer simulation technology in [redacted] County Public Schools. You may contact Gary Foveaux, Coordinator of Industrial Technology 703-208-7801 and begin the study as soon as you read, sign, and return the attached Approval Agreement. Return the form to Tom White, Office of Planning, Testing and Evaluation, Walnut Hill Center. If you have questions about the conditions of this approval, call him at 703-208-7766.

Once you have completed the study, provide one copy of a report of the findings to Tom White. This can be a photocopy or microfiche. The report will be placed in the school division's Professional Library. We look forward to receiving the final product.

Sincerely,

Maryanne Roesch

Maryanne Roesch, Ed.D.
Director

MAR/ma
Enclosure

cc: Tom White
Gary Foveaux

Appendix C: Student Assent Form

Student's Assent

Virginia Polytechnic Institute and State University
Department of Teaching and Learning
College of Human Resources and Education

Dear Student,

My name is Mr. Michael and I am going to do a research project at your School. My research is looking to see how computers affect the creativity of technology education students. The title of my project is going to be:

A Comparison of Students' Product Creativity
Using a Computer Simulation Activity versus a Hands-on
Activity in Technology Education

I would like you to be part of my research project. However, If you don't want to be part of my research project, you don't have to. In addition, if you do agree to participate and then change your mind, you can withdraw at any time just by asking your teacher. Refusal to participate or withdrawal will not affect your grade in any way.

Creative thinking under experimental conditions is sometimes frustrating. This frustration may possibly cause you a mild degree of discomfort during the experiment. If so, you may refuse to participate in the experiment at no consequence. However, because LEGO® bricks are commonly used in the technology classroom, your teacher will still expect you to do a LEGO® project. This project will be separate of the experiment and not graded. You can stay in the classroom with the rest of the class and work at your own pace.

If you choose to participate in my experiment, I will assign you to either a computer activity or a hands-on activity. In these activities, you will be asked to create a creative object using LEGO® bricks. The activity will take one class period. Thanks for helping me with my research project.

Sincerely,

Mr. Michael

Yes, I would like to participate in your research project.

____
Student Name (Please Print)

__________________ _______
Student Signature Date

Appendix D: Parent Consent Form

Parent Consent Form

Virginia Polytechnic Institute and State University
Department of Teaching and Learning
College of Human Resources and Education

Title: *A Comparison of Students' Product Creativity Using a Computer Simulation Activity versus a Hands-on Activity in Technology Education*

Principal Investigator: Kurt Michael, Department of Teaching and Learning

Research Advisor: Dr. Jane Abraham, Department of Teaching and Learning

Purpose of the study:

Technology education has always been concerned with enhancing the inventive and creative abilities of students through hands-on activities. However, hands-on activities are slowly being replaced by computer activities. Though research shows that computers can promote motivation and achievement, little research has been conducted in the area of creativity. For this reason, this study is designed to determine the effectiveness of a computer activity versus a traditional hands-on activity in promoting the creative abilities of seventh grade technology education students.

Procedure:

We would like your son or daughter to participate in this study. If they choose to participate, your child will be assigned to either a computer or hands-on group. The computer group will use software that allows students to assemble and disassemble Lego-type bricks on the computer screen. Your son or daughter will be asked to construct a creative product on the computer then print the results. The hands-on group will use real LEGO® bricks to construct their creative product. The products your child produces will be collected and evaluated by expert judges. Each product will be given a coded number so that no names will be used with the evaluated products.

Risk of this Research:

Creative thinking under testing conditions is sometimes frustrating. This frustration may possibly cause your child a mild degree of discomfort during the experiment. If so, he or she may refuse to participate in the experiment at no consequence.

Confidentiality:

All information gathered in this study will be kept confidential. A coded number will be used to identify your son's or daughter's creative product during analysis and reporting of data. Your child's name will not be used in any way. However, the results of this project may be used for scientific and/or educational purposes, presented at meetings, and/or published in a scientific, educational journal, or dissertations.

Compensation:

Your son or daughter will receive no compensation for participation in this study.

Freedom to withdraw:

Your son or daughter is free to withdraw from this study at any time without penalty by simply asking their technology education teacher or by contacting any of the names listed at the bottom of this form. Refusal to participate or withdrawal will not affect your child's grade in any way. However, because LEGO® bricks are commonly used in the technology classroom, the teacher will still expect your child to do a LEGO® project. This project will be separate of the experiment and not graded. Your child can stay in the classroom with the rest of the class and work at his or her own pace.

Parent Permission:

I have read and understand the informed consent and conditions of this study. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent to have my son or daughter participate in this study. I understand I have the right to withdraw my son or daughter from this study at any time without penalty. If I have any questions regarding this study, I should contact one of the persons named below. Given these procedures and conditions, I agree to allow my son or daughter to participate in this study.

Kurt Michael, Principal Investigator	(540) 231-8169
Dr. Jane Abraham, Research Advisor	(540) 231-8337
Dr. Jan Nespor, Chair, Human Subjects Committee	(540) 231-8327
Dr. Tom Hurd, Chair, Institutional Review Board	(540) 231-5281

____

Student' s Name (Please Print)

____

Parent/ legal guardian's Name (Please Print)

____________________________ _______

Signature of Parent/ legal guardian Date

Appendix E: Virginia Tech's Permission to Conduct Research

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Office of Sponsored Programs
301 Burruss Hall
Blacksburg, VA 24061-0249
(540)231-5281 Fax: (540)231-4384

MEMORANDUM

TO: [redacted] Jane Abraham
Teaching and Learning 0313

FROM: H. T. Hurd

DATE: February 21, 2000

SUBJECT: **Expedited Approval** – "The Effectiveness of Computer Simulation Technology on Enhancing the Creativity of Products Produced by Seventh Grade Technology Education Students" – IRB #00-22

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of (12) months, effective today.

Approval of your research by the IRB provides the appropriate review as required by federal and state laws regarding human subject research. It is your responsibility to report to the IRB any adverse reactions that can be attributed to this study.

To continue the project past the 12-month approval period, a continuing review application must be submitted (30) days prior to the anniversary of the original approval date and a summary of the project to date must be provided. Our office will send you a reminder of this (60) days prior to the anniversary date.

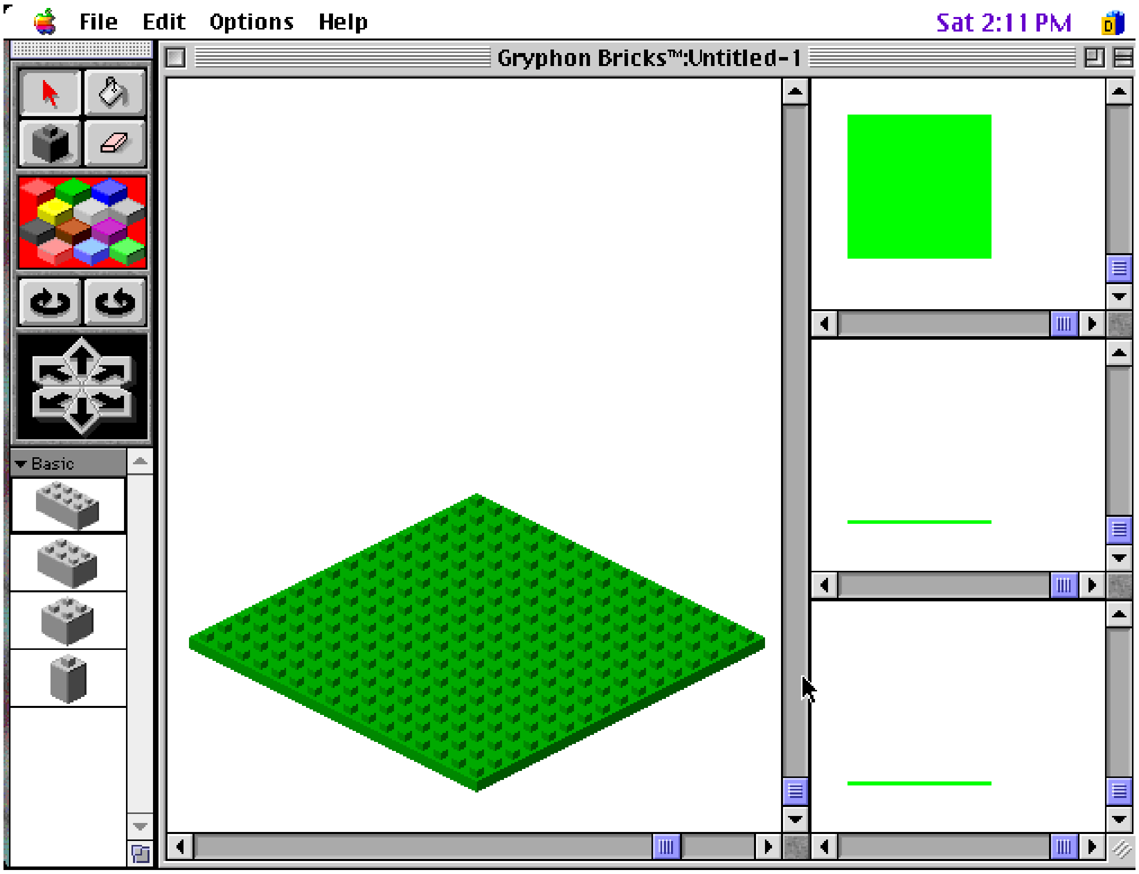
Good Luck!

HTH/bj

cc: Jan Nespor

A Land-Grant University—125th Anniversary
An Equal Opportunity / Affirmative Action Institution

Appendix F: Software Modeling Environment


File
Edit
Options
Help
Sat 2:11 PM
Gryphon Bricks™:Untitled-1
Basic

Appendix G: Test Instrument

Rater:___________ Product Number:______

Original and Usefulness Sub-scales of the
Creative Product Semantic Scale

(Besemer & O'Quin, 1989)

Original ___ : ___ : ___ : ___ : ___ : ___ : ___ Conventional

Useless ___ : ___ : ___ : ___ : ___ : ___ : ___ Useful

Over Used ___ : ___ : ___ : ___ : ___ : ___ : ___ Fresh

Operable ___ : ___ : ___ : ___ : ___ : ___ : ___ Inoperable

Workable ___ : ___ : ___ : ___ : ___ : ___ : ___ Unworkable

Usual ___ : ___ : ___ : ___ : ___ : ___ : ___ Unusual

Unique ___ : ___ : ___ : ___ : ___ : ___ : ___ Ordinary

Functional ___ : ___ : ___ : ___ : ___ : ___ : ___ Non-functional

Ineffective ___ : ___ : ___ : ___ : ___ : ___ : ___ Effective

Predictable ___ : ___ : ___ : ___ : ___ : ___ : ___ Novel

Appendix H: Permission to use the Test Instrument

FREDONIA

Daniel A. Reed Library

716-673-3184
FAX 716-673-3185

March 20, 1998

Kurt Michael
4110 Addison Rd.
Fairfax, VA 22030

Dear Kurt:

I'm pleased that you might find the CPSS useful in your research. I enclose a copy which you may use for research purposes only. I would also appreciate it if you could keep me posted on your results using the instrument. Of course, any use of the instrument should be properly credited and cited.

Along with the instrument itself, I'm sending the scoring guide. This chart lists which items are to go on which facet, and under which factor. You will need this when you score the instrument. Some items need to be reversed in scoring, such that they all run in the same direction, from low to high.

Lastly, is a list of my publications relevant to the CPSS, and two other citations of others who have used the instrument. I hope that they may be of help to you.

Thanks again for contacting me, and good luck!

Sincerely,

Susan Besemer

Susan P. Besemer

State University of New York College at Fredonia, Fredonia, NY 14063

Appendix I: Proctor Instructions

PROCTOR INSTRUCTIONS

(Hands-on Treatment Group)

1. Assign each student to their container of LEGO® bricks and a green base plate with his or her student I.D. number on it.

2. Have the students fill out the demographic information on the top of their instruction sheet (e.g. School, I.D. Number, Age, and Gender).

3. Give the students five-minutes to sort their bricks by color into five piles.

4. At the end of five minutes, the following instructions should be read aloud to the students:

> Each of you will be using LEGO® bricks to complete the following activity. Pretend you are a toy designer working for the LEGO® Company. Your job is to create a "creature" using LEGO® bricks that will be used in a toy set called *Lego Planet*. What types of creatures might be found on a LEGO® planet? Use your creativity and make a creature that is *original* in appearance yet *useful* to the toy manufacturer.
>
> One more thing, the creature you construct must be able to fit within a five-inch cubed box, that means you must stay within the limits of your green base plate and make your creature no higher than 13 bricks.
>
> You will have 25 minutes to complete this activity. If you finish early, spend more time thinking about how you can make your creature more creative. You must remain in your seat the whole time. If there are no questions, you may begin.

5. Upon completion of the instruction, give the students 25 minutes to construct their creative products.

6. Give the students 10 minute and 5 minute warnings as to how much time is left to finish.

7. When the 25 minutes is up, the students should be told to stop working.

8. Have the students place their extra bricks into their container.

9. You should then go around the room and collect each product.

10. Please store the products in a safe place.

PROCTOR INSTRUCTIONS

(Computer Simulator Treatment Group)

1. Assign each student to a Macintosh computer containing the Gryphon® software and a diskette with his or her student I.D. number on it.

2. Have the students fill out the demographic information on the top of their instruction sheets (e.g. School, I.D. Number, Age, and Gender).

3. Have the students watch a five-minute video explaining how to use the Gryphon® software.

4. At the end of five minutes, the following instructions should be read aloud to the students:

> Each of you will be using LEGO® bricks to complete the following activity. Pretend you are a toy designer working for the LEGO® Company. Your job is to create a "creature" using LEGO® bricks that will be used in a toy set called *Lego Planet*. What types of creatures might be found on a LEGO® planet? Use your creativity and make a creature that is *original* in appearance yet *useful* to the toy manufacturer.
>
> One more thing, the creature you construct must be able to fit within a five-inch cubed box, that means you must stay within the limits of your green base plate and make your creature no higher than 13 bricks. In addition, you may only use the following five colors: red, white, blue, black, and yellow.
>
> You will have 25 minutes to complete this activity. If you finish early, spend more time thinking about how you can make your creature more creative. You must remain in your seat the whole time. If there are no questions, you may begin.
>
> 5. Upon completion of the instruction, give the students 25 minutes to construct their creative products.

6. Give the students 10 minute and 5 minute warnings as to how much time is left to finish.

7. When the 25 minutes is up, the students should be told to stop working.

8. Save each product to a diskette labeled with the student identification number.

Appendix J: Rater Instruction Sheet

Rater Instructions

Context:

Pretend you are a consultant to the LEGO® Company. Your job is to evaluate "creatures" made out of LEGO® bricks that will be used in a toy set called *Lego Planet*. Look for "creatures" that are *original* in appearance yet *useful* to the toy manufacturer.

Specifications:

The creature must be able to fit within a five inch cubed box, that means they must stay within the limits of the green base plate and be no higher than 13 bricks. In addition, the creatures may only be made of the following five colors: red, white, blue, black, and yellow.

Format:

On the following page is a form that will help you evaluate each "creature." The form contains a list of paired words. Between each pair of words are seven dashes. You are to place a check mark on one of the seven positions that best describes how you feel about the "creature" or product.

For example, if you feel the product is somewhat more new than old, you would check the fifth position.

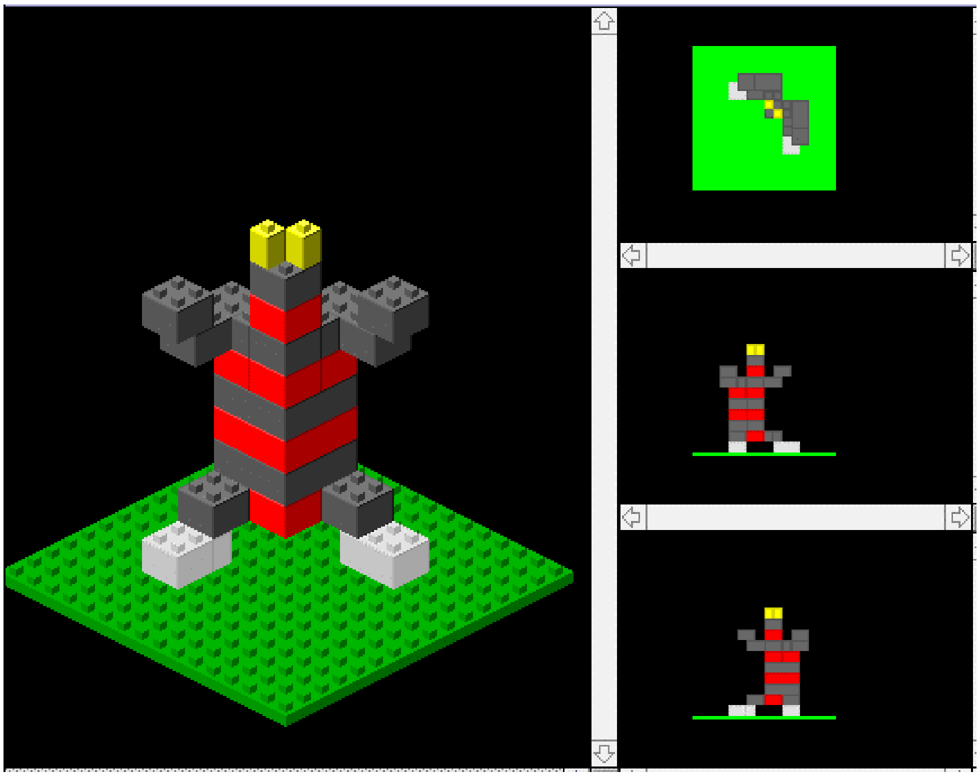
Old ___ : ___ : ___ : ___ : _✔_ : ___ : ___ New

On the other hand, if you think the product is very new, then you would mark the seventh position, and so forth.

Old ___ : ___ : ___ : ___ : ___ : ___ : _✔_ New

Always go with your first impression and remember there are no right or wrong answers. Please, use only one check in each scale. Rate the "creature" or product on all scales and do not leave any blanks.

Appendix K: Sample Product



(103)

VITA

KURT Y. MICHAEL

EDUCATION

Ph.D., Curriculum and Instruction
Concentration in Technology Education
Virginia Polytechnic Institute and State University, Blacksburg, Virginia, May, 2000

M. A., Vocational and Technical Education
Concentration in Technology Education
East Carolina University, Greenville, North Carolina,
May, 1988

B. S., Industrial Technology
Concentration in Construction Management
East Carolina University, Greenville, North Carolina,
May, 1986

EOBC, Engineer Officer Basic Course
U.S. Army School of Engineering, Fort Belvoir, Virginia,
November, 1986

WORK EXPERIENCE

Graduate Teaching Assistant, Virginia Tech University, Blacksburg, Virginia. August 1998 to May 2000.
• Taught undergraduate courses entitled:
"Teaching Drafting in Technology Education (Level I)"
"Teaching Drafting in Technology Education (Level II)"
"Power and Transportation"
• Supervised student teachers

Technology Education Teacher, Fairfax County Public Schools, Fairfax, Virginia. September 1992 to August 1998.
• Taught middle school technology education in a Synergistic's modular laboratory.
• Taught high school technology education courses in Design & Technology, Introduction to Engineering, Materials & Processes, Basic Technical Drafting, Engineering Drafting and Architectural Drafting.

Computer Aided Design Instructor, Northern Virginia Community College, Department of Continuing Education, Woodbridge, Virginia. December 1992 to April 1996.
• Taught courses in basic and advanced AutoCad.
Administrative Assistant/ Highway Inspector, Virginia Department of Transportation, Fairfax, Virginia. May 1990 to September 1992.

• Assisted the Assistant Resident Engineer in reviewing, interpreting, and discussing plans, specifications, and contracts with local and state officials, and the general public. Made recommendations to Assistant Resident Engineer in regard to construction projects. Represented VDOT at public meetings.
• Certified highway Inspector for the State of Virginia. Inspected both road and bridge projects in Northern Virginia.

PUBLICATIONS

Michael, K. (1995, November). Ergonomics for the CAD Lab. *Tech Directions, 55* (4), 16-18.

Carnes, M. & Michael, K. (1996, December). How-to Plan for Teaching Writing in Tech Ed. *Tech Directions,* 56 (5), 20.

Michael, K. (1998, February). Computer Simulation Games Teach Technology Concepts. *VTEA Technologize, 1,* 10.

PRESENTATIONS

Michael, K. (Scheduled for April, 2000). *Enhancing Creativity with Computer Simulation Software.* Presentation at the 62nd Annual Conference of the International Technology Education Association, Salt Lake City, Utah.

AWARDS

The 1996, Region IV, Rufus W. Beamer Award for Incorporating Computer-Aided Drafting in the Classroom. Presented by the Virginia Department of Education, Virginia Council on Vocational Education, and Virginia Tech University.

The 1999 ITEA Maley Spirit of Excellence Outstanding Graduate Student Award. Presented by the Foundation for Technology Education.

PROFESSIONAL MEMBERSHIP

Council on Technology Teacher Education
Epsilon Pi Tau Honor Fraternity
International Technology Education Association
Virginia Technology Education Association