ABSTRACT

THOMPSON, TIMOTHY B. Design Without Make: A feasible direction for American Technology Education. (Under the direction of Dr. Terri Varnado, Dr. Jim Haynie and Dr. Brian Matthews.)

In this study, the researcher examined the effects of STEM and engineering design research, termed Design-Without-Make, which was undertaken at NC State University in 2009 in an NC high school. The hybrid quantitative, qualitative case study was developed with the purpose of capturing what new technological learning occurs and how the new pedagogical learning benefits the technological learner.

The main purpose of this study was: 1) to assess whether students who participate in design-without-make activities achieve learning outcomes as successfully as or better than students of traditional design-with-make activities; 2) to determine student and teacher attitudes towards design-without-make activities within technology education. A one-way analysis of variance was conducted to evaluate the relationship between instruction and the change in pre- and posttest scores between groups.

The study consisted of 27 participants, with the control group having 10 and the treatment group having 17 participants. The grand mean score from both groups came to 14.37 ($SD=5.43$). The assessment used has a standard error of 1.05. The posttest scores ranged from 4 to 22 out of a possible score of 22. With $F(11,15)=2.04$, $p=.05$, it was found there were no significant differences between the control and treatment posttest scores.

Design Without Make: A feasible direction for American Technology Education

by
Timothy B. Thompson

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APPROVED BY:

Terri E. Varnado, Ph.D
Chair of Advisory Committee

Brian Matthews, Ed.D
Member of Advisory Committee

W.J. Haynie, Ph.D
Member of Advisory Committee

BIOGRAPHY

Timothy B. Thompson was born and raised on a family farm in rural North Carolina. In 2003, he graduated Valedictorian of the local high school. From there Timothy moved on to NC State University, where in 2007, he completed his Bachelor of Science degree in Technology Education. From 2007-2009, Timothy B. Thompson worked for NC State University as a Graduate Teaching Assistant in Technology Education while working on his Master of Science degree, also in Technology Education.

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CHAPTER 1

INTRODUCTION

Creativity is becoming increasingly more important to the future because of the ‘unlimited horizons’ it may open up, providing for ever-broadening, multidisciplinary creativity and innovation (Badran, 2007). For years experts have encouraged technology education teachers to take an interdisciplinary, if not multidisciplinary, approach to their classes because technology is the field where all other disciplines and skill sets are applied. Most teachers have tried to use projects of varying types as a means to an end of connecting the various disciplines into hands-on creative ventures where the children get to express themselves (Foster, 1994). However, as educational standards continue to become stricter from year to year, teachers are pressured to modify curricula to include fewer projects thereby discouraging creativity. Are there other ways to encourage creativity that can be better integrated than time consuming projects?

Design-without-make is the direct response to this question. The design-without-make pedagogy comes from David Barlex (2007), who has worked extensively with the Young-Foresight Initiative in Great Britain’s education system. In a design-without-make activity, students progress through the stages of the design process, much as they would in a design-with-make project, but without the prototyping stage. Since students do not actually build the prototype, they are not limited by the construction skills they possess or the resources available to their particular school. This allows for greater freedom in creative designing for technology students of all ages.

Problem Statement

This study seeks to discover whether the design-without-make pedagogy is an effective alternative to design-with-make within the technology education project-based learning environment. Design-without-make by nature resolves the issues of time, expense, and over-emphasis of product construction associated with design-with-make activities, while also encouraging creative and innovative design among students. The hypothesis in this study is that students in a design-without-make environment will have as good as, if not better, learning objective achievement than students in a design-with-make classroom.

Purpose of the Study

The purposes of this study were: 1) to assess whether students who participate in design-without-make activities achieve learning outcomes as successfully as or better than students of traditional design-with-make activities; 2) to determine student and teacher attitudes towards design-without-make activities within technology education.

Basic Methodology

This blended study consists of both quantitative and qualitative components. In the quantitative component a non-equivalent quasi-experimental design is used. The control group used a traditional design-with-make class, while the treatment group consisted of a design-without-make class. Both groups were presented with pre- and post-tests, which were then compared statistically using an ANOVA test. Qualitative data was collected in semi-structured teacher and student interviews.

Operational Definitions

In order to better understand this study, several key terms must be defined.

Assessment-An evaluation of a student's cognitive achievement, which in North Carolina measures the student's performance based upon a series of questions pertaining to the North Carolina Standard Course of Study (NCDPI, 2006) and is derived from the Standards of Technological Literacy as defined by ITEA (2000).

Attitudes-A student's or teacher's feelings towards the design-without-make pedagogical approach.

Creativity-A process, which must be viewed as an investment consisting of a commitment of time, effort, and resources (Badran, 2007).

Design-The process of developing plans to convert resources into a finished product in which a human want or need is satisfied (ITEA, 2000, Wright & Brown, 2004).

Design-with-make-The traditional approach to technology education in which students design, build, and test solutions to real world problems (Banks & Jackson, 2007).

Design-without-make-An approach to teaching technology education in which students design, but do not make, innovative solutions to real-world problems (Barlex & Trebell, 2008).

Project-based learning-A method of teaching problem solving skills in which students work together as they progress through a series of steps to design, implement, and evaluate solutions to real world problems. (Mills & Treagust, 2003).

Assumptions

The following assumptions were made during the planning of this study:

1. Both of the *Fundamentals of Technology* classes used were at approximately the same level of aptitude to begin with.

2. The VoCats test for *Fundamentals of Technology* is a valid and reliable assessment of learning objective achievement within the North Carolina Standard Course of Study framework.

Limitations

The limitations of this study were:

1. The sample was one of convenience limited to two *Fundamentals of Technology* courses within one North Carolina high school and as such is not easily generalized across the entire population.
2. Funding and time for this study were highly limited, which put strict guidelines on the scope and sequence of implemented design activities.

Summary

In short, using quantitative, as well as qualitative methods, this study seeks to examine if design-without-make is as effective a tool in student learning when compared to the traditional design-with-make approach in technology education. Data will be gathered from pre- and post-test assessments as well as interviews in which teacher and student attitudes are reviewed. This study seeks to open teachers' eyes to design-without-make, a more feasible approach to teaching design within the project-based learning environment of technology education.

CHAPTER TWO

LITERATURE REVIEW

Introduction to the Literature

Throughout the years, technology educators have been bridging the ‘gap’ between other core subjects in education (Foster, 1994). Often this is done through the use of innovative projects, which are creatively designed and implemented to provide students with meaningful learning experiences (Banks & Jackson, 2007). However, with new standards, shortages in funding, and greater teacher accountability through state testing, teachers are pressured for time and funds throughout the educational year. To this end, teachers are pressured to modify curricula to include fewer projects, thereby discouraging creativity. The design-without-make pedagogy comes from David Barlex of England. In a design-without-make activity, students progress through the stages of the design process, much as they would in a design-with-make project, but without the prototyping stage. Since students do not actually build the prototype, they are not limited by the construction skills they possess or the resources available to their particular school. This allows for greater freedom in creative designing for technology students of all ages.

Social Learning Theories

Success in education can be directly linked to research done in social learning by Vygotsky (1978), Davydov & Kerr (1995), John-Steiner (2000), Murphy & Hennessy (2001). Trebell (2007) states that designing is a “social activity drawing on interaction between pupil/pupil and pupil/teacher” (p. 2). Teaching tools such as scaffolding and group work are very important in the social learning classroom. Vygotsky, stated “[t]he tasks that

the child can accomplish in collaboration with the teacher today, she can accomplish alone tomorrow” (as cited in Gredler, 2005, p. 324). He encourages teachers to challenge students by designing lessons that kept students in their Zone of Proximal Development, which is a level of performance just above what the student can achieve on their own, but not more than they can achieve with the teacher’s help. He concluded that students learn and reason verbally and that the teacher was only there to provide the social interaction which the students needed since students learn through social interactions with knowledgeable members of culture (Gredler).

Case for Design and Creativity

With the prevalence of so many standards and standardized testing in the education system today, teachers spend more time teaching to the test than to the skills students really need to be successful in society. Sternberg, Reznitskaya, and Jarvin (2007) states that “[t]he memory and analytical skills that are so central to intelligence are certainly important for school and life success, but perhaps they are not sufficient” (p.144). He proposes the “purpose of education is to develop not only knowledge and skills, but also the ability to use one’s knowledge and skills effectively” (Sternberg et al., p.144). This method of educating students to effectively use knowledge and skills is what he calls educating for wisdom. He explains how wisdom is made up of a combination of intelligence, creativity, and wisdom, which is then influenced by one’s personal value system on interpersonal, intrapersonal, and extrapersonal levels.

Notice that the each aspect of Sternberg, Reznitskaya, and Jarvin’s personal value system applies directly to the Standards for Technological Literacy (STL), developed by the

International Technology Education Association (ITEA), and is closely tied to the topics addressed in any technology education classroom. Standards and testing for standards help teachers ensure that students are gaining the intelligence and knowledge base that Sternberg, Reznitskaya, and Jarvin talk about, but how do teachers encourage their students to develop creativity? Why does it matter?

Creativity is becoming increasingly more important to the future because of the “unlimited horizons” it may open up, providing for ever-broadening, multidisciplinary creativity and innovation (Badran, 2007). For years experts have encouraged technology education teachers to take an interdisciplinary, if not multidisciplinary, approach in their teaching because technology is the field where all other disciplines and skill sets are applied. Most teachers have tried to use projects of varying types as a means to an end of connecting the various disciplines into hands-on creative ventures where the children get to express themselves. However, as educational standards continue to become stricter from year to year, teachers are pressured to modify curricula to include fewer projects thereby discouraging creativity. Are there other ways to encourage creativity that can better be integrated into curricula than time consuming, tangible projects?

According to the literature, there are a few ‘must haves’ to developing a creative classroom. First, creativity “involves departing from the facts (norms), finding new ways, making unusual association, or seeing unexpected solutions” (Badran, 2007, p.575). Therefore, creativity can be defined as a process, which must be viewed as an investment consisting of a commitment of time, effort, and resources (Badran). Second, the “Intrinsic Motivation Theory Principle of Creativity...defines that intrinsic, emotionally engaging

activities are highly conducive to creative acts” (Spendlove, 2007, p. 52). Spendlove also lists five ‘sure-fire’ killers of creativity, which are: expected reward, expected evaluation, surveillance, time limits and completion. However, Badran lays out a more positive formula for creativity in the classroom that states:

$$\text{Creativity} = \text{Function} \{ \text{Intelligence, Knowledge, Thinking, Personality, Imagination, Motivation, Environment} \} \text{ (p.576)}$$

In order to develop a technology education learning environment that develops and encourages creativity in its students, a well-rounded technology educator must be present. This person should be “creative, well-experienced...capable of steering the interest of students in solving problems, finding new solutions, taking risk...[and have] a mix of academia, practice, art and imagination” (Badran, 2007, p. 581). Badran also outlines that co-curricular activities, team work, diversified activities, and strong ties with industry are also important factors for developing creativity in the classroom.

Project Based Learning

Project-based learning is a method of teaching problem solving skills in which students work together as they progress through a series of steps to design, implement, and evaluate solutions to real world problems. (Mills & Treagust, 2003). Technology education in North Carolina is built around this concept with its ‘hands-on’ laboratory exercises that allow students to gain real-world experiences in developing, implementing, and evaluating technologies (NCDPI, 2006). In their research, Banks and Jackson (2007), describe how many students are motivated to take technology education by its hands-on, project based approach.

Design-with-Make. Traditionally technology educators have used design-with-make projects to enhance, encourage, and allow for creativity among its students. After all, when students are provided with LEGO™ robotics programming modules, they can easily create and develop interactive storylines and props to accompany any discipline; even literature (Berg, Pezalla-Granlund, Resnick, & Rusk, 2008). However, research has shown that:

“[p]oor practice with education is often focused for reasons of expediency on the product stages of the creative process and in doing so bypassing the essential creative (person) and learning (process) elements and resulting in embellished, rather than creative, novel and inspiring, outcomes with limited contextualized learning, emotional engagement or opportunities to engage in risk taking and uncertainty” (Spendlove, 2007, p. 53).

Kipperman and Sanders (2007) outline six basic steps in every Technology Education design-with-make activity. They are “identify and clarify problems; conduct research which might involve investigations; generate one or more design proposals; develop these so that they can be scrutinized for predicted performance and social/environmental impact; construct a prototype of the most promising design, experimenting with subcomponent designs as necessary; and test/evaluate the constructed solution” (p.227). They also recommend that “during this process the students should document all design, construction and testing procedures” (Kipperman & Sanders, p. 227).

This is what is commonly referred to in Technology Education as a Design Log, Design Brief, Engineering Log, or Design Journal. Regardless of the name, portfolio assessments tend to be ineffective as they are commonly not completed during the design and

construction process, which is largely dominated and regulated by the teacher, but rather after construction is finished to save time and reduce effort on the students' part (Barlex, 2007). A process Trebell (2007) refers to as “the development of creativity in students, the opportunity for them to propose imaginative solutions, take risks, be intuitive, inventive, and innovative in their work, has been sidelined by an approach which has become far too mechanistic” (p. 3).

Some easily integrated substitutes for projects that fit well into standards based technology education curricula and still encourage creativity are history of engineering, biographies of inventors, technical writing, and visits from professionals in technological fields (Badran, 2007). But, many students enroll in technology education courses because in their other classes they say “there was too much note-taking in the classroom and not enough hands-on learning” (Schwartz, 2007, p. 94). Perhaps then, a middle-ground solution still exists allowing for a hands-on design project effect without the time consuming prototyping phase. This process is called ‘design-without-make’.

Design-without-Make. A design-without-make activity is designed around six key concepts. These are “pupils design, but not make”; “pupils design products and services for the future”; “pupils use new and emerging technologies in their design proposals”; “pupils write their own design briefs”; “pupils work in groups”; and “pupils present their proposals to their peers, teachers and mentors and to adult audiences at innovation conferences” (Barlex & Trebell, 2008, p. 124). In their article, *Design-without-make: Challenging the conventional approach to teaching and learning in a design and technology classroom*, Barlex and Trebell, define creative activities as “having four characteristics: (a), imaginative

thought or behavior, (b) purpose, (c) originality (new to the creator) and (d) an outcome of value” (p.121). They also acknowledge that to develop creativity, “children must be actively involved in the learning process...[and] group work and collaboration are now seen as key elements” (Barlex & Trebell, p.121). Barlex and Trebell encourage teachers to challenge students with design-without-make activities which force students to design products based on conceptual (what it does), technical (how it works), aesthetic (what it looks like), constructional (how it fits together), and marketing (who it’s for) criteria without actually having to manufacture a final product for grading (Barlex, 2007, Barlex & Trebell).

Design-without-make activities work well in creative learning environments as defined by Isaksen (1994). He concludes that the more challenge, freedom, support, trust, prestige-free discussions, humor, and risk-taking the individual perceived in the immediate social work environment the more opportunity students have to be creative. This description is closely linked to the beliefs Barlex (2007) identifies as necessary for teachers who wish to host design-without-make activities in their classroom. He says teachers who believe “students intellectual abilities are socially and culturally developed”; “tasks need to be culturally authentic”; “prior knowledge and cultural perspectives shape new learning”; “learners construct rather than receive meaning”; “pupils share responsibility for learning with teachers”; and “pupils are motivated by dilemmas to which they are emotionally committed” (Barlex, p.156), will be most successful at integrating design-without-make activities.

Banks and Jackson (2007) point out how, despite many students being motivated to take technology courses because of the hands-on process of physically making a product,

these physical artifacts often lack any creativity or innovation on the part of the student, due to teacher designed plans. While these projects are easy to implement and fun for students to complete, often they are evaluated based on the completion of the product and an accompanying portfolio activity. In his research, Atkinson (2000) describes how when it comes to portfolio evaluation teachers tend to reward ‘thin’ evidence before rewarding students for exhibiting higher-order thinking skills. Barlex (2007) in a series of interviews with students in design and make classrooms learned that students tend to develop design portfolios after the product has been completed, which undermines the entire portfolio activity. When an entire class of students’ products are identical in appearance and they are not performing the proper design and problem solving processes during the creation phases of said products, are they putting innovation in action? More simply stated, are these students studying technology effectively?

This is the case for implementing design-without-make activities into Technology Education classrooms. Barlex’s research has “revealed that pupils can be successfully engaged in designing without attendant making and that the current use of the portfolio for assessment purposes is for many pupils a highly demotivating experience” (2007, p.160). He attributes this ‘demotivation’ to the fact of students not recognizing the value of the portfolio due to the way in which it is ineffectively implemented with the project, while he also points out that “the advantages of collaboration between pupils can be lost when there is an over emphasis on making” (Barlex, p.160).

Advantages of Design-without-Make. The implementation of design-without-make activities in place of some design-with-make activities within the Technology Education

classroom has many advantages. First, design-with-make is often approached as if the act of designing is a linear process, rather than an inter-connected, reflective, non-linear series of steps (Barlex & Trebell, 2008). Figure 1 shows Barlex's design decision pentagon, which demonstrated the interconnectedness of the elements within the non-linear approach to designing taught in design-without-make activities. Second, group work and active involvement in the learning process, and risk-taking are all encouraged in design-without-make activities (Barlex & Trebell, Trebell, 2007). These happen to also be important aspects of a creative learning environment, which is necessary for students to be innovative designers. A third major advantage of design-without-make in the classroom is the lack of large amounts of physical resources required in traditional design-with-make activities, such as: tools, equipment, and consumable materials (Barlex, 2007).

Figure 1. The design decision pentagon.

From "Design-without-make: Challenging the conventional approach to teaching and learning in a design and technology classroom," by D. M. Barlex and D. Trebell, 2007, *International Journal of Technology and Design Education*, 18: p. 122. Copyright 2007 by Springer Science + Business Media.

Yet another advantage is that design-without-make allows a teacher to bring the latest, newest, still-developing technologies into the classroom without any new cost to the school. This gives students unrestricted access to innovative design decisions that they may not have had otherwise. When students are limited by their own personal skill at building, they cannot design solutions outside of their own abilities. With design-without-make activities however, they can design solutions to future problems, using future technologies and techniques (Barlex, 2007, Barlex & Trebell, 2008, Trebell, 2007). Design-without-make activities are not meant to completely replace design-with-make activities. There is an inherent need for an understanding of how things are made (Banks & Jackson, 2007), but design-without-make is useful in emphasizing the preconstruction phases of product development (Barlex, Barlex & Trebell, Trebell), which is often referred to as the design phase.

CHAPTER THREE

METHODOLOGY

Introduction to Study Methods

This study comparing the effectiveness of design-without-make to design-with-make was conducted using a blended methodology. Quantitative data was collected using a non-equivalent quasi-experimental method while qualitative data was collected using semi-structured interviews. Quasi-experimental design is used for the collection of data when the environment of data collection does not meet the requirements for variable control, which is most often randomization of the sample (Gall, Gall, & Borg, 2007). In this case, a convenient sampling was used consisting of two North Carolina *Fundamentals of Technology* classes.

Experimental Design

Within the framework of a non-equivalent quasi-experimental design, a pretest (Appendix A) and posttest (Appendix B) are administered to the control and treatment groups (Gall et. al, 2007). The pre- and post-tests for this study were formed by pulling questions from the VoCats non-secure item bank relating to the objectives covered in the unit of instruction. For study consistency, both groups received identical pretests and posttests. Furthermore, both groups received units of instruction focused around the same set of objectives as pulled from the course blueprint for *Fundamentals of Technology* (NCDPI, 2006), as viewed in Appendix C.

As defined for this study, the independent variable is the application of design-without-make pedagogy, which takes place as the treatment within the experimental group. The dependent variable being the test scores of the students. Because of natural differences

between the two groups caused by the use of a convenience sampling, an analysis of covariance was used to control internal validity within the study (Gall et. al, 2007). Both groups within this study received instruction in the principles and elements of design as defined by NCDPI. The difference between the two groups was in the supplemental activities implemented as part of the classroom instruction.

Research Questions

The research questions this study sought to address included:

- 1) Did students who participated in design-without-make activities achieve learning outcomes as successfully as students of traditional design-with-make activities?
- 2) What are student and teacher attitudes towards design-without-make activities within technology education?

Research Hypotheses

The following research hypotheses identify the study testing instruments and subsequent data analysis:

HO₁: There will be no significant difference in knowledge gain between the traditional design-with-make (control) and design-without-make (treatment) groups.

HO₂: There will be no significant difference in attitudes between the traditional design-with-make (control) and design-without-make (treatment) groups.

HO₃: There will be no significant difference in the effectiveness of student achievement between the traditional design-with-make (control) and design-without-make (treatment) groups.

Population Sample

Due to the non-random sampling presented in the convenience sample taken, accurate generalization across the population is not possible. The sample chosen for this study consisted of two high school *Fundamentals of Technology* courses taught by the same instructor. The classes consisted of a total of 27 students, which was deemed adequate for statistical (Agresti & Finlay, 1997).

Control Group. For this study, after the pretest, the control group received a standard course of instruction in design principles and elements, consisting of a design-with-make reinforcement activity. Instruction consisted of a PowerPoint lecture on the principles and elements of design, while the design-with-make activity was reserved for students to design and construct a 2D or 3D advertisement for the technology of their choice. The lesson plans and PowerPoint, as well as activity guidelines, can be found in Appendix D. After completion of this course of instruction, students received the posttest and performance was evaluated.

Experimental Group. The experimental group also started with the pretest, which is identical to the pretest taken by the control group. Students then received the treatment, which consists of a PowerPoint lecture on the principles and elements of design which is geared towards the completion of a design-without-make activity. For the design-without-make activity students were asked to brainstorm and research an emerging technology. Then they were asked to design a new product for presentation to the class, incorporating the new technology they had researched to solve a real-world problem. Lesson plans, activity guidelines and PowerPoint lecture, can be found in Appendices C, D, and E. After students

had completed their presentations to the class, they took the posttest and their performance was evaluated. Again, the posttest for the experimental group was identical to the posttest of the control group.

Procedure

Two high school *Fundamentals of Technology* classes were randomly chosen and parental permission obtained for subject participation. This study was planned around a set of strict guidelines and took place during the week of March 16, 2009. One week prior, the researcher and the cooperating teacher met for a 2 hour teacher training session on the treatment pedagogy. The researcher outlined the entire study, the new instructional method, and provided the teacher with a set of materials relating to the instructional unit and activities. The researcher also introduced the subjects to the study.

Upon the start of this study, both groups took a pretest. Next they were taught virtually identical lessons on the unit material, with the only difference being slides related to the learning activities students would be completing in conjunction with the lessons. After completing the lectures, students were given handouts corresponding to the activities designed for their particular group within the study. Subjects then used the remainder of the week of instruction to complete the assigned projects and present them to their peer group. Once the unit requirements and study time had been fulfilled, students took the posttest. Throughout the study duration, the researcher gathered observational data relating to student involvement and problems encountered during implementation of the treatment lesson and activity.

At the end of this study, semi-structured interviews were conducted to gain an understanding of teacher and student attitudes towards design-without-make activities within the classroom. One teacher and two students involved in the design-without-make activity were interviewed.

Specific questions asked of the teacher were:

- What are your views on the quality of ideas produced?
- Would you recommend design-without-make to other [technology] teachers?
- Were the ideas produced creative?
- Did pupils come to value the ideas as a product in themselves?
- Did this strategy alienate pupils from the curriculum?

(Barlex & Trebell, 2008, p. 124)

The two student interviewees were asked:

- Their thoughts of design-without-make.
- What they actually designed?
- What they thought of their design?
- Would they have had to design something simpler if they had to make it?
- Would they recommend design-without-make as a way of enhancing designing skills?
- Did the unit lead to the production of creative ideas?

(Barlex & Trebell, 2008, p. 124)

Upon completion of the interviews, transcriptions were made and the data was collated into tables showing the questions asked as well as the responses given. The data was then

analyzed and conclusions drawn as to whether a positive or negative attitude was shown towards design-without-make overall.

Testing Instrumentation

The pretest and posttest were both derived from the non-secure test item bank that all North Carolina *Fundamentals of Technology* teachers are given with their curriculum guide for the course. Upon the completion of the item bank questions, the test items were evaluated by a panel of professors, teachers, industry professionals, and Department of Public Instruction officials to determine validity of each item (Shown, 2008). Additionally, reliability tests were performed on the questions as they were pilot tested during development by NCDPI (Shown).

In developing these instruments from the overall item bank, the researcher isolated questions relating to the specific objectives involved in the research study unit. Then duplicate items were eliminated. Next, every other item was chosen for the pretest and the remaining items were used in the posttest. Both tests were checked to approximate the consistency of items related to topics within the lesson and then one question was deleted from the pretest to make both tests of equal length for ease of comparison.

Data Analysis

After students took the pretest and posttest, the assessments were scored, and an analysis of covariance was performed to help account for extraneous variables within the study. Upon completion of the covariance, an ANOVA statistical analysis was run to compare effectiveness of objective achievement for each group. These statistics were compared to determine whether a significant difference exists between groups and to see

which hypotheses, if any, was correct. An ANOVA was chosen based upon the assumptions that the posttest score is normally distributed for each population as defined by the pretest, the variances are the same for all populations, and that the sample is randomly chosen from the population (Green & Salkind, 2003, p.161).

The qualitative data were analyzed using keyword coding, which seeks to identify keywords indicating attitudes within the interview transcriptions. The keywords were also assessed based on context to determine whether they exude a generally positive or negative attitude towards the design-without-make process. Additionally, a frequency analysis was run for each question to determine the number of positive and negative comments given by the interviewees. These results were then grouped into charts and conclusions drawn as to student and teacher attitudes towards the design-without-make activity over all.

CHAPTER FOUR

FINDINGS

Quantitative

A one-way analysis of variance was conducted to evaluate the relationship between instruction and the change in pre- and posttest scores between groups. The pretest scores were set as between-subjects factors, because of the comparison of scores between subjects, with two levels (i.e. control and treatment). The posttest score was set as the dependent variable, because of that score's dependence upon the initial pretest score and instructional methods used. Using SPSS statistical analysis software, the data was analyzed using a univariate linear model and then again using a comparison of means. Both tests yielded identical results.

The study consisted of 27 participants, with the control group having 10 and the treatment group having 17. The grand mean score from both groups (Table 1) came to 14.37 ($SD=5.43$). The assessment used has a standard error of 1.05. Posttest scores (Table 3) ranged from 4 to 22 out of a possible score of 22. With $F(11,15)=2.04$, $p=.05$, (Table 2) there were no significant differences between the control and treatment posttest scores.

Table 1

Descriptive Statistics

Variables	Definition		
Groups	Control		
	Treatment		
Independent Variable	Pretest Score		
Dependent Variable	Posttest Score		
Means			
	Pretest	Posttest	Difference
Treatment	10.88	14.71	3.82
Control	10.7	13.8	3.1

Descriptive Statistics-95% Confidence Intervals of Pairwise Differences in

Pretest and Posttest Scores between tests.

Group		<i>M</i>	<i>SD</i>	<i>N</i>
Treatment	Pretest	10.88	3.24	17
	Posttest	14.71	5.02	17
Control	Pretest	10.70	3.92	10
	Posttest	13.80	6.30	10

Table 2

ANOVA Results

		<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	Sig.
Posttest Scores	Between	459.43	11	41.76	2.04	.10
	Groups					
	Within	306.87	15	20.46		
	Groups					
Total		766.30	26			

Table 3

RawTestScores

Control Group				
ID #	Pre	Post	Pre-Post Difference	
1	13	14	1	
2	6	16	10	
3	7	4	-3	
4	8	10	2	
5	11	17	6	
6	9	4	-5	
7	11	12	1	

Table 3 Continued

8	20	22	2
9	11	19	8
10	11	20	9
Mean Difference:			3.1

Treatment Group

ID #	Pre	Post	Pre-Post Difference
1	6	13	7
2	12	18	6
3	14	22	8
4	9	20	11
5	6	8	2
6	14	21	7
7	13	17	4
8	5	16	11
9	17	13	-4
10	13	8	-5
11	8	5	-3
2	12	14	2
13	12	13	1

Table 3 Continued

14	12	22	10
15	10	13	3
16	10	11	1
17	12	16	4
Mean Difference:			3.823529

Qualitative

At the conclusion of the study, brief interviews were conducted involving the teacher and two students, one male and one female. After the interviews, transcriptions were made and the data were analyzed using thematic coding based on the identification of keywords and phrases. The questions asked of the teacher, as well as the teacher's responses can be seen in Appendix K, with the student questions and answers being found in Appendix L.

From this information, keywords/phrases were identified and coded as having a generally positive theme towards design-without-make, or a generally negative theme towards design-without-make. Some of the positive identifiers from the teacher interview were: much higher, not limited, choices, variety, use it all the time, advantage, like, conceptual, far greater, far better, input, and enjoyed. Some of the negative (teacher) identifiers were: especially the one that were with the make, don't like, not as much, why didn't we get to build something? (student quote), disadvantage, non-made, actually fabricate, skills, like making, and enjoy making. Some of the positive identifiers from the

student interviews were: interesting, I liked it, awesome, fun, worked out, different, good, nice, it could be useful, yes, and improve. Some of the negative (student) identifiers were: bad group, difference, and didn't work out.

After coding all of the data, frequencies were tabulated and attitudes were inferred from the frequency of positive to negative identifiers. It can be inferred from the data (Table 4) that the teacher had a generally positive view towards design-without-make, with a 2 positive comments to 1 negative comment ratio. It can also be inferred that the teacher can see both advantages and disadvantages to this methodology, but overall, they had a positive outlook for design-without-make. It can be inferred from the data (Table 5) that the students combined had a generally positive view towards design-without-make, with over 3 positive comments to every 1 negative comment. It can also be inferred that *Student 1* had a much more positive attitude towards design-without-make than did *Student 2*, although *Student 2* still had an overall positive response with a positive to negative ratio of 2:1.

Table 4

Overall responses: Teacher

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Totals
Positive	4	2	2	3	3	3	0	3	20
Negative	0	0	1	1	3	0	3	2	10

Table 5

Student responses

Overall Responses: Students (combined)								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Totals
Positive	9	0	3	1	2	3	0	18
Negative	3	0	1	1	0	0	0	5

Overall Responses: Student 1								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Totals
Positive	4	0	1	1	1	1	0	8
Negative	0	0	0	0	0	0	0	0

Overall Responses: Student 2								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Totals
Positive	5	0	2	0	1	2	0	10
Negative	3	0	1	1	0	0	0	5

CHAPTER FIVE

CONCLUSIONS

Summary of Study

For the purposes of this study, 27 students in two Fundamentals of Technology classes were chosen to participate in a one week unit focused on the principles and elements of design. The purposes of this study were: 1) to assess whether students who participate in design-without-make activities achieve learning outcomes as successfully as or better than students of traditional design-with-make activities; 2) to determine student and teacher attitudes towards design-without-make activities within technology education.

Participants completed a 22 item pretest and then received a standard course of instruction dealing with the principles and elements of design. Next they were assigned an activity related to the lecture. The control group was asked to create a new desktop or drawer type organizer out of cardboard, which is a traditional style design-with-make project. The treatment group designed organizers for use in a classroom and presented them to their peers for evaluation, which is a design-without-make assignment. After the projects were completed at the end of the week, all participants completed another 22 item posttest. The tests were scored and data was analyzed by the primary investigator. Two randomly selected students, one male and one female, were asked to do brief exit interviews. The teacher was also interviewed to assess attitudes towards the design-without-make pedagogy.

Research Question 1

Did students who participated in design-without-make activities achieve learning outcomes as successfully as students of traditional design-with-make activities?

In their research, Banks and Jackson (2007), describe how many students are motivated to take technology education because of its hands-on, project-based approach, but point out how, these physical artifacts often lack any creativity or innovation on the part of the student, due to teacher designed plans. While these projects are easy to implement and fun for students to complete, often they are evaluated based on the completion of the product and an accompanying portfolio activity. By incorporating design-without-make projects in the place of traditional projects, many of these negatives can be avoided. However, if design-without-make activities are not helping students reach their standardized test score goals, then it is of no use to the modern technology education teacher who is revered or condemned based on those scores.

From this study, it appears that design-without-make is as effective a tool for teaching design fundamentals to students as traditional design-with make activities. According to the data, there was no significant difference in student performance between the groups when run at a 95% confidence interval. Part of this can be explained by Badran (2007), who outlines that co-curricular activities, team work, diversified activities, and strong ties with industry are also important factors for developing creativity in the classroom. Creativity, which helps build intrinsic motivation within students (Spendlove, 2007), is becoming increasingly more important to the future because of the “unlimited horizons” it may open up, providing for ever-broadening, multidisciplinary creativity and innovation (Badran). Creativity is directly integrated into the Standards for Technological Literacy (STL), developed by the International Technology Education Association (ITEA), and is closely tied to the topics addressed in any technology education classroom. Standards and

testing for standards help teachers ensure that students are gaining the intelligence and knowledge base that Sternberg, Reznitskaya, and Jarvin (2007) talk about and, based upon the results of this study, design-without-make is an acceptable approach to teaching technology standards.

Research Question 2

What are student and teacher attitudes towards design-without-make activities within technology education?

Technology education in North Carolina is built around the project-based learning concept with its ‘hands-on’ laboratory exercises that allow students to gain real-world experiences in developing, implementing, and evaluating technologies (NCDPI, 2006). In their research, Banks and Jackson (2007), describe how many students are motivated to take technology education by its hands-on, project based approach. However, no research has been done to assess North Carolina student and teacher attitudes towards design-without-make.

The interviews completed in conjunction with this study imply that students and teachers alike have a positive attitude overall towards the design without make process. Interviewees positively favored the overall methodology with at least a 2:1 ratio of positive to negative comments. While the teacher did see some limitations to design-without-make, as well as value in the traditional approach, they still pointed out that design-without-make has many advantages to the traditional approach and that this new pedagogy should have a place in the modern classroom. The teacher emphasized the flexibility and availability of options to the students through design-without-make activities that are not present in design-with-make

activities, as well as the vast difference in the amounts of resources required to complete traditional projects as compared to the new design-without-make projects.

The students interviewed showed an appreciation for the flexibility allowed within the design-without-make approach also and felt they were allowed to be more creative in their designs than if they had been forced to construct their projects. While they too saw some limitations to the design-without-make process within their individual groups, they expressed a positive note in that they were not limited in their designs to the resources available to them as they would have been had this been a traditional design-with-make project. Overall, students and teachers favored design-without-make activities and recommended that others use them to teach technology principles in their own classrooms. These conclusions are further supported by research completed in 2008 by Barlex and Trebell, which states that teachers and students showed a favorable attitude towards the design-without-make approach when implemented in the classroom.

Implications

Design-without-make has many advantages to the modern technology education teacher. It promotes creativity, builds teamwork skills, helps students become more innovative designers, and requires far fewer resources than the traditional design-with-make activities. According to the data collected in this study, the design-without-make pedagogy is as effective as traditional design-with-make methodologies, which makes this pedagogy a new tool for the technology teacher. While design-without-make should not completely replace design-with-make projects in technology education, as technology education moves

towards more integration with other subject areas design-without-make may become an even more powerful resource to many.

Recommendations for Further Research.

This study can be used as a precursor to follow-up investigation with a more in depth design-with-make project or another design-without-make activity. Either may help reiterate and solidify the importance of the design process within students' minds. Future research in this area might focus around:

1. Building stronger data sets using larger samples to test pedagogy effectiveness.
2. Multiple units of instruction to determine which topics are best taught using design-without-make methodologies.
3. Determining the type of teachers for whom this pedagogy is best suited.

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APPENDICES

APPENDIX A

Pretest (5.01, 5.02, 5.03-Design)

1. When all of the parts of a design look as if they belong together, what principle has been achieved?
 - A. rhythm
 - B. proportion
 - C. balance
 - D. unity
2. This element relates to how something feels when you touch it and/or how it looks on the surface is:
 - A. shape.
 - B. texture.
 - C. line.
 - D. color.
3. The size relationship of one object to another refers to:
 - A. proportion.
 - B. emphasis.
 - C. variety.
 - D. balance.
4. What is a design proposal?
 - A. design rules regarding rhythm, balance, proportion, criteria
 - B. a systematic problem-solving strategy, with criteria and constraints
 - C. a written plan of action for solutions to a proposed problem
 - D. an interactive decision-making process that produces plans
5. The element of design process allowing the viewer to see items in an agreeable manner is:
 - A. harmony.
 - B. rhythm.
 - C. contrast.
 - D. variety.
6. The visual weight of an object or image in either formal or informal symmetry is:
 - A. unity.
 - B. harmony.
 - C. balance.
 - D. proportion.

7. The design element that refers to the ability allowing components of design to have agreement with no elements out of place or seem as they do not belong together:
- A. unity
 - B. shape
 - C. form
 - D. none of the above
8. Balance, proportion, contrast, variety, harmony, unity, and rhythm make:
- A. principles of design.
 - B. elements of design.
 - C. problem.
 - D. imagination.
9. A written plan that identifies a problem to be solved, its criteria, and its constraints is a:
- A. design principle.
 - B. design process.
 - C. design proposal.
 - D. design brief.
10. Design rules regard:
- A. manufacturing, machines, process.
 - B. systems, structures, economics.
 - C. rhythm, balance, proportion.
 - D. plan, principles, elements.
11. What is developed through an ongoing process of evaluation that allows a product to improve over time?
- A. symmetry
 - B. products
 - C. items
 - D. designs
12. The process of developing a design brief is to provide a(n):
- A. written plan that identifies a problem to be solved, its criteria, and its constraints.
 - B. explanation of the project that you will be developing.
 - C. graphic of the design process.
 - D. plan of action to give research and development engineers.

13. Which factor of a product's ability to be utilized would be considered to develop products that are produced in harmony with our environment and recyclable?

- A. safety
- B. quality control
- C. ergonomics
- D. environmental concerns

14. The study of workplace equipment design or how to arrange and design devices, machines or workspace so that people and things interact safely and most efficiently is known as:

- A. Ergonomics.
- B. Sociology.
- C. Electronics.
- D. Pharmacology.

15. The factors that influence a product's development must be determined by utilizing:

- A. safety, reliability, environmental concerns, maintenance, and ergonomics.
- B. research and development, product testing, and evaluation procedures.
- C. trial and error procedures, materials processing, and product testing.
- D. product need, public domain, manufacturability, and maintenance.

16. Which of the following defines a prototype?

- A. a rendering that show the exact sizes & shaped
- B. a model that offers color & depth
- C. a full scale working model
- D. a clay mockups with physical descriptions

17. The design of products as they relate to the systems of technology will ultimately change over time by the way individuals weigh the factors of a product's ability to be utilized. These factors include:

- A. reliability, quality control, ergonomics, quality control
- B. reliability, quality control, economics, quality control
- C. reliability, quantity control, economics, quality control
- D. technology, biology, anthropology, sociology

18. To comply with codes and regulations so as to provide safe operation of products by the developer and consumer is:

- A. safety.
- B. quality control.
- C. ergonomics.
- D. reliability.

19. The study of workplace equipment, design, or how to arrange and design devices, machines or workspace so that people and things interact safely and most efficiently is known as:
- A. Ergonomics.
 - B. Sociology.
 - C. Electronics.
 - D. Pharmacology.
20. The factors that influence a product's development must be determined by utilizing:
- A. safety, reliability, environmental concerns, maintenance, and ergonomics.
 - B. research and development, product testing, and evaluation procedures.
 - C. trial and error procedures, materials processing, and product testing.
 - D. product need, public domain, manufacturability, and maintenance.
21. Which of the following is a primary factor in development of new products and systems?
- A. ergonomics
 - B. manufacturability
 - C. safety
 - D. reliability
22. The ability of a product to be produced through feasible means and meet a need using available materials and resources is considered:
- A. manufacturability
 - B. a technological break-through
 - C. impossible
 - D. harmonious

APPENDIX B

Posttest (5.01, 5.02, 5.03-Design)

1. When a design may be separated into two equal parts that are symmetrical, the designer has achieved:
 - A. informal balance.
 - B. formal balance.
 - C. vertical balance.
 - D. horizontal balance.
2. Through repetition of lines, colors, shapes, and/or textures, one can achieve:
 - A. rhythm.
 - B. proportion.
 - C. unity.
 - D. emphasis.
3. The concept of “Design” is defined in this section as:
 - A. an interactive decision-making process that produces plans.
 - B. a written plan that identifies a problem to be solved, its criteria.
 - C. design rules regarding rhythm, balance, proportion, variety.
 - D. a systematic problem-solving strategy with criteria and constraints.
4. Establishing a point of emphasis to draw the viewers eye in on specific elements of a graphic or product is:
 - A. rhythm.
 - B. balance.
 - C. variety.
 - D. contrast.
5. To add elements of interest to a graphic or product to gain interest in a graphic or product:
 - A. variety
 - B. symmetry
 - C. rhythm
 - D. unity
6. Elements of design consist of the development of a product's:
 - A. line, formulas, planning, feedback.
 - B. line, design, concept, contrast.
 - C. line, product development, planning, evaluation.
 - D. line, shape, form, color, texture, space.

7. Which of the following is a systematic problem-solving strategy :
- A. design composure.
 - B. design strategy.
 - C. design process.
 - D. design concept.
8. To comply with codes and regulations so as to provide safe operation of products by the developer and consumer is:
- A. safety.
 - B. quality control.
 - C. ergonomics.
 - D. reliability.
9. The definition of design is an interactive decision-making process that produces plans by which resources are:
- A. converted into products or systems that meet human needs and wants.
 - B. thrown at problems before attempting a solution.
 - C. used to evaluate existing designs.
 - D. deemed necessary to become technologically literate.
10. A written plan of solutions to a proposed problem:
- A. design process.
 - B. design proposal.
 - C. design brief.
 - D. design principle.
11. What is needed to establish contrast?
- A. design agreement
 - B. movement
 - C. point of emphasis
 - D. size relationship
12. Balance, proportion, contrast, and variety are all part of the:
- A. principles of design.
 - B. elements of design.
 - C. universal systems model.
 - D. DEAL.

13. Information feedback related to measurement tolerances and specifications to assure proper production of products are:
- A. quality control.
 - B. ergonomics.
 - C. safety.
 - D. reliability.
14. One of the potential negative consequences of developing new design products or systems may be.
- A. new medicine
 - B. new materials
 - C. hazardous wastes
 - D. clean emissions
15. The product's life cycle is established through:
- A. observations and evaluations.
 - B. checks and balances.
 - C. processes and feedback.
 - D. laws of probability.
16. The developer must comply with codes and regulations to provide safe operation of products is the definition of:
- A. reliability
 - B. functionality
 - C. safety
 - D. ergonomics
17. The process of a product working properly utilizing proper materials within the development constraints is considered the product's:
- A. manufacturability
 - B. maintenance / repair
 - C. reliability / functionality
 - D. ergonomics
18. Information feedback related to measurement tolerances and specifications to assure proper production of products is:
- A quality control.
 - B ergonomics.
 - C safety.
 - D reliability.

19. One of the potential negative consequences of developing new design products or systems may be:
- A. new medicine
 - B. new materials
 - C. hazardous wastes
 - D. clean emissions
20. Which of the following defines a prototype?
- A. a rendering that show the exact sizes & shaped
 - B. a model that offers color & depth
 - C. a full scale working model
 - D. a clay mockups with physical descriptions
21. To comply with codes and regulations so as to provide safe operation of products by the developer and the consumer is the definition of:
- A. reliability
 - B. functionality
 - C. safety
 - D. ergonomics
22. The process of a product working properly utilizing proper materials within the development constraints is considered the product's:
- A. manufacturability
 - B. maintenance / repair
 - C. reliability / functionality
 - D. ergonomics

APPENDIX C

Control Group Lesson Plan

Design Principles and Process

Lesson Length-5 days (7.5 hrs.)

Overview and Purpose

This lesson is designed to help students learn the principles and elements of design. These fundamentals of design are often underemphasized and as such, students often do not spend adequate time considering these factors during the design process.

Objectives

- 1) Students will be able to identify and demonstrate an understanding of the elements, principles and factors of design.
- 2) Students will apply the principles, elements, and factors of design to a design problem scenario.

Standards Addressed

Standard 8-The Attributes of Design-Students will understand what it means to design in the Real-World.

Standard 9-Engineering Design-Students will understand the process of designing a solution.

Standard 11-Apply Design Processes-Students will demonstrate the ability to design a solution to a problem.

State Objectives Addressed

005.01-Identify the principles and elements of design

005.02-Describe how the design process relates to technology and other disciplines

005.03-Create a product based on the principles and elements of design

Prior Knowledge

Students should have a basic knowledge of Technology, its past, and what constitutes a technological system before completing this lesson. Without this knowledge it will be difficult for students to see how the components with the system relate to the part they are designing. If possible, discussion might flow better if students have read pages 145-147 and Chapter 9 in *Technology: Today and Tomorrow* prior to beginning this lesson.

Supplies/Materials/Equipment

For this lesson students will need some type of paper, perhaps colored pencils, the internet, and a place they can congregate in groups to work on their designs. Also, students may want to reference back to Chapters 7 & 9 in *Technology: Today and Tomorrow*.

Suggestions for Instruction

The instruction should be focused around the design process in general, with emphasis placed on the elements and principles of design and why they are important to the design process. Students should be given a chance to discuss this importance, so they can build their own connections within their cognitive framework.

Lesson Plan

Creative Writing- What considerations/factors should one take into account as they begin to design a solution to a problem? Why are some designs better than others? What characteristics must good designers possess?

Review – Reiterate the basis of Technology and its place in society. Give a brief history mentioning famous designers such as DaVinci, Franklin, and Edison. Briefly discuss what characteristics made them effective designers.

Motivation and Focus – Student motivation will come from an interest in changing the society in which they live. Students often can think of something new they would like to design. Emphasize the importance of the design process in the bigger picture of improving society.

Teacher Input – During the lecture, using the PowerPoint provided, the teacher should outline the basics of the design process. Define design, design brief, design principle, design process, and design proposal and identify the importance of each. Discuss the 6 elements of design: line, shape, space, form, texture/shade, and color. Explain the 7 principles of design: balance, proportion, contrast, variety, harmony, unity, rhythm. Identify

the 8 factors of design: safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance/repair, and ergonomics. Discuss how the elements, principles, and factors of design work together throughout the design process and show where each applies within Barlex's design pentagon. During the activity the teacher should give the students proper feedback on the appropriate use of the design process.

Guided Activity

In class students should work in groups on a design-with-make activity. Tell them to research a new technology and design a new implementation of that technology which solves a real world problem. Students should follow the design process outlined in the PowerPoint lecture, beginning with problem identification, then continuing through brainstorming, rough sketching, comprehensive layouts, and finishing with a 2D or 3D advertisement. Teacher input may be needed to help students pick a technology and problem. Students should then present designs to their peers for evaluation.

Assessment of Student

Students will be assessed on their understanding of the design process and the elements of design using a subset of VoCats questioned put together by the teacher.

APPENDIX D

Design-with-Make Activity

- Choose a technology of your choice and develop a 2D or 3D advertisement for that product.
- Advertisements must fit within a 9”x12”x15” space, unless specifically approved by the instructor.
- Students can use cardboard, modeling clay, magazine clippings, glue, or any other teacher approved materials to construct their designs.
- A design log should be kept to document their design process.
- Students will present designs to classmates
- Students will be evaluated using rubric from NCDPI.

Table 6
DPI Grading Rubric

Objectives	4 points	+	4 points	+	12 points	20 points for each objective
Brainstorming and research of information	Individual or group sharing of ideas	+	Organization skills and recording of ideas	+	Evaluation of ideas upon completion of gathering thoughts through more in depth research material with attention to references	
Thumbnails, working drawings, or desktop publishing	Pencil/ ink layout/ Mechanical/ CAD/ Desktop Publishing format	+	Organization skills and recording of ideas Layout and positioning of drawings	+	Finals layout of thumbnails, working drawings including line structure, dimensions, details and notes	
Mockups, product development	Materials or software used related to product development	+	Attention to details	+	Final production of mockup including shape, form, function, harmony, and balance	
Technical reporting or portfolio development	Data collection and processing of information	+	Details of the production methods and procedures	+	Composite of all necessary elements along with details within the portfolio	
Final product development	Production selections and supply list	+	Tools and production methods	+	Final production of product in relations to following the Principles and Elements of Design	
Total Points:						
Comments:						

APPENDIX E

Control Group Presentation

Our Standards for Technology Literacy State That:

“Design is regarded by many as the
core problem-solving process of
technological development.”

(R1 p.90)

Integration of Technology

“It is as fundamental to technology
as inquiry is to science and reading
is to language arts.”

(R1 p.90)

Apply Design Techniques to the Following

Graphic Presentations

Product Development

Principles of Design

- Balance
- Proportion
- Contrast
- Variety

- Harmony
- Unity
- Rhythm

(R1 p.237)

Design is to be a process of:

- Interactive decision-making
- Planning in the production of products and systems
- Converting Materials and resources
- Meeting human needs and wants to solve problems

(R1 p.237)

Design Proposals

“A written plan of action for
solutions to a proposed problem.”

(R1 p.237)

Designers are Driven to:

develop products that are creative
through inventions and innovations
that show resourcefulness ...

Our Human Ability is Distinguished as the:

ability to visualize and think abstractly
along with considering several solutions
for the same problem.

Elements of Design

Line

Shape

Form

Space

Texture/ Shades

Color

Development of Products in:

Communications

Transportation

Manufacturing

Construction

Biotechnology

Energy and Power

Design Factors Include

- Safety
- Reliability
- Economic Considerations
- Quality Control

- Environmental Concerns
- Manufacturability
- Maintenance/repair
- Ergonomics

Benefits -vs- Consequences

Weigh the benefits of the design against the potential hazards.

Remember our society is more environmentally conscious than ever before.

Our Ultimate Design Goal

“Earth is our home,
we must protect and preserve her for
future generations.”

Develop a Product

Students should establish products that are
creative and utilize their imaginations.

Newsletters

Prototypes

Models

Product Evaluation

- Brainstorming activities
- Research information
- Thumbnail sketches or ideas
- Working Drawings (if applicable)
- Mockups
- Technical Reporting or Portfolio Development
- Final product for evaluation

APPENDIX F

Treatment Group Lesson Plan

Design Principles and Process

Lesson Length-5 days (7.5 hrs.)

Overview and Purpose

This lesson is designed to help students learn the principles and elements of design. These fundamentals of design are often underemphasized and as such, students often do not spend adequate time considering these factors during the design process.

Objectives

- 1) Students will be able to identify and demonstrate an understanding of the elements, principles and factors of design.
- 2) Students will apply the principles, elements, and factors of design to a design problem scenario.

Standards Addressed

Standard 8-The Attributes of Design-Students will understand what it means to design in the Real-World.

Standard 9-Engineering Design-Students will understand the process of designing a solution.

Standard 11-Apply Design Processes-Students will demonstrate the ability to design a solution to a problem.

State Objectives Addressed

005.01-Identify the principles and elements of design

005.02-Describe how the design process relates to technology and other disciplines

005.03-Create a product based on the principles and elements of design

Prior Knowledge

Students should have a basic knowledge of Technology, its past, and what constitutes a technological system before completing this lesson. Without this knowledge it will be difficult for students to see how the components with the system relate to the part they are designing. If possible, discussion might flow better if students have read pages 145-147 and Chapter 9 in *Technology: Today and Tomorrow* prior to beginning this lesson.

Supplies/Materials/Equipment

For this lesson students will need some type of paper, perhaps colored pencils, the internet, and a place they can congregate in groups to work on their designs. Also, students may want to reference back to Chapters 7 & 9 in *Technology: Today and Tomorrow*.

Suggestions for Instruction

The instruction should be focused around the design process in general, with emphasis placed on the elements and principles of design and why they are important to the design process. Students should be given a chance to discuss this importance, so they can build their own connections within their cognitive framework.

Lesson Plan

Creative Writing- What considerations/factors should one take into account as they begin to design a solution to a problem? Why are some designs better than others? What characteristics must good designers possess?

Review – Reiterate the basis of Technology and its place in society. Give a brief history mentioning famous designers such as DaVinci, Franklin, and Edison. Briefly discuss what characteristics made them effective designers.

Motivation and Focus – Student motivation will come from an interest in changing the society in which they live. Students often can think of something new they would like to design. Emphasize the importance of the design process in the bigger picture of improving society.

Teacher Input – During the lecture, using the PowerPoint provided, the teacher should outline the basics of the design process. Define design, design brief, design principle, design process, and design proposal and identify the importance of each. Discuss the 6 elements of design: line, shape, space, form, texture/shade, and color. Explain the 7 principles of design: balance, proportion, contrast, variety, harmony, unity, rhythm. Identify

the 8 factors of design: safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance/repair, and ergonomics. Discuss how the elements, principles, and factors of design work together throughout the design process and show where each applies within Barlex's design pentagon. During the activity the teacher should give the students proper feedback on the appropriate use of the design process.

Guided Activity

In class students should work in groups on a Design-without-make activity. Tell them to research a new technology and design a new implementation of that technology which solves a real world problem. Students should follow the design process outlined in the PowerPoint lecture, beginning with problem identification, then continuing through brainstorming, rough sketching, comprehensive layouts, and finishing with presentation graphics. Teacher input may be needed to help students pick a technology and problem. Students should then present designs to their peers for evaluation.

Assessment of Student

Students will be assessed on their understanding of the design process and the elements of design using a subset of VoCats questioned put together by the teacher.

APPENDIX G

Design-without-Make Activity

- Work in groups of 2 or 3 on a Design-without-make activity
- Research a new technology and design a new implementation of that technology which solves a real world problem
- Follow the design process outlined in the PowerPoint lecture
- Prepare Presentation graphics of design
- Present designs to their peers for evaluation

Table 7
DWOM Rubric

Objectives	4 points	+	4 points	+	12 points	20 points for each objective
Brainstorming and research of information	Individual or group sharing of ideas	+	Organization skills and recording of ideas	+	Evaluation of ideas upon completion of gathering thoughts through more in depth research material with attention to references	
Thumbnails, working drawings, or desktop publishing	Pencil/ ink layout/ Mechanical/ CAD/ Desktop Publishing format	+	Organization skills and recording of ideas Layout and positioning of drawings	+	Finals layout of thumbnails, working drawings including line structure, dimensions, details and notes	
Marketing Display	Materials or software used related to display development	+	Attention to details	+	Final production of display including shape, form, function, harmony, and balance	
Technical reporting or portfolio development	Data collection and processing of information	+	Details of the design methods and procedures	+	Composite of all necessary elements along with details within the portfolio	
Marketing Presentation	Design presentation selections and supply list	+	Presentation methods	+	Final presentation of display in relations to following the Principles and Elements of Design	
Total Points:						
Comments:						

APPENDIX H

Treatment Group Presentation

Our Standards for Technology Literacy State That:

“Design is regarded by many as the
core problem-solving process of
technological development.”

(R1 p.90)

Integration of Technology

“It is as fundamental to technology
as inquiry is to science and reading
is to language arts.”

(R1 p.90)

Apply Design Techniques to the Following

Graphic Presentations

Product Development

Principles of Design

- Balance
- Proportion
- Contrast
- Variety

- Harmony
- Unity
- Rhythm

(R1 p.237)

Design is to be a process of:

- Interactive decision-making
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- Converting Materials and resources
- Meeting human needs and wants to solve problems

(R1 p.237)

Design Proposals

“A written plan of action for
solutions to a proposed problem.”

(R1 p.237)

Designers are Driven to:

develop products that are creative
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that show resourcefulness ...

Our Human Ability is Distinguished as the:

ability to visualize and think abstractly
along with considering several solutions
for the same problem.

Elements of Design

Line

Shape

Form

Space

Texture/ Shades

Color

Development of Products in:

Communications

Transportation

Manufacturing

Construction

Biotechnology

Energy and Power

Design Factors Include

- Safety
- Reliability
- Economic Considerations
- Quality Control

- Environmental Concerns
- Manufacturability
- Maintenance/repair
- Ergonomics

Benefits -vs- Consequences

Weigh the benefits of the design against the potential hazards.

Remember our society is more environmentally conscious than ever before.

Our Ultimate Design Goal

“Earth is our home,
we must protect and preserve her for
future generations.”

Design a Product

Students should design products that are
creative and utilize their imaginations.

Sketches

Concept Drawings

Presentations

Design-without-Make

- Design products and services for the future
- using new and emerging technologies in a design proposal, but do not make a prototype.
- Write your own design brief.
- Work in groups.
- Present your proposals to peers and teacher

Design Pentagon

Product Evaluation

- Brainstorming activities
- Research information
- Thumbnail sketches or ideas
- Working Drawings (if applicable)
- Marketing Displays
- Technical Reporting or Portfolio Development
- Marketing Presentations

APPENDIX I

NCDPI Curriculum Guide (Excerpt)

OBJECTIVE 5.01

Identify the principles and elements of design

The following outline characterizes what should be taught under Objective 5.01

- Explain the principles and elements of design
- Define design-related terms

The influence of the basic principles of design is predicated on our ability to visualize applications of design elements that have been established throughout time. The fundamentals of design are incorporated within every element of our lives. A range of knowledge and experience is necessary to become technologically literate. Everyday we are compelled to view developments through our senses as they relate to shape, form, function, harmony, and balance. Students will learn to apply these principles and elements by developing live projects for all disciplines. “Design is regarded by many as the core problem-solving process of technological development. It is as fundamental to technology as inquiry is to science and reading is to language arts.” (R1 p.90)

- Design – “An interactive decision-making process that produces plans by which resources are converted into products or systems that meet human needs and wants or solve problems”(R1 pg 237).
- Design Brief – “A written plan that identifies a problem to be solved, its criteria, and its constraints. The design brief is used to encourage thinking of all aspects of a problem before attempting a solution.” (R1 pg 237)

- Design Principle – “Design rules regarding rhythm, balance, proportion, variety, emphasis, and harmony, used to evaluate existing designs and guide the design process.” (R1 pg 237)
- Design Process – “A systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to winnow (narrow) down the possible solutions to one final choice.” (R1 pg 237)
- Design Proposal–“A written plan of action for solutions to a proposed problem.” (R1 pg 237)

Designers are driven to develop products that are creative through inventions and innovations that show resourcefulness utilizing their ability to visualize and think abstractly along with considering several solutions for the same problem. Ideas are stimulated by our personal senses as they relate to the elements of design. These ideas are processed by individuals and incorporated into new products. Designers work through a collaborative effort to achieve the best possible solution for new products and systems. Designs are developed through an ongoing process of evolution that allows a product to improve over time.

The principles of design consist of:

- Balance-determining the visual weight of an object or image in either formal symmetry or informal symmetry.
- Proportion-distinguishing the size relationship of various parts of the project or graphic as they relate to the finished product.

- Contrast- establishing a point of emphasis to draw the viewer's eye in on specific elements of a graphic or product.
- Variety-used to add elements of interest to a graphic or product to gain interest in a graphic or product.
- Harmony-utilized to add rhythm and allow the viewer to see items in an agreeable manner.
- Unity-refers to the ability to make components of a design have agreement with no elements out of place or seem as they do not belong together.
- Rhythm-the reoccurrence or repetition within a design that gives it the appearance that movement is taking place (R2, 144-146).

Table 8
Principles of Design

Line	shape	form	space	colors	shades

					texture

Product's physical descriptions as they relates to the human senses.

Objective 5.02

Describe how the design process relates to technology and other disciplines

The following outline characterizes what should be taught under Objective 5.02

- Explain how design is related to technology, such as safety, functionality, and economy
- Describe design processes related to various technological fields

The design process should be utilized to develop productive, useful products that may be advantageous to society in many areas such as communications, transportation, manufacturing, construction, energy and power, and biotechnology systems. Students will need to develop a new prototype or system by which they may make their observations and evaluations. The design of products as they relate to the systems of technology will ultimately change over time by the way individuals weigh the factors of a product's ability to be utilized. These factors include safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and the factor of human engineering (ergonomics). (R1 pg.104-105)

Description of each factor stated within glossary:

- Safety-to comply with codes and regulations so as to provide safe operation of products by the developer and the consumer
- Reliability/functionality- the process of a product working properly utilizing proper materials within the development constraints
- Economic considerations-development of jobs and products for the marketplace for individuals to purchase and pay tax on.
- Quality control-requires information feedback related to measurement tolerances and specifications to assure proper production of products
- Environmental concerns- developing products that are produced in harmony with our environment and recyclable

- Manufacturability-the ability of a product to be produced through feasible means and meet a need using available materials and resources
- Maintenance/repair-products produced with the intention of long life and low maintenance along with simple field replacement units
- Ergonomics- the study of workplace equipment design or how to arrange and design devices, machines, or workspace so that people and things interact safely and most efficiently

Design firms around the world are striving to compete with the ever-changing global marketplace. The human capability to initiate invention and innovation of new creative products and systems are evident in our world. Development of new products to fill our needs and wants will continue to change the way we think and act within our environment.

Benefits vs. Consequences of New Designs. As one develops new products and systems in this ever-changing society, he or she must weigh the benefits of the design against the potential hazards of it. The benefits of a new product must outweigh the hazards. For example, the development of energy sources that create pollution (such as fossil fuels and hazardous waste) must be compared to the development of energy sources that have clean emissions, as our society no longer accepts pollution as a trade-off for lower priced energy sources. Our society today is more environmentally conscious than ever before. Earth is our home—we must protect and preserve it for future generations.

The designs of new medical technology, equipment, and the development of many of the medications over the years have saved countless lives. Medicines to fight off diseases, such as polio, measles, and small pox, offer one hope in the current race to cure AIDS, cancer, and the numerous other incurable diseases that plague our world today.

Our current observations and discoveries about the design of genetic codes (such as DNA & RNA) are leading to many new, amazing rewards that will indeed change our future. Our ability to implement preventive measures for many birth defects is only one of the benefits. Another breakthrough medical advance is the ability to design agricultural products that are utilized in diet and medications for the treatment of a variety of health-related conditions. We now have the ability to create artificial devices that extend our lives by repairing or replacing certain parts of the body. Biotechnology is applied in advances toward the development of products that produce higher yields to feed the ever-growing world population. New developments in caring for our environment and developing specialized products have resulted in spin-offs such as pharmaceuticals, energy sources, and control of our environment, which help our world every day.

Table 9
Real World Examples of each System

Discipline Field	Design Example
Communications Systems	Wireless systems utilizing the Internet and advances in satellites present a future not yet imagined.
Manufacturing Systems	CAD/CAM control technology and the use of Robotics offer advances everyday.
Transportation Systems	Magnetic levitation systems and Automatic Guided Vehicles move products and people daily.
Structural Systems	Cities, and communities on earth along with the new development of the International Space Station.
Energy and Power	Solar, wind, hydroelectric energies are present example of only a few sources that are environmentally conscious.
Biotechnology	Genetic Engineering related to agriculture, environmental concerns, and medical advances.

Objective 5.03

Create a product based on the principles and elements of design

Creating Designed Products (For the Teacher)

The process of designing products based upon the principles and elements have been thought-out by many predecessors before us. We should include the variety of products that are common to our everyday use and incorporate new ideas that will change the world of tomorrow. Frank Lloyd Wright stated that, "Form should do more than follow function. It should enhance it." This in mind, students should establish products that are creative and utilize their imaginations. The extension of creating a prototype based upon the principles and elements of design should not be limited to an individual instructor's interpretation, but to the imagination and resourcefulness of the students. Students may choose to build prototypes that analyze how technology relates to other disciplines within the school. Students should consider constructing items of personal interest to explain the principles dealing with their scientific studies, mathematical concepts, or the processes related to the development of structures, energy, power, and transportation.

Product models are excellent ways to make learning fun and interesting.

Biology

Transportation

Physical Science

Structural Systems

Energy & Power Systems

Mathematics

Develop a graphic design using the basic graphic design components. Be prepared to present the graphic design to the class specifying the intended message and the target audience.

Evaluation of a graphics related prototype will be based on the following criteria:

1. Use of design elements (balance, proportion, contrast, rhythm, unity/harmony, emphasis) 0-20 points
2. Communicates an idea to the audience 0-20 points
3. Mechanics (method of development, rough sketch to camera ready art) 0-20 points
4. Final graphic (neatness, typeface uniformity, general appearance) 0-40 points

Evaluation of a three dimensional prototype will be based on the following criteria:

1. Prototype uses design elements (balance, proportion, contrast, rhythm, unity/harmony, emphasis) 0-20 points
2. Prototype design was communicated via sketches and CAD 0-20 points
3. Prototype design takes into account design factors such as ergonomics, safety, design-for-assembly and other relevant factors. 0-20 points
4. Prototype model was of good quality and served those purposes of prototypes such as showing a working version of the product idea 0-40 points

APPENDIX J

NCDPI Suggested Project Grading Rubric

Table 10

Creation of a product based on the Principles of Design

Use of design principles

Four or more of the Principles of Design are missing from the graphic design or have not been used according to design rules.	No more than three of the Principles of Design are missing from the graphic design. Or three principles have not been used according to design rules.	No more than two of the Principles of Design are not used according to design rules. Or one principle is missing.	The graphic design utilizes the Principles of Design (balance, proportion, contrast, rhythm, unity/harmony and variety) according to design rules.
0-11	12-14	15-17	18-20

Idea Communicated to Audience

Idea was not communicated to the audience without a detailed explanation and does not relate to design.	Idea was communicated requiring minimal explanation and varies from graphic design.	Designer communicated idea with minimal explanation.	Idea was communicated effectively to the audience.
0-11	12-14	15-17	18-20

Table 10 Continued

Mechanics

The method of development was not complete. There are no thumbnail sketches or rough layout.	The method of development has thumbnails sketches missing and the rough layout does not convey page layout.	The method of development is missing thumbnail sketches.	The method of development followed graphic design criteria. thumbnail sketches to camera ready art.
0-11	12-14	15-17	18-20

Final Graphic

The final product has no typeface uniformity. The general appearance of the product lacks neatness and organization.	The final product has no typeface uniformity. The general appearance of the product lacks neatness but is organized.	The final product has typeface uniformity and organization. The general appearance lacks neatness.	The final product has organization, neatness and typeface uniformity.
0-31	32-34	35-37	38-40

Total

Score

Comments:

APPENDIX K

Transcript of Teacher Interview

Table 11

Questions asked and answers given by the teacher

Questions	Teacher response
1. What were your views on the quality of the ideas produced in the Design-without-make group?	The class without make was much higher. One reason is because they are not limited to materials or supplies and the biggest thing is because they have more variety and choices. I think several of the students came up with two or three choices, whereas there were some that only came up with one choice, but at least they had more options.
2. Would you recommend the DWOM process to other Technology Teachers?	I use it all the time. One of the biggest reasons is because you can get more variety. One of the problems with making something is you have to have money, supplies, materials, tools, you have to spend the time in fabrication. And when you go through that process, you can consume large amounts of time just getting stuff together and that's the biggest disadvantage to it. Now, we don't have traditional woodworking shops and facilities of that nature anymore, so you are in the classroom most of the time building things and when you do that you are limited to space and what you can actually fabricate safely.
3. Would you consider the ideas that your students produced creative?	Yea, most of them were, especially the ones that were with the make. We used cardboard construction components and there were some very creative but some more than others depending on how many people were in the group, what the make up of the group was, and that type of thing. In the design without make the same thing. The make-up of the group, the individuals in the group, the brainstorming they went through, how much drafting skills and design skills each individual team member had to add to the group. That makes a lot of difference. They just got more variety since they weren't building something physical.

Table 11 Continued

4. Do you think students valued the ideas as products?	Well, there are some that no matter what you do with those students, they don't value anything. I'll be honest with you, now most of the students see building stuff and designing stuff as important because everything we use in life is designed and everything we buy is designed products and they make choices based on what they like and what they don't like. And like you and I, we both decide what we want based on what somebody else designed, but we also think, if I could have done this myself... And students do the same thing. That's an advantage for them understanding that each product is something they can put together and they can modify it to fit their needs.
5. Do you think students valued the products as much in the group that did not make compared to the group that did make?	No, not as much. Because the one's that actually built something can physically hold it and see it, and they understand that it's going to a purpose, it's a useful product, and I actually have them on my desk, the ones that did the desktop organizers. They will see them from now until the end of the year. Whereas the group that didn't make anything, they will see those others and they will say, "why didn't we get to build something?" That's a disadvantage. On the other hand they also know and understand that they had more conceptual ideas of far greater projects of far better demand, but if I'm given the opportunity, I could actually build those products. In some cases there are a few things that I will produce, but I will have to go home and do it in my own shop because I won't be able to do it here.
6. Do you feel that the DWOM strategy alienates students from the curriculum as far as what you are trying to get across to them?	No, I don't think so because everyone had input. I think without making something, they had more input to the group about the idea, about the structure of the group, the design brief within the group, the proposal on what they wanted to design, coming up with color, size, shape, and dimensions. It wasn't one person coming up with something, so much as the whole team having some input into developing the product for presentation purposes and when you see the presentations you'll get that because you'll notice everybody had a little bit of something to do with it.

Table 11 Continued

7. Is there anything you would change about this activity?

You know we've done these types of things in the past. After 25 years of teaching; I started in years where we built products, everything was fabricated. Every student designed something. Every student built something and from there we actually manufactured, fabricated, sold the products for a profit. You know my disadvantage today in technology education is because we are so computer driven and so design driven that yes, we can come up with 47 different non-made products, and they can learn from each of them, but until they actually fabricate something, then they don't have those skills that are necessary to work in workforce. On the other hand, everything in this society is being made by someone from a foreign country anyway, so it doesn't, its not the type of thing where we're producing things here all the time and there are many jobs where people design stuff all day long but never ever see the finished product. And that's a shame to me to see that.

8. Is there anything else you would like to add?

Yea, I really enjoyed the products. Conceptual ideas and product concepts seem to be the big trend today. Because we just don't have the facilities in technology education to build products like we used to. And that's a big change for us. And being old school teachers that came from the days of old vocational education; I'm one of those in that I still see the benefit of what we used to do. As opposed to lets just give them a computer and teach them all of the touchy-feely stuff about it. I've never been one to just lay all that out to them as being as important as just letting them build something themselves. I like making products. I think students enjoy making products. On the other hand we do things in class. We do the Metric 500 race cars. We do the bridges. We try to do small prototypes in class. But again we are limited in size, and scope, and time because everything is about that end of course test. I'm still one of those in that I still think that a test is not going to tell me everything about a student.

APPENDIX L

Transcript of Student Interviews

Table 12

Questions asked and answers given by the students

Questions	Responses from student 1	Responses from student 2
1. What were your thoughts about the design without make process?	I liked it. It was different. I've never done that before, but I thought that it was a good way to do something. We were able to take the project to the next level, with like knowing that if we were to actually build something out of like wood, it would take time and we got to actually design. I liked how we got to look at all aspects of it.	I thought it was very interesting that we had to design something without making it, but I liked it. It was awesome and fun. I had a bad group at times. But it worked out all right. Having a good group would have made a difference.
2. What did you design?	I did a podium and a desktop organizer.	I designed a desktop organizer. You could just sit it here and organize paper, pencils, rulers, markers, etc.
3. What did you think of your designs?	I thought my design could be...I don't know...I thought it could be useful.	It was interesting. We tried drawing it in a CAD program, but it didn't work out very well. But, overall, I think it went pretty nice.
4. If you were making this product, would you have to design something simpler?	Yes. It would take longer and we probably wouldn't have liked the resources at our school to buy the materials.	No.

Table 12 Continued

5. Would you recommend design without make as a way to enhance the design skills for students?	Yes.	Yeah.
6. Do you feel that this unit led to the production of creative ideas within your groups? Were you creative?	We looked at other peoples' designs and then we saw how we could improve them and stuff like that.	Yeah. Basically we made inferences about stuff that could be improved, attributes that could be added, such as we added a clock to our desktop organizer.
7. Anything else you would like to add?	No.	No.