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Introduction

Technology education is a field of study that seeks to promote technological literacy for all students. According to a recent study, in the United States, technology education is part of the state framework for 38 states, there are approximately 35,909 middle or high school technology teachers, and technology education is most frequently an elective course (Meade & Dugger, 2004). Indeed, students have an opportunity to learn about the processes and knowledge related to technology that are needed to solve problems and extend human capabilities through technology education. Wright and Lauda (1993) defined technology education as a program designed to help students "develop an understanding and competence in designing, producing, and using technological products and systems, and in assessing the appropriateness of technological actions" (p. 4).

The processes associated with technology have become key elements in technology education curriculum. A guiding influence in the development of this process-based curriculum has been the Technology for All Americans Project (Lewis, 1999; Loepp, 2004; Satchwell & Dugger, 1996; Wamsley 2003). With the publication of *Technology for All Americans: A Rationale and Structure for the Study of Technology* (ITEA, 1996), the suggested structure for the study of technology became the Universals of Technology which were identified as the processes, knowledge, and context associated with the development of technological systems:

> The processes are those actions that people undertake to create, invent, design, transform, produce, control, maintain, and use products or systems. The processes include the human activities of designing and developing technological systems; determining and controlling the behavior of technological systems; utilizing technological systems; and assessing the impacts and consequences of technological systems. (p. 16)

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Thus, solving problems in the context of technological systems has been identified as a key aspect of the curriculum commonly associated with technology education (Sanders, 2001). Activities that involve solving problems have been called the "philosophical nucleus" (Dugger, 1994, p.7) of technology education. Hill (1997) indicated that solving problems remains a major component of technological literacy.

Although this structure has been provided for the field, various paradigms for delivering the curriculum of technology education exist (Bensen, 1995; Devore, 1968; Hatch, 1988; Maley, 1973; Dyrenfurth, 1991; Savage & Sterry, 1990; Snyder & Hales, 1981; Wicklein & Rojewski, 1999). The actual practice of technology education in the United States has been a somewhat eclectic mix of approaches and instructional methods (Foster & Wright, 1996; Sanders, 2001). Bensen (1995) found that some programs operated with a singular concept of technology in which all the supporting parts of the curriculum were related to the whole. Others were characterized by a plural concept in which various technologies are emphasized without an effort to relate them to the larger picture of technology and its effect in our world. *The Standards for Technological Literacy* (ITEA, 2000) do not mandate a particular curricular approach (LaPorte, 2001) and technology education programs in the United States employ various approaches (Boser, Palmer, & Daugherty, 1998; Satchwell & Dugger, 1996). This fragmented focus and lack of a clear curriculum framework have been detrimental to the potential of the field and have hindered efforts aimed at achieving the stated goals of technological literacy for all students.

In recent years there has been a growing emphasis in the literature of technology education not only on the process of problem solving but also, more recently, on the integration of subject matter from various disciplines within those activities (Cotton, 2002; Engstrom, 2001; ITEA, 2003; Merrill & Comerford, 2004). This development leads to many questions for the field of technology education regarding the nature of the curriculum being offered and the proper approaches to take in administering that curriculum in technology education classrooms. As the field has begun to broaden its perspective and embrace ties with other disciplines, the topic of engineering design has begun to appear frequently in the literature (Dearing & Daugherty, 2004).

Engineering design is not simply a frequent topic in the literature of technology education; it has already begun to be included in the curriculum in some areas. Some states have adopted technology education curriculum models that are pre-engineering in nature (Lewis, 2004). *Project Lead The Way* and *Career Academies* that emphasize engineering, engineering magnet schools, and other conceptions such as the "Stony Brook" model are all examples of engineering content making its way into the middle and high school curricula (Lewis, 2004).

Conceptually, there are close ties between engineering and the field of public education known as technology education since "both engineering and technology treat solving practical problems as their philosophical nucleus"

(Dugger, 1994, p. 7). In fact, engineering has been defined as "the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind" (Accreditation Board for Engineering & Technology, 1986, p. 1). Engineers have been described as "creative problem solvers, often imagining and designing new technologies as a means to solve problems" (Burghardt, 1999, p. 1).

However, it is evident from an examination of the literature that there are certain aspects inherent to the engineering design process which are not included in technological problem solving (Fales, Kuetemeyer, & Brusic, 1998; Wright, 2002; Hailey et al., 2005). Technology educators have indicated the need for further explanation of these differences (Gattie & Wicklein, 2007) in order to gain the expertise necessary to be able to incorporate the engineering design process in technology education classrooms. The purpose of this study was to address the question: What are the essential aspects and related academic concepts of an engineering design process in secondary technology education curriculum for the purpose of developing technological literacy?

Method

Research Design

This study relied on input from experts in the field of engineering regarding the nature of the engineering design process and how it should be taught to secondary students enrolled in Technology Education classes. The Delphi research method was used because it allows experts to have input on the topic of this study in a very efficient manner. The primary purpose of the Delphi procedure is to obtain a consensus of opinion from a group of panels (Borg & Gall, 2003; Dean & West, 1999; Salancik, Wenger and Helfer, 1971; Rojewski and Meers, 1991). Delbecq, Van de Ven, and Gustafson (1975) stated, "Delphi is a group process which utilizes written responses as opposed to bringing individuals together" (p. 83). In addition, Rojewski and Meers (1991) stated that:

> Typically, the Delphi technique is used to achieve group consensus among participants. Consensus is determined using the interquartile range refers to the middle 50% of responses for each statement (i.e., distance between first and third quartiles). (p. 11)

This study used a four round Delphi process to ascertain and prioritize the essential concepts of engineering design for the secondary technology education curriculum. Descriptive and ordinal level data collection and analysis were used to interpret panel suggestions and opinions into a collection of descriptive information for decision making. In the case of this study no prior research had been done to explain the needed curricular components of engineering design for technology education. Therefore, the Delphi technique was deemed the best research strategy to ascertain a starting knowledge base for this topic.

Population and Sample

An initial group of engineering design experts was identified through contact with Dr. Clive Dym, director of the Engineering Design Center at Harvey Mudd College, Claremont, California. Dr. Dym is an internationally recognized expert on engineering design. In April of 2006, Dr. Dym was asked to identify a panel of 10 engineering educators whom he considered to be experts in engineering design who could serve as participants in this study. Dr. Dym actually identified 12 engineering educators whom he considered to be highly qualified. These 12 individuals were contacted through email and asked to identify an additional 10 leading experts in engineering design. Ten of the original list of 12 agreed to supply names and generated a pool of 59 names. All 59 experts in the area of engineering design were invited to participate in the study with plans to narrow the pool to the 25. The number of participants desired was 25 because this number would leave room for the possible attrition of some members of the panel during the study due to circumstances beyond their control (Martino, 1983). Twenty-two (22) individuals agreed to serve on the Delphi research panel. It is important to note that each of the participants completing all rounds in this Delphi research process had a background in mechanical engineering. They were also all employed in academic settings except for one. This commonality among participants provides strength and focus for the study in that it is easy to categorize the results of this study and compare them to the results of other studies with similarly homogenous groups.

Delphi Procedure

The first Delphi probe asked the participants to provide 7-10 phrases or short answers to the four research questions: (a) What aspects of the engineering design process best equip secondary students to understand, manage, and solve technological problems?; (b) What mathematics concepts related to engineering design should secondary students use to understand, manage, and solve technological problems?; (c) What specific science principles related to engineering design should secondary students use to understand, manage, and solve technological problems?; and (d) What specific skills, techniques, and engineering tools related to engineering design should secondary students use to understand, manage, and solve technological problems? A total of 15 out of the 22 original participants completed the Round 1 survey. Two hundred and thirty-four total responses to the four research questions were recorded. Categories were created as a way to organize the responses. This was accomplished with the use of two outside reviewers who evaluated each of the responses with regard to the four research questions of the study.

The second probe of the Delphi allowed the participants to indicate their level of agreement or disagreement with each statement categorized by the reviewers based on their assessment of the Round 1 data. In addition, participants were asked if there were any additional items that they wished to add to the list of responses from Round 1. The data from Round 2 were analyzed using descriptive statistics, yielding the mean, maximum, minimum, standard deviation, and interquartile range. The most important statistic involved in a Delphi study is the median response to each item (Dalkey, 1968) because this outcome most accurately describes the overall rating of the particular item. A third probe was used to allow the experts to see how others in the sample group responded in Round 2 and to give them a chance to revise their own responses in light of the group response to the same items. A fourth probe using descriptive statistics, and the mean, maximum, minimum, standard deviation, and interquartile range were calculated to determine the degree of stability and the level of consensus among the expert panel.

Results

A four-round Delphi research process was used to elicit the responses of experts to four open-ended research questions related to engineering design in technology education.

Round 1

The survey instrument was completed by 15 of the 22 persons who had agreed to participate. A total of 234 responses were received from the 15 participants during Round 1. In order to establish content validity, these data was sent to Drs. Paul Schrueders and Tim Taylor, engineering professors at Utah State University, so that they could review the entire list of responses and categorize the data into a list of unique items. The professional literature regarding the Delphi research process recommends a panel of at least two persons to monitor this process (Turoff, 1970) of identifying the items that will form the Round 2 survey instrument.

Round 2

The list of unique responses identified by Drs. Schrueders and Taylor during the review process became the items in the Round 2 survey instrument. Participants were contacted via email and directed to access the online survey in order to indicate their level of agreement with each item on a 6-point Likert-type scale. Thirteen (13) of the original 15 participants from Round 1 completed the survey. The Round 2 survey also included space for participants to add additional items they felt should be included in order to more fully answer the four research questions.

Round 3

The Round 2 survey responses were emailed to each participant to remind each of the their previous choices. The 13 participants who completed Round 2 also completed Round 3 of the Delphi probe. The survey contained all items from Round 2 along with statistical data. The mean, maximum, minimum, standard deviation and interquartile range were calculated for each item and displayed for the participants.

In addition to the original items and corresponding statistical data, fifteen new items suggested by participants in Round 2 were added to the Round 3 survey instrument. Since these were new items, they were identified as such and had no statistical data brought forward from the previous round. As in Round 2, participants had the opportunity to add any additional items they felt would help them to answer the four research questions. Eight additional items were suggested by participants and these items were added to the Round 4 survey instrument. In addition to having the opportunity to add new survey items, participants were encouraged to provide an explanation of their answer on any particular item.

Round 4

Since the literature supports a three-round Delphi (Linstone & Murray, 1975) and also indicates that most changes will occur in early rounds of the Delphi study (Dalkey & Helmer, 1963; Dalkey, 1968), it was decided to only include items in the Round 4 survey instrument that met one or more of the following criteria: (a) Items that had a mean shift of >15% between Round 2 and Round 3 were considered to be unstable and were included in Round 4; (b) Items with an interquartile range of >1 had not reached the level of consensus desired and were included in Round 4; (c) Items on which comments were made during Round 3 were included in Round 4, along with the comments, so that all participants could see their colleagues' feedback; and (d) Items that were added in Round 3 were included in Round 4.

Fifty items fell into one or more of these categories and were included in the Round 4 survey instrument. The Round 3 survey responses were emailed to each participant to remind each of the previous choices. Twelve (12) of the 13 participants who completed the Round 3 survey accessed and completed the Round 4 survey. Each item on the survey that was brought forward from previous rounds had the associated statistical data (mean, maximum, minimum, standard deviation, and interquartile range) listed beside the question. In addition, any comments made by participants whose previous answers were outside the interquartile range (IQR) were also listed along with the survey item.

Final Results

The final results for each item appear below in Table 4. In addition to the mean, median, standard deviation, and interquartile range scores, the mean shift during the previous two rounds is reported for each item. This score indicates the degree of stability for each individual item, while the IQR indicates the level of consensus afforded the item by the participants. As described in the methods section of this study, an IQR score of < 1 is considered to be an indication that the item has reached an acceptable degree of consensus. A mean shift of < 15% is an indication that the item can be considered stable.

The literature was vague as to the appropriate method to attribute different levels of significance to the statistical scores that result from Delphi studies. Therefore, a decision was made to maintain the highest standards for the purpose of this study. It was determined that applying the most stringent criteria to the data resulting from the Delphi process would ensure that only items that were undeniably very important would be placed in the highest category and considered in the conclusions and recommendations. All other items would fall into a secondary category of lesser importance. Items considered to be very important for the purposes of this research met each of the following criteria: (a) An inter-round mean shift percentage of <15% (indicating stability); (b) A median score of 5 or 6 (indicating a strong level of agreement among participants); and (c) An IQR range of < 1 (indicating consensus).

Only the forty-eight (48) items represented in Table 1 through 4 that met the strictest requirements would be considered valid for identifying the essential aspects and related academic concepts of an engineering design process in secondary technology education curriculum. Some of the definitions of engineering design in the literature are succinct and extremely broad: "Engineering design is a systematic process by which solutions to the needs of humankind are obtained" (Eide et al., 2002, p. 79). Another one is "Engineering design is the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints" (Dym, 1994, p. 17). Particularly for research question one in Table 1, many of the items are aspects for solving technological problems and they are not exclusive to the engineering design process. For research question number 4 in Table 4, note also that many of items pertain to general skills, techniques, and tools for solving technological problems and are not exclusive to the engineering design process.

Table 1 presents the final analysis of the Delphi research. The following items received the highest mean scores with regard to the essential features of the engineering design process for secondary students ($M \geq 5.0$): Ability to handle open-ended/ill defined problems (M = 5.77), Acceptance of multiple solutions to a single problem (M = 5.77), Systems thinking (M = 5.69), Oral communication (M = 5.54), Graphical/pictorial communication (M = 5.54), Understand problem identification/formulation/development of requirements lists (M = 5.38), Teamwork (M = 5.31), Conceptual design (M = 5.23), Critical thinking (M = 5.23), Ability to break down complex problems in manageable pieces (M = 5.17), Personal ethics (M = 5.15), Brainstorming and innovative concept generation (M = 5.15), Written communication (M = 5.08), Ability to integrate multiple domains of knowledge (M = 5.08), and Understanding of customer needs (M = 5.00).

In Table 2, the following survey items from the Delphi study received the highest mean scores: Multiple solutions to a single problem (M = 5.69), Basic Algebra (M = 5.54), Ability to handle open-ended/ill defined problems (M = 5.54), Geometry (M = 5.46), Spreadsheets (M = .23), and Trigonometry (M = 5.00).

According to the results of the Delphi study, the following survey items for research question three received the highest mean scores: Newton's laws: forces, reactions, velocity & acceleration (M = 5.42), Types of energy (M = 5.25), and Summation of forces/force equilibrium (M = 5.00) (See Table 3).

In Table 4, the following survey items received the highest mean scores: Ability to synthesize (*M* = 5.75), E-mail (*M* = 5.18), Ability to abstract (*M* = 5.17), Analogical reasoning (*M* = 5.17), and Presentation software (*M* = 5.00).

Table 1
Final Results for Research Question One Ranked by Mean Score

Research Question One: What aspects of the engineering design process best equip secondary students to understand, manage, and solve technological problems?

Item	Item #	Mean	Mean Shift (%)	Median	SD	IQR
Ability to handle open-ended/ill defined problems	15	5.77	5.65	6	0.439	6
Acceptance of multiple solutions to a single problem	17	5.77	2.75	6	0.439	6
Systems thinking	38	5.69	7.20	6	0.480	5-6
Oral communication	8	5.54	0.03	6	0.519	5-6
Graphical/pictorial communication	9	5.54	5.91	6	0.519	5-6
Understand problem identification/ formulation/development of requirements lists	1	5.38	7.97	6	1.387	5-6
Teamwork	5	5.31	1.51	5	0.630	5-6
Conceptual design	19	5.23	3.45	5	0.725	5-6
Critical thinking	35	5.23	0.01	5	0.832	5-6
Ability to break down complex problems in manageable pieces	14	5.17	3.40	5	0.718	5-6
Personal ethics	12	5.15	3.00	5	0.689	5-6
Brainstorming and innovative concept generation	18	5.15	3.00	5	0.801	5-6
Written communication	7	5.08	4.38	5	0.900	5-6
Ability to integrate multiple domains of knowledge	16	5.08	4.29	5	1.115	5-6
Understanding of customer needs	3	5.00	5.80	5	1.414	5-6

Table 2
Final Results for Research Question Two Ranked by Mean Score

Research Question Two: What mathematics concepts related to engineering design should secondary students use to understand, manage, and solve technological problems?						
Item	**Item #**	**Mean**	**Mean Shift (%)**	**Median**	**SD**	**IQR**
Multiple solutions to a single problem	53	5.69	4.18	6	0.480	5-6
Basic Algebra	40	5.54	2.89	6	0.660	5-6
Ability to handle open-ended/ill defined problems	52	5.54	1.34	6	0.660	5-6
Geometry	43	5.46	5.94	6	0.776	5-6
Spreadsheets	56	5.23	1.48	5	0.927	5-6
Trigonometry	44	5.00	3.23	5	0.913	5-6

Table 3
Final Results for Research Question Three Ranked by Mean Score

Research Question Three: What specific science principles related to engineering design should secondary students use to understand, manage, and solve technological problems?						
Item	**Item #**	**Mean**	**Mean Shift (%)**	**Median**	**SD**	**IQR**
Newton's laws: forces, reactions, velocity & acceleration	65	5.42	2.12	5.5	0.669	5-6
Types of energy	67	5.25	0.37	5	0.622	5-6
Summation of forces/force equilibrium	66	5.00	1.52	5	0.603	5

Table 4
Final Results for Research Question Four Ranked by Mean Score

Research Question Four: What specific skills, techniques, and engineering tools related to engineering design should secondary students use to understand, manage, and solve technological problems?						
Item	**Item #**	**Mean**	**Mean Shift (%)**	**Median**	**SD**	**IQR**
Ability to synthesize	86	5.75	1.01	6	0.452	5.75-6
E-mail	82	5.18	7.17	5	0.603	5-5.5
Ability to abstract	85	5.17	1.16	5	0.718	5-6
Analogical reasoning	87	5.17	1.70	5	0.718	5-6
Presentation software	84	5.00	3.17	5	0.738	4-5

Conclusions and Recommendations

As professionals in the field of technology education grapple with incorporating engineering design in secondary level classes, several conclusions can be drawn from this research. As the process of curriculum development moves forward, professionals in the field of technology education should make use of research-based content and instructional methodology in the creation of an overall curriculum framework for understanding and implementing engineering design. The development of a curriculum that emphasizes engineering design should be prefaced by the creation of a framework which provides insight from experts in the area of engineering design and extends the current Standards-based context of curriculum development. Currently there is no overarching framework for understanding and implementing engineering design content into secondary technology education classes.

Conclusion One

With the foregoing in mind, the first conclusion to be drawn from this research is to suggest that the field of technology education could be better served if the curriculum would focus on the integration of engineering design in technology education classes. The creation and widespread acceptance of such a curriculum framework could help to bring a greater degree of solidarity to a fragmented assortment of approaches to the delivery of technology education courses currently practiced in high schools across the country. This overarching strategy of creating and implementing a solid engineering design focused curriculum framework is significant to avoid a haphazard and disjointed experience for students and also for teachers attempting to use engineering design as a curriculum organizer.

There are numerous approaches to the delivery of technology education content currently practiced in the United States, and this fragmented approach has led to confusion. It has also eroded the ability of the field to create a unified public image that would give technology education a greater degree of acceptance and influence among high school students, teachers, and parents. Technology teachers have indicated that they feel engineering design has a positive perception by the general public (Wicklein, 2004). Major stakeholders in the educational environment including administrators, teachers, parents, and students need to be able to clearly identify the goals and major activities associated with technology education. Incorporating engineering design into technology education and clearly articulating the learning outcomes, class activities, and related career opportunities could serve to improve the public perception of the field and thus alleviate many of the image problems that exist.

Conclusion Two

The second conclusion to be drawn from this study is that integrating engineering design concepts into technology education classes could provide increased rigor as students apply academic skills and knowledge to technological problems. Career, technical, and agriculture education teachers are being encouraged to provide increased rigor in the curriculum and to emphasize the application of academic content where possible. Given this context, technology education would benefit greatly from the development of an engineering design focused curriculum that features a logical progression in course content from elemental skills in introductory classes to advanced work involving the integration of concepts from mathematics and science in upper-level classes.

Engineering design is a desirable curriculum component for technology education courses for curriculum developers who are seeking to move beyond trial and error problem solving. Participants in this study were able to identify and indicate a high level of agreement with 48 items that should be included in a technology education curriculum that emphasizes engineering design. This finding gives a strong indication that engineering design can in fact be considered as a potential contributor to the field of technology education. Professionals in the field of technology education should look seriously at the benefits of infusing the curriculum with content and methodology from the field of engineering design. It is therefore incumbent upon current technology teachers to seek out ways to educate themselves about engineering design and to seek out opportunities to learn more about an engineering design focused curriculum through professional development, additional coursework, and other opportunities.

Conclusion Three

The third conclusion that can be made from the results of the Delphi study is that since survey items that addressed such as issues as generating multiple solutions to a problem ($M = 5.77$), solving open-ended problems ($M = 5.77$), the ability to synthesize ($M = 5.75$), systems thinking ($M = 5.69$), and problem identification ($M = 5.38$) received the highest scores overall, an engineering design focused curriculum should emphasize these broad concepts. These findings had strong correlation to the *Standards for Technological Literacy* (ITEA, 2000) and other literature in the field that emphasizes problem solving and the ability to think broadly in the context of solving technological problems. A curriculum focused on engineering design could add significantly to student learning and the knowledge base with regard to synthesizing a variety of variables (science, technology, engineering, and mathematics) to solve ill-structured problems.

An important consideration at this juncture is the current educational climate of accountability in which secondary technology education programs exist. Technology teachers should clearly communicate the goals of their curriculum and the strategies employed so that parents, administrators, and counselors are aware of the traditionally academic content that students apply in technology education classrooms while solving technological problems. This can best be done through requiring students to carefully document and communicate their design process to others. This documentation can be in the form of background research, written descriptions, hand sketches, computeraided drawing (including 3D models), mathematical models, etc. Developing potential solutions in the planning stages may represent an improved way to enhance student understanding of design processes. Thus, teachers can display examples of student work so that stakeholders in the community become aware of the scope and nature of the technology education curriculum.

Conclusion Four

The fourth conclusion is that a variety of communication means should also be emphasized since items related to communication also received high scores. Oral, written, and graphical communication all were emphasized by the participants and were deemed an extremely important component of engineering design. This finding again has correlation to literature in the field of technology education which specifically emphasizes the necessity of good communication in a variety of forms (ITEA, 2003). A project-oriented curriculum that emphasizes teamwork and communication would be best suited for teaching the engineering design process.

Conclusion Five

The fifth conclusion from this study is that an engineering design-focused curriculum should emphasize teamwork and personal ethics. There was a high level of agreement that a secondary level technology education curriculum with an emphasis on engineering design should foster teamwork and interpersonal skills. It should also focus on the ethical responsibility of the designer to his or her fellow human beings. This finding somewhat contrasts with the typical instructional model that emphasizes the individual's responsibility to perform independently on standardized tests. This approach is congruent with the literature in the field (ITEA, 2000; ITEA, 2003) that emphasizes the importance of thinking broadly and looking for multiple points of view.

Conclusion Six

The sixth conclusion that can be drawn from this study is that the emphasis of a secondary level program should be on applying aspects of mathematical and science such as Multiple solutions (M = 5.69), Ability to handle ill defined problems (M = 5.54), Algebra (M = 5.54), Geometry (M = 5.46), Newton's Laws of Force (M = 5.42), Types of energy (M = 5.25), Spreadsheets (M = 5.23), Summation of forces (M = 5.00), and Trigonometry (M = 5.00) in ways that are directly connected to solving technology technological problems. At the outset of this study, it was thought that participants would identify many specific aspects of the various branches of mathematics and science that are especially useful in design situations. However, participants focused on general, course-related areas such as algebra, geometry, etc. rather than on detailed explanations of what specifically was most applicable. The emphasis seemed to be on structuring the curriculum so that students were required to make use of a wide range of mathematical and scientific knowledge in order to solve problems.

This wide range of subject matter encountered in the course of solving technological problems is a very beneficial development because it naturally fosters interdisciplinary instruction. Technology education teachers should seek out their colleagues in mathematics and science in order to foster collaboration on subject matter that might be unfamiliar. Collaboration with teachers from other disciplines can increase the depth of the content for students, enrich the teachers understanding of the related subject matter, and provide a more positive problem solving experience.

Conclusion Seven

The seventh conclusion from this study is that an engineering design-focused curriculum should include a hands-on component because prototyping/fabrication skills received high scores, as did product dissection. This finding fits well with typical technology education practice. In a time when the hands-on component of the curriculum has been de-emphasized in some circles, this study provided strong evidence that such learning experiences have an important place in the curriculum. Activities that emphasize modeling, fabrication, and so forth tend to be of higher interest for students and would help to create a contextual learning environment that would encourage students to truly apply academic skills and knowledge in the process of creating solutions to technological problems. Carefully structured activities can be of high interest to students while requiring them to use a variety of mental processes (Halfin,1973; Wicklein & Rojewski,1999), related academic content, and concepts from engineering design. This contextual based learning environment could be greatly beneficial to students and would follow established contextual learning models (Parnell, 1995).

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