Design Competitions as Tools for Change in Secondary (9-12) Technology Education: A Regional Case Study

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Abstract

Technology Education faculty at the secondary level share a kinship with college level Engineering, Engineering Technology and Architecture faculty in the kinds of open-ended design and team problem-solving projects given to their students. This kinship also provides a mutually beneficial relationship in terms of recruitment and access. However, there is a fundamental difference between the two in the epistemological tools they use to solve problems. At the secondary level the design and analysis tools are primarily practical and craft oriented using trial and error, whereas, at the collegiate level these tools are theoretical and based on a rigorous scientific paradigm.

The Creative Crane Competition was first held as part of an ASEE Regional Conference in Spring 2000. One of the goals of the competition was to foster a paradigm shift in the epistemological tools that secondary technology educators use in the design and problem solving process. This paper will present the theory, with supporting data, for using this design competition as an instrument for pedagogical change at the secondary level over a three-year period. It will also examine some of the issues and impediments confronting Technology Education in this process of change.

Introduction

The shift from Industrial Arts to Technology Education in the public secondary education system seems to be superficial. The name change more accurately reflects a shift from the industrial tools used in a wood or metal shop to that of a more current and identifiable technology. The issue here is real change that must also include the type of knowledge used and the role it plays in the learning process. This paper will discuss the use of Design Competitions, developed in academia, as a tool for change in secondary (9-12) Technology Education as a regional case study. The paper will outline the types of knowledge and the role it plays in today's society, the current pedagogical approach in Technology Education, and evidence of its reduced status and factors limiting change. The paper will also explain the Creative Crane Competition as a pedagogical model and will provide supporting data and analysis of its success.

Types of Knowledge[1]
Two basic types of knowledge are defined in this paper: practical knowledge and theoretical knowledge. Practical knowledge is comprised of three subgroups: literacy, craft knowledge and empirical knowledge.[2] Literacy is the knowledge to identify components without actually knowing from doing. Craft knowledge is the knowing that comes from actual hands-on doing. Empirical knowledge is a compiled understanding of knowledge codified into a rule-of-thumb, tables, or charts to predict simple behavior. These types of practical knowledge lack the ability to explain phenomena, thereby limiting its ability to accurately drive complex decision-making. Theory knowledge is the explanation of phenomena using a commonly agreed upon scientific methodology that is developed through a rigorous set of rules by a discipline of observation, identification, description and experimental investigation, to formulate a theoretical explanation of phenomena.[3] This type of knowledge is important in complex decision-making because of its ability to explain the underlying reason a phenomena will occur and why.

The Role of Knowledge
Knowledge is power, and it plays an important role in today's society.[4] The work of theorists Jean-Francios Lyotard[5] and Daniel Bell[6] form the working model used in this paper for understanding this role in, as they term, a post-modern or post-industrial society, respectively. Lyotard focuses primarily on two aspects. The first is the role of knowledge as a tool for productive power in a post-modern society that produces and consumes it in large quantities. The second role is the increase status and legitimation in a post-modern society of knowledge based on scientific theory versus other forms of knowledge.[7] Bell's focus on knowledge is related to the role it plays in a post-industrial society where the production and manufacturing of goods are replaced by a service society of managers, professionals and technical workers. He argues that the old industrial society was based on raw material and the use of practical knowledge as the mode of production.[8] The post-industrial society on the other hand is based on theoretical knowledge. Theoretical knowledge gives managers, professionals and technical workers the tool to make better decisions in a complex environment. In both theories the key is a highly educated society and the role specific types of knowledge play. Herein lies the mainspring argument in this paper. The only legitimate type of knowledge, in the context of our compulsory education system designed for social reproduction and global economic advantage

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[1] This is not a broad epistemological discussion rather its focus is limited in the use of knowledge in Technology Education.

[2] Peter McCleary, "Some Characteristics of a New Concept of Technology" in the Journal of Architectural Education 42, no 1 (Fall 1988). This article helped to develop and define aspects of this type of knowledge.

[3] Based loosely on the definition of science in the American Heritage® Dictionary of the English Language, Third Edition.

[4] Michel Foucault, Knowledge/Power: Selected Interviews and Other Writings 1972-1977, ed. C. Gordon. (New York: Random House, 1976).

[5] Jean-Francios Lyotard, The Postmodern Condition: A Report on Knowledge (Minneapolis: University of Minnesota, 1979). This work is one of the primary sources of post-modern theory and epistemology.

[6] Daniel Bell, The Coming of Post-Industrial Society (New York: Basic Books, 1973). This work presents a socio-economic forecast for the period after modernism, much of which has come to fruition.

[7] Lyotard defines the other primary form of knowledge as the literary narrative. He points out that the reduced status of this type of knowledge has a deleterious effect in areas such as architecture and aesthetics.

[8] Many of the complicated technologies developed during the Industrial Revolution relied on practical knowledge whereas today's complicated technologies are most likely backed up by science (i.e., the scientific theory) behind it.

with the appropriate status and value, is that which is based on a scientific and theoretical paradigm.[9]

Current Pedagogical Approach in Technology Education[10]

Technology Education has never really divorced itself from its traditional roots of the practical problem solving found in Industrial Arts Education. Industrial Arts Education was generally acknowledged to be vocational and occupational in nature, and the use of practical knowledge made sense. From an academic standpoint, Industrial Arts Education gave students an applied *humanities* appreciation and literacy of industrial artifacts and processes.

There is an effort in Technology Education to move away from its practical past, thereby increasing its status. Evidence of this can be found in the incorporation of more mathematics and science on student projects, the lobbying attempts for increased state assessment and course mandates, recognition of advanced coursework for college credit, etc.

There are many things of value that Technology Education should take with it in the context of distancing itself from its historical tradition: first, the valuable educational contribution it makes in technological literacy; second, the unique approach to design and problem solving. This approach includes open-ended projects, multidimensional real-world problems, cooperative teams, management, and hands-on learning.

Technology Education needs to leave behind the practical knowledge approach that it currently uses as a learning tool for problem solving. Practical knowledge is important, but not in the context of formal education because it's too artificial and has little currency outside this closed system. The process by which design decisions are made should be theory-driven using a scientific paradigm. In this form, it would be used as a powerful tool for decision-making in the design process. This important aspect fits into the larger context of a post-modern and post-industrial society where high levels of theory-driven education are necessary for it to function.

Two examples will be used to highlight the problem. The first is the Egg Drop Contest that is given in Technology Education all across the country. Using a limited amount of material, students design a cradle to cushion an egg dropped from a specific height. Unfortunately, this contest omits the introduction and application of theory explaining the laws of physics or engineering principles involved. What a student learns is the practical knowledge of crafting a protective basket through trial and error. A second example highlights the cultural difficulties Technology Educators have in seeing this issue. Several years ago at a meeting of the Suffolk Technology Educators Association (STEA) a senior faculty member presented an exemplary hands-on classroom assignment.[11] Using a given amount of paper, string, paperclips, glue and cardboard base, the assignment was to build the tallest tower that would then be put on a

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[9] Along the same lines, it could be argued that the best and most efficient place for practical knowledge to be learned is in the work environment. The educational environment can't properly reproduce the entire set of internal variables, external pressures and cultural values that goes into the decision making process in the real world that results in the acquisition of practical knowledge.

[10] This section pertains to secondary Technology Education at the High School level only. Technology Education at the Middle School level is more standardized and to some degree institutionalized due to a number of factors including State standards and assessment, commercially available text and learning modules, etc.

[11] Winter 2000 STEA meeting at Rocky Point Middle School, NY.

machine to simulate horizontal shaking similar to those in an earthquake. The teachers were divided into teams and proceeded to build and test the tower constructions. The assignment lacked a theory component. What would the designs be based upon, and what was learned regarding the decision making process? In both cases, design decisions were based on intuition external to the process and future refinements based on a trial and error schema. It is clear from these examples that this problem is not generally perceived by most technology educators.

There has been a relatively recent movement in Technology Education called MST standing for the integration of Mathematics, Science and Technology. This link provides some increase in status and reputation, but from my observation mathematics and science are used as descriptive tools for measuring and testing design performance, not as an applied theory tool. High-end Technology Education courses like Principles of Engineering (POE) are trying to integrate theory and MST, but its success has been uneven, the number of course offerings are low and it remains highly marginalized.[12]

Evidence of Reduced Status[13]
The status of Technology Education has been reduced in the academic political economy at the secondary level for reasons that are clearly linked to this argument of theoretical versus practical knowledge. First, it lacks the status and legitimacy of a state mandate above the eighth-grade level, and current discussions of making that assessment optional further erodes its status. At the same time, the state has increased the mandatory graduating requirements to include three years of Mathematics, Science and a Foreign Language. This increase in graduating requirements of courses with theoretical knowledge is directly at the expense of practical knowledge courses since many had only been only electives before. Second, because of the lack of a state mandate, Technology Education operates in a market economy for students to take these courses as electives. This creates obvious tension between enrollment, work levels and grades with compromises resulting. Third, because of the practical aspects of many of the course offerings, guidance counselors continue to steer students who perform poorly in academic subjects toward technology courses resulting in a *dumbing-down* effect.

Factors Limiting Change
Technology Education is constrained from change by both external and internal factors. Externally, the degree and certification process for becoming a Technology Education teacher is regulated by the state. The traditional path for becoming a Technology Education teacher is to obtain a Technology Education degree as a step in becoming certified. All other methods for certification are highly subjective and are at the discretion of the local BOCES regions.[14] This process of preparing technology teachers differs from the strictly academic subjects such as Mathematics, Physics, Chemistry, Biology, English, History, Political Science, Foreign

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[12] I have reviewed many POE courses as part of the articulation agreement process at the College. The success of POE in terms of the use of theory has more to do with who is teaching the course, their background and educational experience, than any other factor.

[13] This discussion applies specifically to New York State throughout this paper although this trend can be found elsewhere in the country.

[14] BOCES is an acronym for Board of Cooperative Educational Services that provides cost-effective instructional programs and shared services. BOCES has the authority to review and make recommendations on behalf of the State for interpretation of credits, life experience and additional coursework resulting in certification for holders with other than the Technology Education degree.

Languages, etc., who obtain academic degrees in their discipline. The point here is that pure academic disciplines are theory-driven with broad applications, whereas the Technology Education degree is practice-driven with a very narrow teaching application only. The problem compounds itself in that this degree does not require the basic Mathematics, Science and Engineering courses a freshman or sophomore would take in an ABET accredited program.

Internally, Technology teachers tend to recruit and encourage their successful students with specific aptitudes to enter Technology Education careers, and this acts like a form of institutional inbreeding. This is significant because these students fit a profile, with an inclination and orientation toward practical hands-on, non-traditional academic work.

Creative Crane Competition as a Model
There were two main reasons for developing the Creative Crane Competition.[15] The first reason was marketing in nature; promoting interest, rewarding excellence, inspiring students, etc. Although this is not central to the theme of this paper, it provides a justifiably pragmatic reason for the College, technology educators, and corporate sponsors to support the effort. The second reason was pedagogical in nature. This was to be a new kind of student competition, designed around a different model than that was currently being used. It was to integrate a specific type of knowledge that was learned in a very formal way that could be used as a tool in the design and decision making process. In short, there was a great deal of idealism as to the goals and contribution it would make in changing the culture of design competitions and in a broader sense the dialogue in technology education.

The competition was a two-part activity. The first part consisted of a series of learning modules that introduced various theoretical engineering concepts similar to a science laboratory course. Students tested, measured, recorded, charted and answered various questions regarding the concepts learned in the laboratory assignments. Learning the theoretical concepts in a rigorous environment accounted for more than two-thirds of the time spent on the competition. The second part consisted of the application of these concepts in a design problem. In this case, the initial design decisions were based on theoretical knowledge learned form the laboratory assignments. Refinements to the design after the first prototype could obviously include practical knowledge, but the overall basis is constructed from theoretical knowledge. And the point is that students could explain the design in theoretical terms and note where practical considerations were made. The competition utilized a number of mechanisms to assess all levels of investigation, understanding and application of theoretical knowledge. This included laboratory and assignment portfolios, the actual application through design, building and testing of the theory and an interview, by industry and academic judges, to assess correct understanding and application.

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[15] For a comprehensive description of the Creative Crane Competition see, Betz, Joseph A., "High School Design Competitions and ASEE Regional Conferences: Preliminary Data from the Competition held at the spring 2000 Mid Atlantic Conference," Proceedings of American Society for Engineering Education (ASEE) Fall Regional Conference, at C.U.N.Y. College of Staten Island, November 2001. The paper acts as a blueprint for successfully developing and marketing student competitions as part of ASEE Regional Conferences. It includes development of rules, laboratory experiments and assignments, costs and funding, marketing and delivery, external steering committees, student assessment and judging, competition day items and activities, on-line outcome surveys, quality control, etc.

The competition was also designed with many traditional and innovative pedagogical underpinnings. The competition was set up as a structured classroom learning activity that fully integrated components of Mathematics, Science and Technology along with the new State learning standards. The competition needed to target a wide range of student abilities (9-12) and Technology Education course electives, including World of Technology, Design and Drafting for Production (DDP), Architectural Drafting, Principles of Engineering (POE), Independent Study, Club Activity, etc.[16] Learning was conducted in a cooperative environment that emphasized teamwork. It was one of the first-of-its-kind to deliver a comprehensive competition entirely over the Internet.[17] The competition was peer-reviewed by the Technology Educators themselves through an external Steering Committee. Other valuable mechanisms for quality control included on-line feedback surveys from teachers and students, and corporate accounting reports for obtaining and sustaining the grant funding. All three mechanisms allowed for ample feedback, analysis and corrective modification of the entire competition, thus completing the assessment cycle.

Analysis of Data
Technology Education teachers who participated in the Creative Crane Competition over the past three years can be classified as having qualifications that fall into three basic categories, listed in the Teacher Qualification/Experience Categories below:

> *Teacher Qualification/Experience Categories:*
> 1. Traditional Technology Education degree. *
> 2. Traditional Technology Education degree plus intensive workshop participation in POE areas. **
> 3. Professional degree in Architecture, Engineering or Engineering Technology. ***
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> * This category accounts for the overwhelming majority of certified technology teachers and includes related degrees in Industrial Arts, Vocational & Occupational Education and combinations of AAS in Engineering Technology and Technology Education.
> ** Participants of a multi-week summer workshop in Principles of Engineering (POE) similar to the NSF funded program run by Stony Brook University and Hofstra University mid 1990's.
> *** Defined as Bachelors degree with significant theory content and design.

These categories are important in that they provide a baseline to measure trends and change. A simple understanding of change in this case would be if a very small percentage *at the head of the curve* were able to move the larger *middle group* to that position; then we could say there was a trend or change occurring. Let's define the *head of the curve* as teachers in Category 2 and 3 and the larger middle group as Category 1. The composition of teachers who attended the competition the first year (Y 2000), based on the Teacher Qualification/Experience Categories, is charted below. The composition of teachers who attended the competition two years later (Y 2002) is charted also for comparison. It is also important to note that 4/7th (57%) of the teachers who attended the first year (Y 2000) of the competition did not participate in the competition two years later (Y 2002).[18] This comparison chart clearly shows an increase in the number of

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[16] It is important to note that the introduction and application of theory is not as limiting as the sequential application of Mathematics and Science in grades 9-12.

[17] The URL is www.tech.farmingdale.edu/crane

[18] With one exception, the reasons for this turnover were factors unrelated to the quality of the competition such as retirement, transfer to a Middle School assignment or transfer to administrative assignment.

teachers with traditional technology backgrounds category 1. This shift indicates some level of change is in effect and some degree of acceptance of this pedagogical approach.

Comparison of Teacher Qualification/Experience Categories per year

Category	1	2	3	N
Y 2000	2	3	2	7
Percentage	28.5%	43%	28.5%	100%
Y 2002	8	2	2	12
Percentage	67%	16.5%	16.5%	100%

There are also some interesting observations that can be made from the increase level of commitment to the competition over the past three years. The trend is an increase in the number of teachers who attended the competition and a leveling off of the number who intend to participate. This trend shows that although teachers may want to participate in the competition, it takes time to prepare them. Also, the data may suggest that the competition may never grow much beyond twenty districts in any one year, but the number who attend could possibly come close to the number who intend to participate and that attrition may provide a continual supply of new participants.

Levels of commitment per year

	Y 2000	Y 2001	Y 2002
Districts/Teachers Attending[19] the Competition	7	8	12
Districts/Teachers that signed intent to Participate[20]	8	19	19
Districts/Teachers that <u>Attended</u> the year before that did not sign the intent to Participate next year	-	3*	3**

*Districts/Teachers and reasons for not participating:
Eastern Suffolk BOCES – This was a student club activity and not a classroom one. The student club elected to participate in another competition.
Islip - the teacher was reassigned to an administrative position in the same district.
Lindenhurst – The teacher elected to participate in another competition. This is the only voluntary case of a teacher not participating.
** Districts and reasons for not participating:
Carle Place – the teacher was reassigned to Middle School in another district.
East Meadow – the teacher was reassigned to Middle School in the same district.
West Hempstead – the teacher retired.
(Note, all teachers indicated they would have participated and attended the Competition again if their teaching status had not changed.)

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[19] Attending is defined as teachers whose students completing all parts of the competition and had one to three teams present at the day of the competition.
[20] Participate is defined as teachers who indicated they would on some level try the competition and who received a classroom competition kit. Although hard statistics were not kept on those who participated but did not attend, it is probably safe to say that about half of the group did some portion as a classroom activity and whose students did not finish in time for one reason or another.

Support Mechanisms

What has typically happened was that if a new teacher wanted to participate in the competition, they usually came to observe the competition the year before. The following year they would then attend one of the formal group workshops offered. The teacher would usually follow this up with individual workshop sessions and several weeks of e-mail and phone questions. Teachers in Category 1 tended to require the most intensive preparation. The support mechanisms helped with capability and confidence, but the most important factors for a teacher's participation were initial interest, the challenge offered in a conceptually new competition and being part of the *in-group* among teaching peers.[21] Very minor factors include administrative suggestions and student enthusiasm.

Conclusion

This is a paper about the power of an idea, the making of change and the value of specific types of knowledge. It is not a definitive study, so its conclusions are broad and general, and it asks more questions than gives answers. Three major points can be made from this regional case study that can be useful to us as educators. First, the role a design competition has to effect change. Although there is some degree of success, this change is really quite small in terms of a percentage of the overall technology teacher population. The competition's larger value is in its currency of ideas to effect other competitions, in modeling future classroom design projects and in making a contribution to the dialogue in Technology Education. Second, the competition is used to give us an understanding of the issues Technology Education is facing. This is important because of the kinship technology education has with engineering, architecture and engineering technology. Do we promote technology education, discard technology education or attempt change from our positions in academia? If we want our programs to connect to Technology Education, then we have to make a choice and take a position. Third, the issues presented allow us to reflect on the role and type of knowledge we use in our courses, curriculum and degree programs. What is the correct mix of theoretical and practical knowledge that a student needs to be successful as a design professional, manager or technical worker and where should learning each type take place, in the academy or in practice?

Acknowledgement

Biography
JOSEPH A. BETZ is an Associate Professor in the Department of Architecture & Construction Management at the State University of New York at Farmingdale. He received his undergraduate and professional degrees in architecture from the Rensselaer Polytechnic Institute and his post-professional degree in architecture from Columbia University. He is a recipient of the SUNY Chancellor's Award for Excellence in Teaching.

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[21] Most of the teachers who participated in the competition were well socialized in the local technology educators associations and hence felt part of the *in-group*.