AC 2010-2063: A FUNCTIONAL K-12 CONCEPTUAL FRAMEWORK FOR TEACHING TECHNOLOGICAL LITERACY

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A functional conceptual framework for teaching technological literacy

Abstract

This is a presentation of an epistemological framework for teaching technology such that it will bring about improved technological literacy in ALL K-12 students. Design, Living, Productivity, and Foundational Technical Concepts anchor our conceptual framework for teaching technology educators. This conceptual framework for teaching technology literacy is functional, standards based, and can accommodate multiple pedagogies. It meets the standards of ITEA/CTTE, the _______ State Dept of Ed., NCATE, and others. It also aligns with drafts of the NAEP Technological Literacy Assessment.

We have several successful Engineering Technology programs and a Technology Education program within our department. In 2007, faculty these programs worked together to provide engineering education professional development experiences for nearly 400 teachers; who in turn have taught thousands of K-12 students. This was facilitated with the assistance of a $1.7 million grant, and visiting faculty from several leading design centers in England. This conceptual framework is partially a result of the findings of that project. Within our Technology Education program, this is our framework for preparing technology teachers. These teachers promote technological literacy and engineering.

The four elements of the framework are 1) Design, 2) Living, 3) Productivity, and 4) Foundational Technical Concepts (FTCs). These elements are based upon decades of best practices from all over the world. The Design Element relies heavily upon the British successes in the past 25 years. Design is not only a summary experience for students but also pedagogy for practitioners. Design is an active mode of learning and a proper way to become literate in the tools and processes that promote productive life. The Life/Living Element becomes the students' mechanism for personalizing the learning experiences. All technological content is delivered relative to the learners' existence; hence it is all relevant. The Productivity Element explores how to determine if a process, tool, or system produces desired results. Productivity is known through consideration of benefits, expenses, and undesired effects. Every technology has values according to measures of productivity. FTCs are a large set of common technical concepts (commonly contained within the many "standards" or "benchmarks" for teaching technology). FTCs range from classic mechanics to biotechnology. It is not as important that every FTC be mastered by the learner -- as it is only FTCs the learner can integrate into their context that are truly learned. This strategy for defining relevant technical content by the life of the learner is radical.

Introduction

> "When we are accustomed to use bad reasons for proving natural effects, we are not willing to receive good reasons when they are discovered." (Pascal, 1662, passage 96)

Science, Technology, Engineering and Math (STEM) education have received a great deal of attention in the past few years. Perhaps the popular book, The World is Flat, by Thomas Friedman (2005) was the first of the series strong statements to escalate national concern with STEM. His interview with Rensselaer Polytechnic Institute President Shirley Ann Jackson spoke plainly to need for improved STEM education. The theme of that interview, Rising above the Gathering Storm, coincidently became the title of the 2007 National Academies report. The full title of this publication was: Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine. These experts clearly state:

> The United States takes deserved pride in the vitality of its economy, which forms the foundation of our high quality of life, our national security, and our hope that our children and grandchildren will inherit ever greater opportunities. That vitality is derived in large part from the productivity of well-trained people and the steady stream of scientific and technical innovations they produce. Without high-quality, knowledge-intensive jobs and the innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living. Economic studies conducted even before the information-technology revolution have shown that as much as 85% of measured growth in US income per capita was due to technological change. (p. 1)

Keeping pace with this pressing need, the white house has taken upon the Educate to Innovate (WhiteHouse Press release(s) (2009 & 2010) initiative):

> The AP (1/7) reports that on Wednesday, President Obama launched his $250 million "Educate to Innovate" campaign "to train math and science teachers and help meet his goal of pushing America's students...to the top of the pack in those subjects in the next decade." According to the President, "teacher quality is the most important single factor" influencing students' success or failure in STEM subjects. Educate to Innovate, he added, "will help train more than 100,000 teachers and prepare more than 10,000 new educators in the next five years." The AP listed "Intel Corp., the National Math and Science Initiative, PBS and the National Science Teachers Association" as investors in the initiative. Moreover, Obama "called on the 200,000" scientists employed by "the federal government to help by speaking at schools and participating in hands-on projects to help stoke a youngster's curiosity in science."

> The Washington Post (1/7, Anderson) reports that President Obama "announced the initiative in an afternoon ceremony at the White House as he honored...about 100 outstanding math and science educators from around the country." It also points out that the campaign "effectively doubles, to more than $500 million" the "philanthropic" STEM education campaign that the President "launched in November." Specifically, Educate to Innovate includes "a $13.5 million expansion of a university-based program called UTeach that aims to deliver 7,000 expert teachers by 2018; a commitment from public universities to prepare 10,000 math and science teachers a year...and efforts by NASA and PBS to promote effective math and science teaching." Said Education Secretary Arne Duncan, "If we're going to be economically competitive and continue to innovate and create jobs, we have to get much, much better in STEM education. ... There's a huge sense of urgency." (2010, ¶1, ASEE FirstBell@asee.custombriefings.com)

Currently, we have no courses named "How to do things," "How to solve problems," "How to build solutions," or "How to use what you have learned to make life better." Rather, we rely upon an age old assumption that the worthy students will "do" this on-their-own. However, as the drive towards "Educate to Innovate" by enhancing Science, Technology, Engineering, and Math (STEM) education gathers momentum, it becomes critically important to examine the epistemological base of teaching technological literacy. This paper is a functional conceptual framework for teaching it.

There are answers that can be immediately applied without need to acquire expensive equipment or curricular support materials. By adopting design as pedagogy, centering the design experiences within the living context of the students and using productivity as a value judgment, technological literacy can become a relevant topic for all students. These three principals (Life, Design, and Productivity) can be thought to act as three legs capable of holding any content within a Systemic Phenomenological approach to defining knowledge (Figure 1). In England & Australia, the Design Engineering and Technology approach to teaching incorporates content defined in a set of Foundational Technical Concepts (FTCs). These ideas will be examined in detail later in the paper.

Life, Design, and Productivity supporting any content can be thought of as a three legged stool supporting any content as illustrated in Figure 1. While FTCs are the part of the content definition in other countries, these three concepts can be used to support any learning objective. It is only a matter of the practitioner's expertise and creativity to contrive design experiences that demonstrate the mastery of any chosen learning objective.

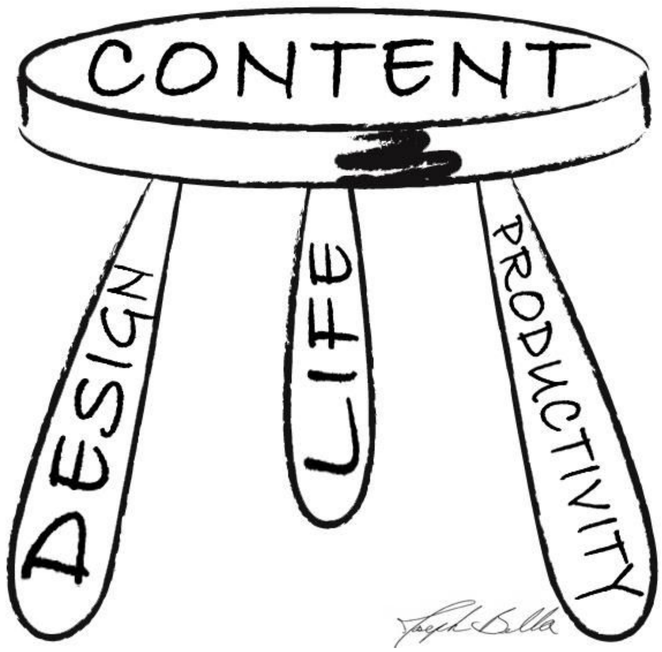

Figure 1: Life, design, and productivity supporting any content

Background

Technology is a topic of relevance to everyone. We all use techniques and tools to sustain life. We can imagine examples ranging from food production, gathering, preservation, preparation, eating (which has all use tools and techniques), to finally disposal of human waste. Our existence in a modern society is inexorably tied to the use techniques, processes and tools. Learning about techniques and tools makes everyone more capable. Hence, the discipline of Technology Education endeavors to impart technological literacy.

Technology is a study of techniques, tools and common concepts (DeVore, 1980, p.4). This study does include computers, the many parts of which computer is comprised, and the ways computers are used. However, it is worth stating that many more techniques, tools and concepts sustain our lives. Computers do not grow our food, heat our homes, or transport us from here to there. Common concepts and elements of computers have improved the productivity of many of the things that sustain life, but the computer does not do this by itself. Computers (control systems) are a group of common concepts in the study of technique (technology).

It is critically important to establish exemplary sample techniques and tools that are a part of every student's everyday life. Most adults I speak with have not touched a band saw (planer, joiner, etc) since high school wood shop because it is not in the common context of existence in our society and culture. Many of the common floor-standing machines that were common to a public school "shop" class are not common to the existence of the citizens whose taxes pay for it. The wood shop is an excellent form of self expression like pottery or painting, and should perhaps be folded into the crafts portion of the Arts curriculum. Collaboration among Art and Technology teachers could lead to some interesting things. Rather it far more appropriate to think of the techniques, tools, and concepts that are common to everyday life.

Technology Education as inherited from Industrial Arts, in the worst case has several serious issues: 1) an ethnocentric & sexist curriculum, 2) a general perception is that the curriculum prepares the next generation assembly line worker (and should be avoided by those who have greater aspirations), and 3) a lack of common understanding of what the curriculum is. These issues lead to several other problems that may diminish the role Technology Education could play in educating to innovate.

Technology (Education) has been so misunderstood that the name of the teacher-prep program became the name of the discipline; public schools list courses as Technology Education as opposed to Technology. Pre-service (university) programs that prepare Math teachers are "Math Education", programs that prepare Science teachers are "Science Education", programs that prepare Art teachers are "Art Education", etc. In the public schools, a math teacher teaches Math, not "Math Education"; a Science teacher Science, not "Science Education", an Art teacher teaches Art, not "Art Education"; etc. Even the Technology Teachers professional organization is named after the pre-service preparation program (_______ S**TE**A or I**TE**A), not the discipline taught. These organizations should be _______ S**TT**A or I**TT**A; the **TT** being Technology Teachers. It is worth noting that changes are afoot as this is being written.

In these worst case scenarios, there are no metrics to determine if a program or instructor is performing as expected. This can lead to ineffective teachers who have no-expectations of themselves or their students. This can be summed as:

- Shop as a holding pen for disruptive students.
- Shop as a holding pen for tenured and in-effective teachers.

Currently in the State of _______ , the term Technology Education is used to describe a broad range of different curriculums. The variety ranges from 1950s style "shop" classes to completely current pre-engineering career preparation. Technology (Education) was conceived as an academic discipline. It was expected that everyone would benefit from a greater understanding of techniques and tools. Technology (Education), the academic discipline, was supposed to be the next step in the evolution of Industrial Arts. It was supposed to be productive industrious action and a sense of responsibility combined with abstract knowledge with the intent of producing the new world citizen. As stated by DeVore "This will require a new kind of citizen, a citizen capable of intelligent individual and cooperative action" (1980, P. 310).

Supporting empirical evidence from the EoF Program

The _______ State College EoF program did not aim to implement a prescribed engineering education curriculum. Rather, this program introduced internationally proven pedagogical approaches for the content of engineering education. A design approach was presented and practiced as an integral aspect of the EoF workshops to give the participants hands-on experience with this teaching method. The program participants were encouraged to incorporate those instructional strategies within their classrooms. British educators embraced design as a pedagogical foundation for engineering and technology education related disciplines. EoF participants were advised to adopt this design-centered approach as a basic instructional strategy. EoF instruction emphasized the need for incremental incorporation of a design-centered pedagogy.

The program gathered many nationally and internationally recognized experts. Twelve British design experts were recruited to teach various design courses for the program. The British group was comprised of professors, teachers, authors and other design experts. They brought both their expertise and supporting instructional materials. In addition to the British experts, many nationally recognized American Technology Education professionals were recruited. The Americans included professors (both as instructors and external evaluators), and many other experts to support the program.

This was a multi-regional (statewide) program that sought to provide opportunities for teachers across four separate thematic areas. Each of these areas had a distinct connection to the future economy and employment landscape on a state, national and global level. Nationally and internationally recognized education leaders and industry representatives in concert with _______ State College technology education and engineering technology faculty collaborated to deliver this program. Teachers and school districts were able to choose from twelve separate 60-hour design/engineering based courses that occurred over a six week time span. The schedule enabled individuals to complete three of these courses if desired. Courses were available at regional satellite locations and a centralized site.

The objective of this initiative was to provide teachers with design based teaching methods, curricular content and activities that enabled design-engineering relevant learning in middle school and high school classrooms at a low to moderate cost. Participants were able to choose between a stipend or receive 4 graduate credit hours from _______ State College; an NCATE, and ABET accredited institution. The courses were formed around four themes:

1. Design, Innovation, Engineering and Technology
2. Engineering and Prototyping
3. Biotechnology and Bioengineering
4. Digital Electronics and Control Systems

This program considered a number of factors. First were the results of a general survey of engineering topics that had emerged in successful commercial programs that provide engineering education curriculum and resources. Secondly, a captive audience of technology education teachers currently enrolled at _______ State College in the M.S.Ed. program had been formally and informally queried over the four previous years. The result yielded three major impediments to implementing engineering based instruction: cost, capacity, and access. This initiative sought to eliminate those three obstacles through an essentially no cost experience for participants with low to moderate implementation costs.

Evaluation Overview

The evaluation plan for the _______ State College 2007 Engineers of the Future program was based upon four evaluation questions. All four of these evaluation questions implied that a measurable change would occur. The four evaluation questions were:

1. Did partnering schools implement rigorous pre-engineering curricula?
2. Did partnering schools teach mathematics, science, and technology through hands-on experiences in engineering-related content?
3. Did participating teachers gain subject matter expertise?
4. Did partnering schools offer engineering-related career paths awareness?

Evaluation of the program was performed in a fashion similar to a classic pre/post design. Data was gathered from various stakeholders within participating schools: teachers, counselors, and administrators. Data were gathered in four different phases: 1) prior to the summer sessions (during the registration process), 2) at the conclusion of each session, 3) at the beginning of the school year, and 4) 8-10 weeks into the school year. The primary instrument for Data collection was questionnaires mostly employing Likert Scales. Certain evaluation questions required the gathering of ethnographic data via response to essay questions and interviews. Post-implementation interviews and visits to selected participants were also undertaken by EoF staff. Data were analyzed to establish baselines and to determine if there were changes within the four categories.

Results of the early project analysis served as a formative evaluation dataset used to fine tune the curriculum for the summer courses. Instruments similar to those applied in the registration process were applied near the end of each the session, and twice again (start of the school year, and weeks 8-10). Data from the four different collections periods were compared to determine significant differences.

Method(s) of Analysis

Data collected during this project was grouped into four sets. Each set represented a progression in time and expected changes in behaviors. Common metrics were uses in the Likert Scale questionnaires. Data collected from each of the four phases was compared to determine any significant differences. Significance was determined by an alpha of 0.05 or less; (less than 5% chance of random selection providing results).

The nature of the data collected for this evaluation lent itself to analysis by the use of a General Linear Model (GLM). The method of analysis for the data collected from this project was an Analysis of Variance (ANOVA

The ANOVA, both factorial and one-way, used the General Linear Model (GLM). The GLM was selected because the data are arranged in categories. The method is essentially a form of regression, evaluating the distance from an "expected mean", however the expected mean was not based upon the slope of a "y = mx+b" sort of line. Instead of determining the "expected value" of y from the x-position, the expected value of y is determined by the mean of the category to which the value is assigned. If it were displayed on a Cartesian coordinate system, the y-axis is a continuous variable, however -

the x-axis of data is on a non-continuous scale - due to the data being based upon categorical groupings - as opposed to a continuous scale.

The arrangements of the groups are related in time; each of the four phases of data gathered occurs sequentially. However, there is not an equal interval by which the data are gathered. Therefore, to demonstrate change presumably due to project activity over time an ANOVA was the method chosen. This permitted the comparison of the categories of data collected at various phases of the project.

Finally, please note research results of this project are a quasi-experimental design. It is classified as such because the independent variables were not randomly assigned to the participants.

Findings

The entire findings document for the project is quite lengthy; therefore findings presented are condensed into a brief. This brief review of the project findings reveals several of the significant findings: Differences in participant teacher pre-post measures indicated:

- Improved belief in their subject matter expertise. $F(1, 411) = 49.87$, $p < 0.001$.
- Believed they had received materials to support teaching engineering related career paths awareness. $F(1, 403) = 56.35$, $p < 0.001$.
- Improved belief they were able to align rigorous pre-engineering curricula with appropriate state standards. $F(1, 422) = 12.32$, $p < 0.001$.
- Believed they had administrative support for teaching engineering related career paths awareness. $F(1, 394) = 6.08$, $p = 0.014$.
- Believed their schools' administrators had a clear vision of rigorous pre-engineering curricula. $F(1, 409) = 7.80$, $p = 0.005$.
- Improved belief teachers were able to deliver hands-on experiences in engineering-related content with the _______ State Technology Education Framework Initiative. $F(1, 407) = 10.57$, $p = 0.001$.
- Believed their schools' administrators had a clear vision of what constitutes a hands-on experience in engineering-related content. $F(1, 405) = 4.97$, $p = 0.026$.

Findings from immediately after the program and qualitative interview responses from several months after the program:

- Believed the program presented materials to support engineering-related career paths awareness? $F(1, 144) = 5.42$, $p = 0.021$.
- Believed their schools' administrative support for engineering-related career paths awareness had improved. $F(1, 239) = 3.15$, $p = 0.045$. Multiple comparison findings revealed that several months after returning to their schools, teacher belief in administrative support had significantly improved. Tukeys HSD , $p = 0.041$ in comparing pre with post qualitative interviews.

A sample of 34 qualitative interviews were conducted with teachers across the state several months after the teachers returned to their schools. Among those findings, of particular interest was the degree to which the schools implemented rigorous pre-engineering materials. Figure 2: Implementation of materials illustrates the proportion of teachers who were using the program materials and what they planned to do in subsequent terms.

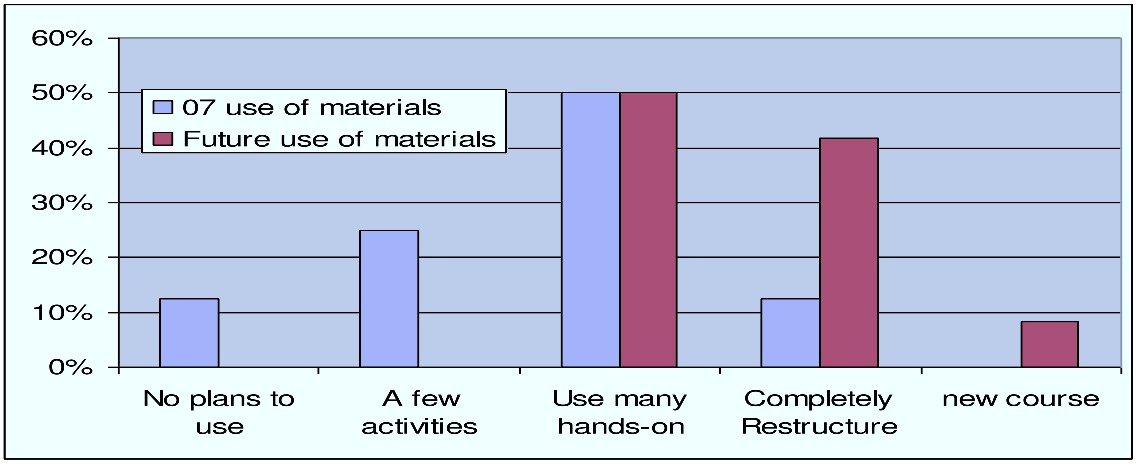

Figure 2: Implementation of materials

Generally, the teachers indicated they needed more time to implement the materials received through the project. Their experience in the program ended only a few weeks before the start of the school year. Many of their classes had already been planned prior to their participation. However, they did make use of the materials in subsequent terms.

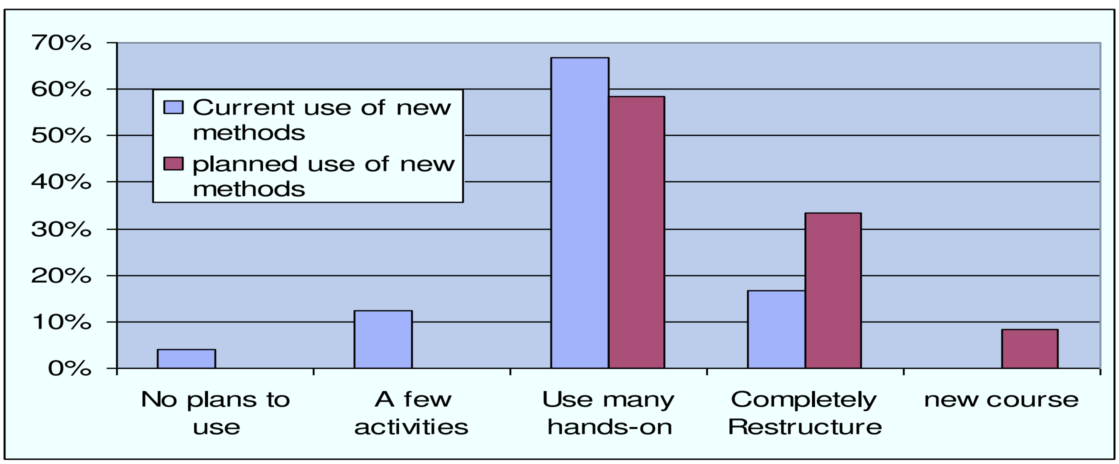

Figure 3: Implementation of new methods of instruction

Figure 3: Implementation of new methods of instruction was based upon a sample of 34 qualitative interviews conducted with teachers across the state several months after the teachers returned to their schools. Among those findings, of particular interest is the degree to which the schools implemented new methods; e.g., design as pedagogy. As with the new materials, time to integrate the new methods into their existing courses was an important factor. Interviews with participating teachers revealed

initial adaptation of new methods was slow. Mostly, teachers added a design activity. In-service teachers stressed that they need time to integrate it into their courses.

Conceptual Framework

The technology literacy curriculum needs to be firmly founded in the context of the student. Every student is alive, and has an interest in sustaining life. This notion is eloquently stated in John Dewey's famous pedagogical declaration. It was published in The School Journal, Volume LIV, Number 3 (January 16, 1897), pages 77-80. He states:

> I believe that all education proceeds by the participation of the individual in the social consciousness of the race. This process begins unconsciously almost at birth, and is continually shaping the individual's powers, saturating his consciousness, forming his habits, training his ideas, and arousing his feelings and emotions. Through this unconscious education the individual gradually comes to share in the intellectual and moral resources which humanity has succeeded in getting together. He becomes an inheritor of the funded capital of civilization. The most formal and technical education in the world cannot safely depart from this general process. It can only organize it or differentiate it in some particular direction.
>
> …
>
> I believe that the school is primarily a social institution. Education being a social process, the school is simply that form of community life in which all those agencies are concentrated that will be most effective in bringing the child to share in the inherited resources of the race, and to use his own powers for social ends.
>
> I believe that education, therefore, is a process of living and not a preparation for future living.

Given Dewey's stated beliefs, it is critical to treat the learner "as-if" they are living, and engage them in solving real design problems in their life. It becomes the role of the teacher to manipulate the design process to include the abstracted principals of Science & Math in a meaningful way such that the learner applies these principals to solve their problems. These real design problems can be presented to learners as problems centered in the lives. Categorical examples include:

Living: The acts of using techniques and things to LIVE THE LIFE WE WANT
- Where we live (environments- natural & contrived)
- How we live (sustaining life, and ways of life)
- How do we want to live (sustainability, scale, qualities vs: quantities)
- Safety (feeling secure - can technology do that?)
- Entertainment (gaming, movies, music technology)

The learner will contemplate the techniques used in living. Their problems may define issues with a lack of productivity (expectations not met can lead to design briefs). The role of the teachers includes the responsibility to ensure the real design problems criteria are manipulated to direct the learner to master desired objectives. Their solutions to the real design problems will then be demonstrating that the desired learning has occurred.

In Language Arts (Literature), the curriculum does not attempt to cover **all** literature or **all** poetry – rather exemplary samples are presented. Music, Art, Science, and History do not attempt to cover **all** of History, Science, Art or Music -- rather exemplary samples are presented. The samples selected typically represent a common framework (Epistemology) of the society and culture; of which the school is a part.

Technology, the study of techniques and tools, will also be best presented as a reflection of the society and culture; of which the school is a part. There are common techniques and tools in our society and culture; of which the school is a part.

<u>Design (observe, choose & create)</u>

Design includes the acts of PLANNING WHAT WE WANT. Design, as a process referred to in this paper, can be best defined in the works of Victor Papanek. Papanek was the author of Design for the Real World (1971, rev 1984).

> All Men are designers. All that we do, almost all the time is design, for design is basic to all human activity. The planning and pattering of any act towards a desired, foreseeable in constitutes the design process. … Design is the conscious effort to impose meaningful order. (1971, p. 3)

Dr Andrew Horton has established himself as an expert practitioner of the use of design as pedagogy. He has taught design for over 25 years in settings that include international schools, regional American universities, and high schools. He was also a co-author of the textbook Creativity, Design and Technology (1989). During a May 21, 2009 interview with Dr Horton, he stated "teach at the students level – there should be no perception of a social superiority purported from the teacher … Let the student find their design passion …"

Design as pedagogy means the method of instruction is to engage students in the design process. The process generally consists of several familiar steps:

1. Developing a design brief (design statement/problem definition)
2. Research
3. Proposing solutions (creative problem solving)
4. Selection of a solution
5. Building a prototype
6. Testing & evaluating solution
7. Reiterate the process

Design portfolios are developed as documentation of the steps listed above. A design portfolio would include the design brief, notes, research, drawings, and artifacts developed in the process. The portfolio is evidence that learning objectives have been mastered. This becomes especially clear when engineering principals are practiced; they typically exemplify the application of math & science principals.

British Design and Technology

Design and Technology has been a part of the British national curriculum for more than twenty years. The British Design and Technology approach as defined by their Design and Technology Association:

> The teaching of Design and Technology (D&T) prepares pupils to participate in tomorrow's rapidly changing technologies, learning to think creatively. The subject calls for pupils to become problem solvers, both as individuals and in groups - looking for needs, wants and opportunities and responding to them by developing a range of ideas, making products and systems. Practical skills are combined with an understanding of aesthetics, social and environmental issues, function and industrial practices. In the learning process pupils can reflect on and evaluate present and past D&T, its uses and effects. (Design and Technology Association, ¶1, 2010)

As summarized in Developing Industrial Design Education: A British perspective a paper by David Weightman, Professor/Director & Deana McDonagh, Associate Professor of Industrial Design of the School of Art and Design, University of Illinois at Urbana-Champaign:

> After establishing the context of design and design education in the UK, the authors describe emerging themes in industrial-design education. These themes can be classified into three types. The first theme involves enabling students to utilize a variety of research approaches at different levels. The design process has always involved elements of researching, but the evidence based design approach requires a new designer-friendly research tool kit to be assembled. The new tools now available include ways of eliciting user needs by focus groups and user observation techniques. We also examine how these research (with a small r) approaches relate to necessary developments in Design Research (with a big R).
>
> The second theme involves considering how products could respond more effectively to the suprafunctional needs of users, arising from a better understanding of needs, particularly those in the emotional domain. These include the definition of product personality, to evaluate suprafunctional performance and develop a better understanding of product semantics.
>
> The final theme centers on the changing relationship between users and designers, brought about by shifts towards user-centered design, inclusive design, participatory design and customisation. This paradigm shift, with users becoming more involved and empowered in the design process, creates a corresponding shift in our approach to design education. This paper describes the development of a more empathic approach to.

The authors combine experience of education in the UK with that in their new roles in the USA, enabling them to have a distinctive perspective on the field.

Wright (1993) wrote the Journal of Technology Education paper British Design and Technology: A Critical Analysis.

Design and technology (D&T) is expected to be taught through themes and projects in the primary school and as a separate subject in the secondary school. D&T instruction is couched within home, school, recreation, community, and business and industry contexts and explores an interrelationship between environments, artifacts, and systems, Figure 4. These three elements, according to Hampshire Education (1990), are defined as follows:

Environment: Surroundings made or developed by people.

Artifact: An object made by people.

System: A set of objects or activities that together perform a task.

D&T includes four basic areas: construction materials, food, textiles, and graphic media (London Borough of Barnet, 1992). Each of these areas focuses on four attainment targets (AT) which are the major organizers of the curriculum. These targets and their objective are described by the National Curriculum Council (1990) as follows:

AT1 Identifying Needs And Opportunities

"Pupils should be able to identify and state clearly needs and opportunities for design and technological activities through investigations of the contexts: home, school, recreation, community, business and industry" (p. 3).

AT2 Generating A Design

"Pupils should be able to generate a design specification, explore ideas to produce a design proposal and develop it into a realistic, appropriate and achievable design" (p. 7).

AT3 Planning And Making

"Pupils should be able to make artefacts, systems and environments, preparing and working to a plan and identifying, managing and using appropriate resources, including knowledge and processes" (p. 11).

AT4 Evaluating

"Pupils should be able to develop, communicate and act upon an evaluation of the processes, products and effects of their design and technological activities and of those of others, including those from other times and cultures" (p. 15).

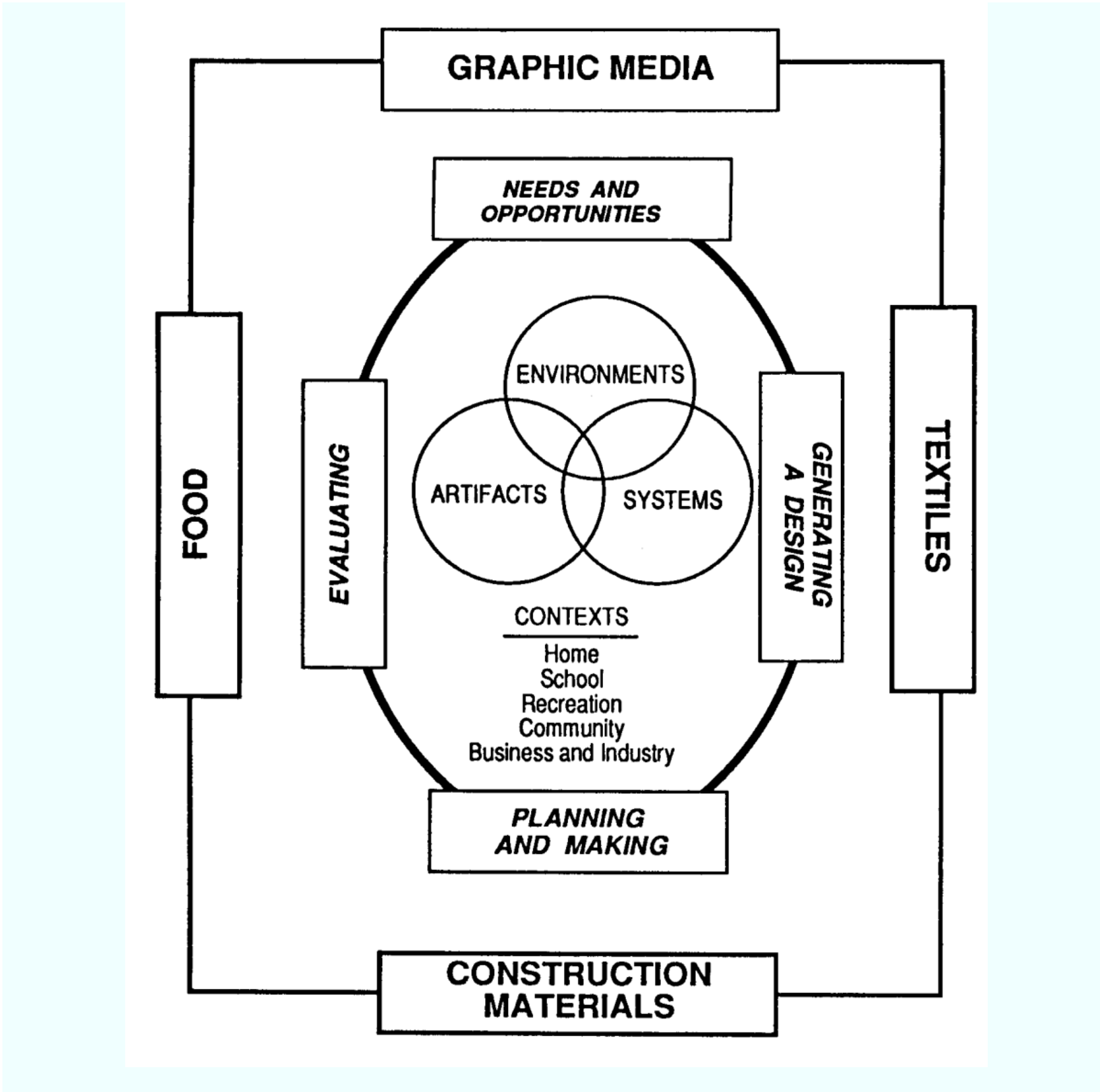

Figure 4: National curriculum model. [adapted from London Borough of Barnet. (1991). Design & Technology Design Cycle (transparency)]

Design as Pedagogy in Practice (how to do it in the classroom)

The design process promotes learner creativity, innovation, invention, and problem solving. Design as pedagogy can be practiced in three different levels: 1) Assigned Design Briefs, 2) Negotiated, and 3) Free-4-All. The selection of level depends upon many factors, such as the desired learning objective, resources available, and factors of the learners.

Level 1: Assigned Design Briefs

In Level 1, Assigned Design Briefs, each student or the entire class is assigned a design statement. The teacher either selects a design brief from existing resources or creates one for a particular situation. These resources include text books, websites, and etcetera. The selection would likely be determined by the content standards the teacher is striving to have students learn. The teacher also may choose to create a design brief for the student.

The tactical version of this level would likely contain a speaking point like: "Class – you will design a _____. It will need to meet the following criteria ..."

Level 2: Negotiated

In Level 2, negotiated design briefs, each student or the entire class negotiates a design statement. The teacher is mindful of a particular learning objective(s) and the design brief created for the particular situation. The instructor negotiates the design brief and criteria in a fashion that will lead the learner to demonstrate mastery of any given learning objective.

The tactical version of this level would likely contain a speaking point like: "Class – what would you like to design that contains _____. It will need to meet the following criteria ..."

Level 3: Free-4-All

In Level 3, Free-4-All Design Briefs, each student or the class is assigned to develop a design statement. The teacher entertains design briefs from the students. The selection would likely be determined by the student's existence. The teacher needs to monitor the design portfolio to ensure adequate progress is occurring. The teacher can then document what learning objectives are to be mastered. This provides the benefit of the design being "owned" by the learner.

The tactical version of this level would likely contain a speaking point like: "Class – consider what you need in your existence, and design it. Please state the criteria your design will meet…."

<u>Design as pedagogy illustrated</u>

June 11, 2009 Mike Bastoni (an expert technology teacher from a South Boston suburb and founder of GEARs Inc) stated: "You must develop a narrative for some students (especially females) to become engaged in the design process." We spoke a potential design brief - "the lonely cat" – quickly dubbed the "cat-bot" – combining aspects of robot design and bio-tech. His point was that developing a narrative for a design brief like this is critical to get young girls involved in the design process.

The discussion developed into describing a scenario: "a traveling executive who loves her cat is concerned that it needs more cat-excitement." Many details to describe the environment and cat can be added. She wants her cat to be healthy & happy. The design brief could be: Design a (contraption) system to entertain a cat. Criteria: it should be autonomous (battery powered, self deployed), the system should adapt to the cats behavior (time of day to play, it may patrol for cat -time, place, & speed), it may include a form of artificial intelligence to adapt to cats behaviors, it could monitor cats' reaction & behaviors, it may be armed with various cat toys, it should be able to "re-charge" on its own, it needs to be durable (can withstand cat abuse/play), and finally it should provide a utility to monitor the cat over the web. Questions for the students to contemplate include size: can this be a mouse sized robot? Or can it fly like a bird? Design briefs like this could be morphed into things like the dog-bot, etcetera.

This design brief could be used in all three levels, dependent upon the discretion of the instructor. Typically, learning objectives, content standards or performance objectives will play a large role in determining what level of design experience will be applied.

Productivity (values, efficacy, qualities)

Productivity is essentially a value laden term. It immediately surfaces questions to judge the value of the design: Does it work? Is it efficient? How does the solution exist within the context? What interactions with the environment have been considered? What is the total life path of existence for the proposed product? What trade-offs are considered in selecting a solution? Does the ratio of input to output make sense?

Much like Robert Pirsig's exploration of the metaphysics of quality in Zen and the Art of Motorcycle Maintenance, the term productivity has deeper connotations. Within this conceptual framework, productivity is intended to include a comprehensive consideration of factors. This would include environmental, social, and cultural factors in determining if the ratio of input to output makes sense.

"Lewis Mumford observed in The Transformations of Man that there have probably been no more than a half-dozen profound transformations of Western society since the time of primitive man. Each of these, Mumford states, "rested on a new metaphysical and ideological base; or rather, upon deeper stirrings and intuitions whose rationalized expression takes the form of a new picture of the cosmos and the nature of man."" (Harmon, 1979, p. 21) As such transformations become reality in our study technology, "We need to find out what nature is doing so we can be in harmony with her." (Fuller, 1972, p. 32) We need to become more intimate with nature to exist in our world. "A more organic life-pattern has begun to take possession of our minds, and is laying the foundations for a conception of technology that will do justice to all the dimensions of life, past, present, and possible." (Lewis Mumford, 1974, p. 60) The term productivity is intended to be all-inclusive in determining if the ratio of input to output makes sense.

FTCs, universal truths of technology, content

Typically, technology concepts such as the FTCs (Foundational Technical Concepts ~ highly transferable concepts) used in England & Australia, or the ITEA's STL contain both broad categories of knowledge and specific skills. These broad categories can typically include: bio-related-technologies, energy, transportation, materials, structures, communications, consumer electronics, control systems, manufacturing, and construction. Skill sets can range from general hand tools skills to highly specialized career specific skills.

Some means of conceiving all human knowledge independent of common academic constructs is needed for future application of modeling the vast content that can be contained in the topic of technology. Conceptually, this is necessary for a framework to adequately define the body of knowledge it can encompass. Tactically, documents such the ITEA's Standards for Technological Literacy (STL) serve as an excellent interim guide for determining content. The developing National Assessment of Educational Progress (NAEP) Technological Literacy exam may also be a potent influence in determining curricular content for technological literacy. It is likely that the diversity of design problems posed by learners would easily exceed any set of benchmarks or standards, yet this schema would contain it. From the standpoint of a conceptual framework for teaching technological literacy, the potential content is literally everything.

Implications

There are many positive implications to this conceptual framework. It does not require schools to acquire expensive new curriculums, tools, equipment, software or other fiscally intensive stuff. Rather it relies upon developing the capacities of the practitioner.

<u>Management of Standards – documenting what happened</u>

Most educators need to form their lessons around a set of standards set forth by their respective state department of education, or national standards; e.g., the ITEA Standards for Technological Literacy. Teachers typically document an intention for students to learn particular standards in their lesson plans. This conceptual framework is consistent with this practice. The teacher can select the appropriately related standard(s), and choose a level of design pedagogy to ensure the learner will demonstrate a mastery of the chosen objective(s). The design portfolio is the evidence of the demonstration of learning that is integrated into the life of the student.

<u>Blending the Silos – "a blank slate knows no categories"</u>

Another aspect of the dilemma of STEM education is that content is delivered in silos. Science & Math principals are rarely applied in a meaningful context to the learner. Further, there is a negative social stigma attached to the matters of the "T" within STEM content. This is an old traditional issue. As famously stated by C.P. Snow in the two cultures:

> A good many times I have been present at gatherings of people who, by the standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also

negative. Yet I was asking something which is the scientific equivalent of: Have you read a work of Shakespeare's? (1959, p. 14-15)

Real or perceived -- when we teach, we tend to reinforce our perceptions. We may inadvertently teach students to separate and juxtapose humanities & sciences. Other dichotomies can be modeled within a Two Cultures construct: i.e., science vs technology, or scientist vs technician. Does our western way of living characterize improved social status by a detachment of practical utility?

Perhaps these cultures separated as the amount of human knowledge increased. It was sensible that a hierarchical scheme of organization evolved. It became tradition to educate within that hierarchical framework. Knowledge had been categorized for efficacy in teaching, learning, and keeping records. Even credentials are assigned in these categories.

In 1963, Snow concluded education was a path to emancipation from the perils of the Two Cultures. Such an education could blends arts & humanities with science & technology in an organic fashion from the prospective of the learner. The conceptual framework naturally integrates disciplines typically separated by the disciplinary walls of the school. As clearly demonstrated in the Engineers of the Future project at _______ State, Engineering Technology faculty from Mechanical, Electrical and Electronics all had exceptionally meaningful interactions with teachers during the in-service training sessions. This is partially due to the fact the faculty could serve as content specialty experts (which they are) instead of acting like education experts. The use of design pedagogy had established a context that facilitated meaningful interactions. The context was established with the help of the design expertise provided by British Design Technology & Engineering experts who have been doing teacher in-service training for more than 25 years. The teachers gained first hand experiences they took back to practice in their classrooms affecting thousands of students.

Teacher Collaboration

Opportunities for teachers of various disciplines to collaborate abound from this conceptual framework. The design problems will encompass content according to their own nature. If a student wants to solve a real problem, it will not neatly exist within the construct of any given academic discipline. Rather, it will require knowledge from any number of given sets of inquiry. It will require an integration of various principals determined by the nature of the problem, not the scope of a text book or boundaries of an academic discipline.

In addition to teachers' potential to collaborate, any expert whose competencies align with matter of the learners design problem can become a resource to the learner. The dimension of collaboration would be determined by the availability of experts. Just as it is in the rest of our existence. However, the education process would be fostering this critically important skill at a much earlier age.

Tools & Materials (how to make anything)

The knowledge of available materials, skills to manipulate, and confidence to form them to the will of the designer will bear a strong influence on the solutions. Prototypes can be formed of readily available materials. Things can be substituted to achieve the form of a prototype. Readily found materials from home improvement centers can be combined in creative ways to prove designs.

The mastery of tools is not the focus of the learning in this conceptual framework. It is a rather pleasant side effect. The learner will acquire skills in the course of designing. They will seek out the skills and processes needed to achieve their solutions. There are intrinsic benefits to a student providing their own motivation to learn tools, processes and techniques. The students are learning "how to learn." They are proving to themselves they can figure out how to do new things.

Processes & Timing

Scale and scope are important factors to consider in setting expectations of results of the design process. Time is also an important factor to consider. It should be the intention of the instructor to lead the learner to a conclusion of the process. While it may not be a scale working prototype ready for production, it should be a satisfying conclusion for the learner.

It is important to note a design can be brought to a successful conclusion without making a full scale working prototype. If a student is designing a home, it is more likely that a model would be constructed.

Physiological learning theory support

This conceptual framework is in alignment with our understanding of human learning. The neural physiological approach to human learning is consistent with this conceptual framework. By arranging design briefs that are already in existence within the learner, the desired learning objective has a "hook" to latch onto. The abstracted Math & Science content become integrated in the neural structure of the learner. The objective becomes integrated into their living schema. The learning objective in not an isolated bit unrelated to the learners existence.

Finally, this conceptual framework empowers STEM learners as living members of their culture. They become designers shaping their world.

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