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From the Editor

What's in the Purpose, Mission, and Scope?

In 1978, the Technology Student Association (formerly the American Industrial Arts Student Association) was formed. Today's mission statement of the Technology Student Association (TSA) is to

> …foster personal growth, leadership, and opportunities in technology, innovation, design, and engineering. Members apply and integrate science, technology, engineering and mathematics concepts through co-curricular activities, competitive events and related programs.

The TSA motto is clear and concise "Learning to live in a technical world". Further, the creed for TSA is as follows:

> I believe that Technology Education holds an important place in my life in the technical world. I believe there is a need for the development of good attitudes concerning work, tools, materials, experimentation, and processes of industry. Guided by my teachers, artisans from industry, and my own initiative, I will strive to do my best in making my school, community, state, and nation better places in which to live. I will accept the responsibilities that are mine. I will accept the theories that are supported by proper evidence. I will explore on my own for safer, more effective methods of working and living. I will strive to develop a cooperative attitude and will exercise tact and respect for other individuals. Through the work of my hands and mind, I will express my ideas to the best of my ability. I will make it my goal to do better each day the task before me, and to be steadfast in my belief in my God, and my fellow Americans.

As I complete my second issue and first volume of the *Journal of Technology Education*, I find myself reflecting on the purpose, motto, and creed of the TSA and comparing that organization's written words to that of the *JTE* (in addition to being Editor of the *Journal of Technology Education*, I am Executive Director of the Illinois Technology Student Association). For example, the mission (labeled the "scope") of the *JTE* is to "Provide a forum for scholarly discussion on topics relating to technology education." The forum for scholarly discussion comes in the form of manuscripts focused on technology education research, philosophy, and theory. In addition, book reviews, editorials, guest articles, comprehensive literature reviews, and reactions to previously published manuscripts also help to fulfill the mission of the *JTE*.

The TSA motto is clear. The TSA creed highlights such terms as *technical world*, *work*, *tools*, *materials*, *experimentation*, *industry*, *initiative*, and *hands and mind*. As Editor of the *JTE*, I believe our mission is also clear, but certainly has been expanded, much like that of the TSA, to include science, engineering, and mathematics as these disciplines relate to, or are integrated with, technology education. As our world continues to be shaped by the advancements in science, technology, engineering, and mathematics, the *Journal of Technology Education* will also reshape itself, but the mission should not change from publishing appropriate research, philosophy, and theoretical manuscripts dedicated to topics relating to technology education.

In this issue of the JTE, you will find two international manuscripts (1) development of technological competence from adolescence to adulthood and (2) using traditional cultural examples to explain modern technology education; a book review on creativity and human innovation; an historical examination of the yearbook series that is central to the Council on Technology Teacher Education; a study examining the effects of solid modeling in technical problem solving; and a study focusing on collaborative information and multimedia in technology teacher preparation. All manuscripts published in this issue relate to the purpose and mission of the *JTE*. Further, all manuscripts directly relate to the scope of technology education even though each manuscript is different in nature. So, what's in the purpose, mission, and scope? I believe that the purpose, mission, and scope define an organization (or journal in this case) – nothing more and nothing less.

Chris Merrill

Articles

The Effects of Solid Modeling and Visualization on Technical Problem Solving

Technology education and many other fields are placing increased emphasis on problem solving. The *Standards for Technological Literacy* (STL) state that “Problem solving is basic to technology” (ITEA, 2000, p. 90). Jonassen (2000, p. 63) contends that “most psychologists and educators regard problem solving as the most important learning outcome for life.” “Problem solving is a critical process skill that involves virtually all aspects of existence” (Wu, Custer, & Dyrenfurth, 1996, p. 56). “Virtually everyone, in their everyday and professional lives, regularly solves problems” (Jonassen, 2000, p. 63). All problems are not the same and must be approached differently than rote or component skills (Westberry, 2003). The fields of Technology and Technology Education place strong emphasis on problem solving and application, as teachers strive to promote technological literacy.

Many would contend that technology education and related fields have been teaching and employing problem solving since their inception(McCade, 1990; Todd 1999). Few will argue the importance of problem solving, yet little is known about it. It is unclear how to define problem solving. There are many definitions for problem solving, and it can be conducted through various means (Hill, 1997). To further complicate the matter, problem solving takes on many different meanings, depending on the type of problem or the specific problem being addressed. There is also a myriad of problem solving models and terminology currently in use (Flowers, 2010).

STL (ITEA/ITEEA, 2000/2002/2007, p. 5) considers design the primary problem solving approach in technology education. Few, if any, technology education processes have received as much attention in the literature in recent years as problem solving has, particularly design, although design is not the only problem solving method. Custer (1995) considers design a major subset of technical problem solving. One unique aspect of design problems is that the designer “typically, does not know in advance what the goal state will be, although he [sic] usually has criteria to evaluate potential goal states” (Carroll, Thomas, & Malhotra, 1980, p. 143). For teaching problem solving and design, Williams (2000) suggested focusing on activities. The problem and the student

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determine what aspects of problem solving are needed in order to solve a particular problem. The most important aspects of problem solving he identifies are: evaluation, communication, modeling, generating ideas, research and investigation, producing, and documenting. The majority of these aspects are within the capabilities of many solid modeling programs. The problem solving aspects Williams identifies are very similar to a variety of problem solving models teachers present to their students. One issue with most of these models is that they are very linear and suggest that all problems are solved in this linear manner. Research on design shows that both experts and students develop flexible approaches to solving individual problems. When students are forced to follow a teacher-defined process, the students often use their own strategies and then do the work necessary to meet their teacher's requirements (Williams, 2000).

Technical problem solving encompasses and oftentimes involves design, but also includes other aspects and employs various technologies in reaching a solution. Boser (1993) states that technical problem solving "refers to the systematic way of investigating a situation and implementing solutions" (p. 12). Childress (1994) defines technical problem solving as:

> The problem solving process… combined with the processes of technology in engineering, architecture, industrial workshops, research and development laboratories, the home, the office, and field, etc., and certainly the technology education laboratory. The processes of technology employed to solve problems of human need or want characterize this method. (p. 94)

Spatial visualization is an important component of the problem solving process, particularly in technical problem solving and design. Visualization has been correlated with problem solving (Mack, 1992). One must be able to visualize, or "see" in one's mind, a mental picture of possible solutions and outcomes to a particular problem. Visual thinking is constantly used and pervades all human activities. For almost all activities we undertake, we create or think visually (Arnheim, 1974; McKim, 1980). Many cognitive tasks that we undertake involve cognitive representations (Zhang, 1997). When you describe driving directions to someone or tell someone what your living room looks like, you see a visual image of those things in your mind. An important aspect of visualization is that it can be improved by practice. (Blade, 1949; Brinkmann, 1966; Cohen, 1981; Rosenfeld, 1985)

Programs that involve the study of technological processes have always taught technical design and other forms of standardized visual communications. The equipment and techniques have changed a great deal in the last few decades, as advancing computer technologies have made it possible to produce complex models using personal computers. The equipment and software for technical design is often very costly and can require a great deal of time and effort to learn its proper use. Current CAD programs have made visualization of designed objects easier by adding true three-dimensional functions and high quality, rendered images of those designs. The trend in industry has shifted greatly from simple 2D designs to these detailed 3D models. A question that remains unanswered is the extent to which these CAD programs aid students in problem solving, designing, communicating, or learning these concepts.

Long (2003) pointed out that increasing graphic realism does not always lead to better learning. “Like many things with technology, just because we can do something may not mean we should” (p.8). Godfrey (1999) contends that “viewing three-dimensional solid models removes it from its usual two-dimensional form of abstraction and makes it more suitable for use as a method for spatial visual learning” (p. 2).

The purpose of this study was to determine whether or not the use of solid modeling software increases participants’ success in solving a specified technical problem and how visualization affects their ability to solve a technical problem. Little is truly known about how individuals go about solving problems and what tools better equip them to solve certain problems. Jonassen (2003b) concludes, “The potential for research confirming positive relationships between modeling and problem solving is great” (p. 377) and goes so far as to state “no empirical research has examined the effects of using technology tools for representing problems on problem solving performance.” A great deal more research is needed to better understand how problems are solved and what methods and tools best prepare individuals to face future problems.

Purposes

The purposes of this study were to determine if (a) students’ visualization skills affect their problem solving ability; (b) the use of 3D modeling software in the design and production of a prototype for a technical design problem is more effective than using sketching; and (c) the use of 3D modeling software offsets any differences in low spatial visualization skills for solving a technical design problem.

The potential exists for students to be able to better visualize problems when designing with 3D representation. Research dealing with assembling objects shows that students tend to do better when they can view a physical or 3D object as opposed to 2D drawings (Pillay, 1998).

Methodology

Design

The design for this study was an experimental posttest-only design. Each participant completed the Purdue Spatial Visualization Test–Visualization of Rotations (PSVT-R). The participants were randomly assigned to either the control group or the experimental group. The control group designed a solution to the design problem using sketching and then physically constructed their prototype with the provided materials. The experimental group participants each used ProDesktop solid modeling software and sketching to design their solutions and then constructed a prototype with the provided materials. The physical models or prototypes were then scored as either successful or unsuccessful.

Research Hypotheses. The following hypotheses were investigated in this study:

> *$H_0$1:* Participants' spatial visualization skills, as measured by the Purdue Spatial Visualization Test–Visualization of Rotations, will not affect their technical problem solving ability.
>
> *$H_0$2:* Participants using solid modeling software to design solutions to technical problems will not show greater success in the construction of a physical model or prototype than those using sketching.
>
> *$H_0$3:* Participants with lower visualization skills, as measured by the Purdue Spatial Visualization Test–Visualization of Rotations, will not perform better using solid modeling software than those with equal scores using sketching in the design and production of a prototype for a technical problem.

Selection of Participants

The experimental and control groups were comprised of 24 and 23, respectively, randomly assigned participants from the Industrial and Engineering Technology Program at Southeast Missouri State University. Each student was randomly assigned, irrespective of which class the student was enrolled in, to either the experimental or control group. Specifically, participants were students enrolled in an introductory or advanced computer-aided solid modeling course taught by the researcher. The majority of the participants were technology education, engineering technology, and graphics technology majors in different stages of their academic programs. The remainders of the participants were university studies majors, undeclared majors, or minors in engineering technology. Most of the participants had little previous experience with drafting or CAD. Few of the students had any formal exposure to solid modeling software prior to the instruction at Southeast Missouri State University.

Variables

Independent Variables. The independent variables in this study were: (a) the method the participants used to design their prototype, and (b) the participants' spatial visualization ability. Participants in the control group used sketching in the design of their prototype, while experimental group used ProDesktop solid modeling software for the design of their prototype. Spatial visualization was measured with the Purdue Spatial Visualization Test–Visualization of Rotations (PSVT-R).

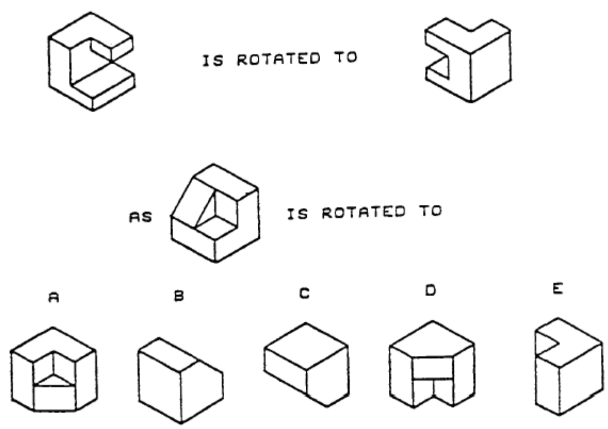
Sketching was selected as the control method because students in technology education are generally required to produce sketches of possible solutions to problems prior to constructing a solution. A survey by Römer, Weißhahn, Hacker, Pache, & Lindemann (2001) of 106 designers indicated that sketching was the dominant external aid for early stages of the design process. Sketching was used significantly more than simple models, complex models, and CAD in the development of solutions. CAD was used more for documentation and complex testing of solutions.

The Purdue Spatial Visualization Test–Visualization of Rotations (PSVT-R) instrument was designed to measure the participants' ability to visualize the rotation of three-dimensional objects. This instrument was chosen because of its higher correlation with similar instruments measuring visualization such as the Shepard-Metzler tests. The format for the PSVT-R is thirty questions. For each question, an object is pictured in one position, then that object is pictured again, having been rotated to a different position. The participants are shown a second object and given five choices, one of which matches the rotation of the original object example. They are to select the object that shows the same rotation as the original example for that question. A sample PSVT-R question is shown in Figure 1(see next page). Bodner & Guay (1997) attest that these tests are "among the spatial test least likely to be confounded by analytic processing strategies." (p. 13). The Minnesota Paper Form Board Test a similar test used to measure visualization but has a weaker correlation with other spatial visualization instruments and is likely to be confounded by analytic processing (Bodner & Guay, 1997).

A shorter 20 questions Purdue Visualizations or Rotation (ROT) version of the PSVT-R was derived by removing 10 items from the instrument. Studies on reliability for the shortened ROT of chemistry students report Kuder-Richardson (KR20) internal consistency test values of .80, .78, and .80 with samples of 758, 850, 1273 respectively. They also reported Split Half reliabilities of .83, .80, .84, .85, .82, and .78 with samples of 757, 850, 127, 1273, 1648, and 158 respectively. The construct validity for the 30 item PSVT-R is supported by a study of five measures of spatial ability. The highest correlation was between the PSVT-R and the Shepard-Metzler test ($r = 0.61$, $p < 0.001$). The lowest correlation was between the PSVT-R and the Minnesota Paper Form Board

(MPFB) test ($r = 0.25$, $p < 0.01$) (Bodner & Guay, 1997). For this study the original 30 item PSVT-R test was used.

Figure 1
Sample PSVT-R problem



Dependent Variable. The dependent variable was participant performance in solving a technical design problem. The technical design problem used to measure problem solving performance was designed to require a substantial amount of design skill and effort within the limitations of time and resources. The problem selected for the study involved the conversion of rotational motion to reciprocal motion. Such a conversion is fundamental to many applications and can be found in many technical devices and systems, such as the internal combustion engine, windmills, and early water-powered devices. The problem also required the consideration of multiple planes or surfaces, adding to its complexity and requiring high level visualization and problem solving skills. Real world examples were not intentionally mentioned to the participants, but it was anticipated that the participants would associate or mentally transfer this problem to devices or mechanisms with which they were familiar. The problem solving activity studied in this research was an ill-defined design problem. That is, there was no set procedure for arriving at a solution, and there were many possible solutions.

The problem was also intended to have a cost high enough to benefit from the construction of the solid model for analysis and design purposes. The external representations created using solid modeling exhibit many of the characteristics of physical objects, as well as allowing for analysis and manipulation that is not possible on physical objects.

The participants were instructed to design a mechanism that would convert rotary motion to reciprocal motion and move a block forward a fixed amount within specified tolerances (see Appendix A). Upon completion of the design, the participants were instructed to construct a working model or prototype using supplied materials.

The prototype had to successfully advance three 1.5 in. by 1.5 in. by 3 in. blocks a distance of 3.5 in. with a tolerance of plus or minus $^1/_8$ in.. The prototypes were dichotomously scored as either successful or not successful. If all three blocks were successfully advanced, the required 3.5 in. within the $^1/_8$ in. tolerances in one of two possible attempts, the prototype was scored as a successful solution to the design problem. If the prototype failed to consecutively advance all 3 blocks during the attempts, it was scored as not successful.

The dichotomous value, either successful or not successful, was the dependent variable. This method of evaluation was selected because many ill-defined problem solving activities may have multiple, correct solutions. For this problem, the participants were only evaluated on mastering the stated objective. Other aspects of product design and manufacturing, such as creativity, aesthetics, cost, durability, and manufacturability, were not considered within the scope of this research.

Both groups were limited to three hours for completing the design and three hours for construction of the prototype, but they were not required to use that entire amount of time. Each group completed the design and construction of the prototypes over two consecutive days. During the first three hour session, the participants designed their solutions. The next day, the participants constructed their designed solution. They were instructed that they had to construct the design that they created in the previous session and were not allowed to change their designs. This was done to eliminate any influences they may have been exposed to between sessions. The completed prototypes were compared to the designs in order to verify that they did match.

Results

Descriptive Statistics

Both groups completed the PSVT-R prior to beginning the design problem. The mean score for the PSVT-R or the 47 participants was 22.26 with a standard deviation of 4.55. The mean score for the 23 participants in the control group was 21.49 with a standard deviation of 4.39. The mean score for the experimental groups 24 participants was 23 with a standard deviation of 4.66. There were 11 successfully constructed prototypes, five from the control group, and six from the experimental group (see Table 1 next page).

Table 1
Purdue Spatial Visualization Test – Visualization of Rotations Descriptive Statistics

Source	*df*	*F*	r^2	*p*
Visualization Score 1		1.325	.029	.256

Group	N	M	SD	Successful Completion of Prototype
Control	23	21.49	4.39	5
Experimental	24	23.00	4.66	6

Hypotheses Tests

Even though random assignment was used for the control and experimental groups in order to control for any variation in spatial visualization abilities, the control and experimental groups' visualization scores were analyzed using analysis of variance to ensure that there were no significant differences between the groups spatial visualization abilities as measured by the PSVT-R These results revealed that there were no significant differences between the groups, F (1, 45) = 1.325, p = .256, indicating the experimental and control groups were equivalent in spatial visualization (see Table 1).

The successful or unsuccessful completion of a working prototype and the visualization scores were processed using logistic regression to determine if any statistically significant differences existed between the groups. This methodology was selected because the dependent variable was dichotomous. Logistic regression was chosen over linear regression because the latter could result in predicted values greater than one (successful) or less than zero (unsuccessful) when testing dichotomous variables, and the effects of the independent variable could be greatly underestimated (Pedhazur, 1997, p. 715). They were also analyzed to determine if there was any interaction between the method of design and the visualization scores (see Table 2 on next page). The interaction was investigated to determine if using solid modeling software would offset low scores in visualization.

Table 2
Summary of Logistic Regression Results for Successful Construction of Prototype (N = 47)

Variable	*B*	*B/SE*	Wald	x^2 *(df)*	*p*
Model 1				7.787(1)*	.005
Constant	-9.018	3.539	6.494		
Visualization*	0.332	0.144	5.313		.021
Model 2				7.977(2)*	.019
Constant	-9.057	3.536	6.559		
Visualization*	0.339	0.146	5.402		.020
Method	-0.242	0.767	0.100		.752
Method 3				8.732(3)*	.033
Constant	-6.671	4.010	2.768		
Visualization	0.239	0.169	1.986		.159
Method	-6.503	7.405	0.771		.380
Interaction	0.256	0.299	0.731		.393

Note. *p<.05

$H_0 1$: As suggested in the literature, the analysis indicated that spatial visualization skills were a significant predictor of being able to successfully complete the design problem. The higher the spatial visualization score a participant had, the more likely they were to be able to solve the design problem and successfully produce a prototype that met the requirements to be considered successful.

The results from model one (see Table 2) indicated that spatial visualization was a significant predictor of being able to complete this technical design problem. The coefficient on the visualization variable has a Wald statistic equal to 5.313, which is significant at the .05 level (p = .021). The overall model was significant at the .05 level according to the model chi-square statistic. The model predicts 77% of the responses correctly. The null hypothesis ($H_0 1$) was rejected.

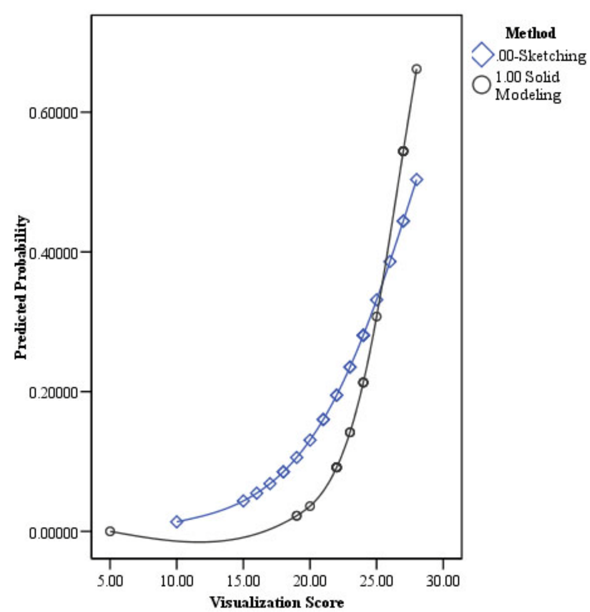
Does a participant's visualization ability have an effect on their problem solving ability? The data from this study revealed that visualization ability has an effect on, or significantly correlates with, the participants being able to solve this technical design problem. The participants' visualization ability, as measured by the PSVT-R was a significant predictor of their success for the given technical design problem.

$H_0 2$: The results from step two indicated that there was no significant difference between participants who used solid modeling and those who used sketching to solve the given design problem. The results of the analysis supported the null hypothesis, thus the null hypothesis failed to be rejected.

Step two of the logistic regression analysis included the addition of the Method variable, which takes into account whether the participants used ProDesktop solid modeling software and possibly sketching or if they used only sketching. The model was significant at the .05 level (p = .019) with a chi-square statistic of 7.977 (df = 2). The Method was not significant at the .05 level (p = .752) and a Wald statistic of 0.100. Five participants of the control, or sketching only, group constructed successful prototypes and six of the experimental, or ProDesktop, group constructed successful prototypes.

$H_0$3: Because there was no significant difference in performance between the two groups and no significant interaction between the method of design and spatial visualizations scores, the null hypothesis failed to be rejected. Using ProDesktop to design the solution did not offset differences in the participants' visualization scores (see Table 2). The model was significant at the .05 level (p = .033) with a chi-square statistic of 8.732 (df = 3). The interaction was not significant at the .05 level (p = .393) and a Wald statistic of 0.731. A graph of the logistic regression curves for the two methods used (sketching and solid modeling), which shows the predicted probability of successfully solving the problem compared to the visualization score, reveals some trends that contradict hypothesis three (see Figure 2).

Figure 2
Logic Regression Curves for Sketching and Solid Modeling



Discussion and Implications

Discussion

Caution must be used when generalizing the results of this study because the participants consisted of 47 randomly assigned engineering technology students. The results from this study also suggest that because the interaction between the type of design method and spatial visualization ability did not result in a significant difference, the design method and visualization ability were homoscedastic for this particular problem. Using solid modeling software to design a solution did not offset low spatial visualization scores or offer any advantages to those with high visualization scores. Examination of Figure 2 provides some evidence that the opposite might be true. Though the results of the analysis of interaction was not significant, the graph reveals that the participants with lower visualization scores, under 24, that used sketching had higher probabilities of success than those that used solid modeling. The participants that used solid modeling showed a higher probability of success above a spatial visualization score of 24. In this case using solid modeling did not offset low visualization scores and increase the probability of solving the design problem. Using solid modeling actually decreased the probability of success for participants with low visualization scores and increased the probability of success for participants with high visualization scores. This could indicate many things, such as, high spatial visualization ability may be needed to effectively use and design with solid modeling software. It was hypothesized that using solid modeling would reduce the cognitive load on the participants. Several researchers contend that using various technologies could assist in problem solving, reducing cognitive load, and increase learning (Jonassen, 2000; Pillay, 1998; Renkl & Atkinson, 2003). More research is needed to further investigate these findings and examine their significance and implications.

Examination of the prototypes produced by the participants reinforces several basic strategies regarding design problem solving and ill-structured problem solving activities. Eight non-successful solutions properly advanced the blocks, but they failed to limit the distance to the specified tolerance. Many of the participants seemed to feel that they had successfully completed the problem but overlooked the specific requirements. This points out the importance that the problem and the requirements for the problem be understood and reviewed.

Some participants failed to consider things such as the materials, tools, and time constraints. By looking at the design ideas and the prototypes, it becomes apparent that many participants chose solutions to the problem that may not have matched well with the available materials and tools. Several of the ideas appear to be viable solutions, if other materials were used, but not when trying to construct a solution from foam board using a utility knife. Many of the designs tried to incorporate threaded mechanisms and/or gears. The precision needed to produce functional gears and threads cannot easily be reached with the tools and materials provided. Here again, this could relate to a less than thorough understanding of the problem. The participants did not fully understand the materials they had available or how they could best be shaped with the provided tools. The available materials and resources are an important component of any problem, and understanding the properties and function of the materials as they relate to the particular design problem is important.

Some of these differences could also be because the participants were novices at solving problems of this nature. Experts are better able to retrieve and distinguish between pertinent information and information, or ideas, that offer no real advantage to arriving at a solution (Wu, Custer, & Dyrenfurth, 1996). If they have not experienced problems within this context before, they may have experienced difficulty transferring similar schemas to this particular problem (Bransford, Brown, & Cocking, 2000; Jitendra, 2002; Westberry, 2003).

Implications for the Classroom and Research

Continued research in spatial visualization and technical problem solving is needed. This study and related literature suggest that relatively little is known about how individuals solve technical design problems and how visualization and the use of technology affect the outcomes.

The study needs to be replicated with additional participants to further investigate the findings. As most design problems pose different challenges and opportunities, the use of different design problems, instead of one specific problem, could expand this study. A process to categorize different technical design problems would be beneficial to establish, and would aid in further analysis.

In the classroom, good problem solving practices need to be observed and implemented. Although there is still some controversy about whether or not a step-by-step procedure that works for all problems exists, good strategies still need to be employed. Many things were overlooked or not properly considered by the participants, such as the materials and tools they had to use. Another component of the problem that needs to be clearly understood is the objective of the solution. Participants need to completely understand the requirements and the goal of the problem. If they don't know what the target is, it makes it very difficult to hit. It would be like shooting baskets on a basketball court while blindfolded. If they don't know and truly understand the goal, it is difficult to achieve.

It was found that spatial visualization ability was a predictor of success for the technical design problem presented. This is an important concept that we seldom consider in the classroom. Many programs teach and require some kind of design or CAD classes, but the research on whether or not continued education in those classes improves visualization is somewhat mixed (Frey & Baird, 2000; Devon et al., 1994). Many overlook materials that focus on teaching visualization and preparing students to be able to better visualize objects. As solid modeling is employed, this may become even more prevalent. How to best use solid modeling in the design process needs further exploration. It is a tool, and as with all tools, it needs to properly be employed. How it must be used in the educational setting may differ from how it is used in industry by experienced designers and engineers. This and other studies demonstrate that visualization is an important component of the process. Possible suggestions for the classroom would be to focus on visualization. Pretesting of students could be done to assess their spatial visualization abilities, so that students with lower visualization scores could be assisted or given some additional instruction that would help improve their abilities. If visualization abilities were known, students could be grouped to work on projects based on their abilities. Grouping students with high visualization skills with those of less developed visualization skills could help to ensure success of the projects, as well as provide exposure and practice to the students that are developing those skills.

Another important characteristic of technical problem solving and visualization is that these skills both need to be practiced. Whether or not these skills or abilities are perishable is a question that needs to be addressed. Teachers need to ensure that their students practice problem solving and visualization. Often students are given a design problem as a culmination of a class or program. Having a series of small technical design problems, which require multiple problem solving components and various visualization skills, would prepare students for larger, more difficult projects. While teachers typically use this approach for many subjects, when it comes to problem solving and visualization teachers often jump right in with both feet. Concepts like scaffolding, structuring, and sequencing need to be properly developed and practiced.

Several studies have showed the importance of visualization to problem solving. This study also supports that spatial visualization can be an important component and predictor of problem solving success. Educators need to continue to develop problem solving skills and visualization skills. Many times, the underlying principles of visualization are overlooked, and research of this kind points out that the implementation of activities and instruction that teach students the skills and abilities they need is the key to their success.

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APPENDIX A: PROCEDURES FOR TREATMENT GROUP

Design Challenge

Problem
You are to design and develop a solution that advances 1.5 in. by 1.5 in. by 3 in. blocks, one at a time, a distance of 3.5 in. (see figure 1 and the video provided). You must include some type of handle to turn to advance the blocks. The blocks will be fed into the opening one at a time by hand. The mechanism you design must be powered by rotary motion, meaning you must turn or crank the handle to advance the blocks. Sliding a handle back and forth is not acceptable. The fixture that the blocks must fit in and be advanced through is provided.

Figure 1
Block

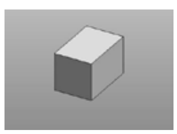
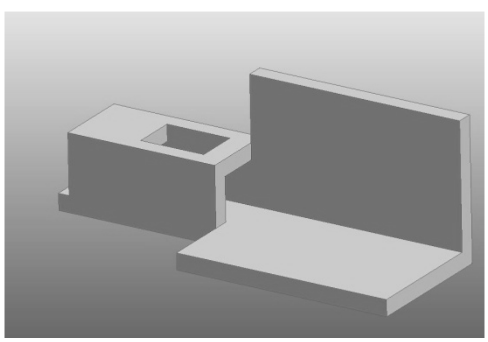


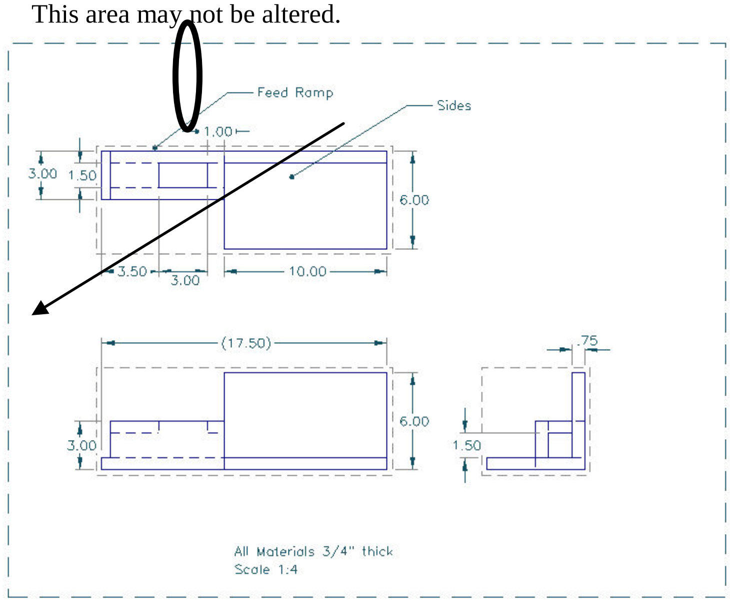
Figure 2
Fixture Through Which Blocks Must Fit and Be Advanced



Procedure for the Treatment Group. You will need to design a mechanism that converts rotary motion into reciprocal motion. You are to design the mechanism using ProDesktop. The drawings for the fixture and blocks are already drawn and your instructor will inform you where they are stored on your computer. Once your mechanism is designed you will be constructing a prototype from the materials listed below. The prototype must successfully advance 3 blocks 3-1/2 inches with a tolerance of plus or minus 1/8th of an inch and should be reflective of your drawn design. Save all of your ProDesktop solution at the instructed location.

You may not alter the feed ramp end but you may alter the sides of the device in any way.

This area may not be altered.



Criteria Used to Evaluate Prototypes/Solutions Developed

1. You have 3 hours to complete your design and 3 hours to construct the prototype/solution.
2. You must include some type of crank that is turned to operate the solution.
3. The device must advance 3 blocks within these tolerances in order to be successful.
4. The blocks must be advanced 3.5 in. with a tolerance of plus or minus $1/8^{th}$ of an inch.

Materials Provided From Which Prototypes/Solutions May Be Constructed
Hot glue gun, glue sticks, double sided tape, wood glue, masking tape, duct tape, 1/4" dowel rods, 3/8" dowel rods, 1/2" dowel rods, foam core board, 1/2" rigid foam, corrugated cardboard, 1/4" hardboard, 1/2" plywood, assorted nails, screws, bolts, and nuts.

APPENDIX B: EXAMPLES OF SUCCESFUL AND UNSUCCESSFUL PROTOTYPES

Figure 1
Successful Sketch

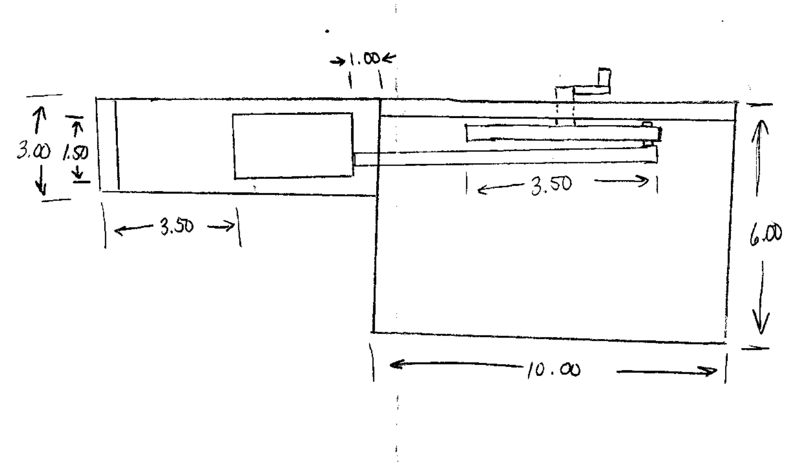


Figure 2
Successful Prototype Constructed from Sketch

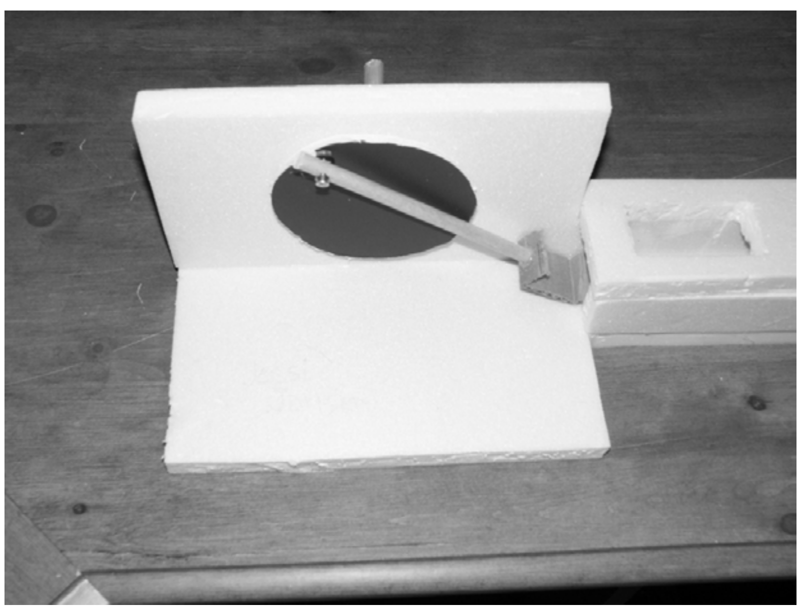


Figure 3
Unsuccessful ProDesktop Design

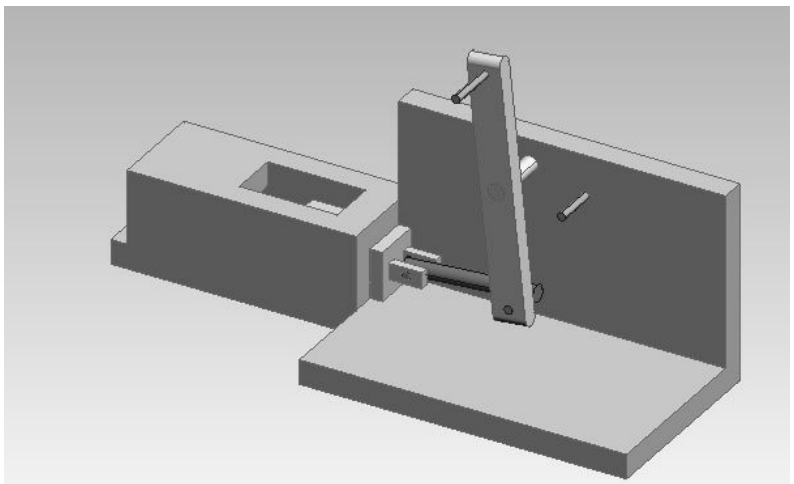
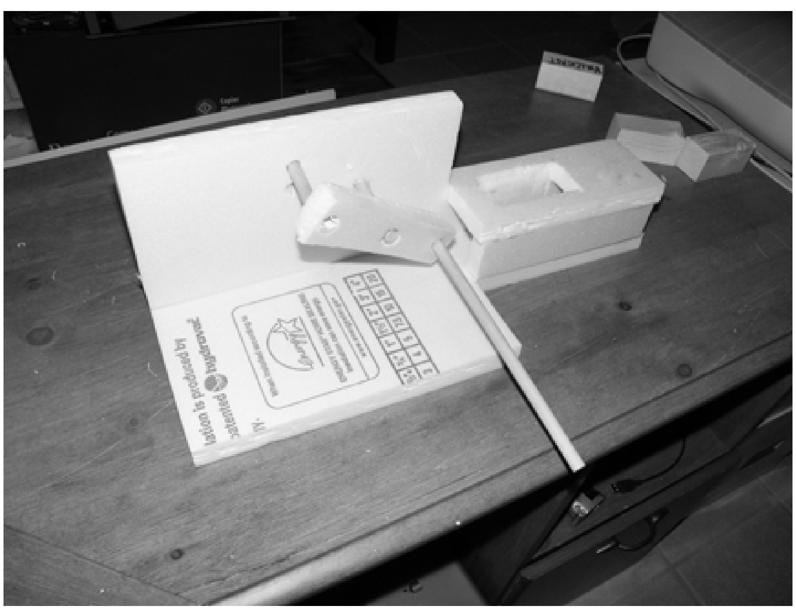


Figure 4
Unsuccessful Prototype Constructed from ProDesktop Design



Genesis and Early Evolution of the Yearbook Series of the American Council on Industrial Arts Teacher Education

The Council on Technology Teacher Education (CTTE)'s 2011 yearbook is its sixtieth, making the series one of the longest-lived of its kind in the US. The yearbook series was founded in part to demonstrate the intellectual maturity of the field; today professionals in the field affirm its "uninterrupted tradition of scholarly excellence and promotion of discourse in technology teacher education" (De Miranda, 2007, p. iii). On the other hand, volumes have also been characterized by uniformity in ideology and the selection of topics and authors (e.g., Braundy, 1999; Petrina, 1998; Ritz, 1999).

Yearbook decisions are made by the 11-member Yearbook Planning Committee, chaired by the CTTE's past president for a three-year term. The remaining ten members serve staggered five-year terms; the council's executive committee (its officers and past-president) selects two new members each year to replace two veterans. Proposals for future yearbooks are accepted, rejected, or tabled as *packages*; that is, when the committee formally schedules a yearbook, it has accepted not only the topic, but also the editors, table of contents, and chapter authors.

Neither the committee structure nor the yearbook approval process has changed since 1962. Yet, as I argue in this article, both are fundamental deviations from the original conception of the yearbook program of the American Council on Industrial Arts Teacher Education (ACIATE)—the name under which the CTTE operated until 1986.

The questions of how and why the series assumed its current form have been inadequately addressed in the literature. Aside from brief discussions in three of the yearbooks themselves, and in reviews of some individual books, Chapter 4 of Kinzy's (1973) dissertation contains the only treatment of the ACIATE yearbooks as a series.

Kinzy's dissertation, the only history of the ACIATE, was partly underwritten by the Council itself. It is a history of the organization seen through the eyes of Whitesel, Williams, and Hunt, each of whom was interviewed extensively, and each of whom reviewed and commented on a pre-publication draft of the study. The paper's lack of critique and skepticism may also be partly explained by the fact that among the three members of Kinzy's dissertation committee were the ACIATE's President and immediate Past-President.

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Purpose and Approach

This article is an attempt to trace the development of the ACIATE yearbook series to the point at which it established the *modus operandi* in place today. I sought to discover why and how the series evolved into a form so different from the original plan. In addition to published materials, I drew upon a number of primary sources in the archives of the American Industrial Arts Association (AIAA), the parent organization of the ACIATE. These records are part of the archives of the International Technology and Engineering Educators Association (ITEEA), held by the Helen A. Ganser Library, Millersville University of Pennsylvania. Although reliance on the Kinzy (1973) study is problematic, his section on “The Prodigious Undertaking” (pp. 102-112) included valuable data unavailable in the archives.

This article is divided into two main sections, *synthesis* and *analysis*. In the first, I try to recover the early development of the yearbook series, emphasizing changes in leadership, locus of influence, and decisionmaking structure. In the second section, I analyze the record to address this question: How and why did the ACIATE’s yearbook program evolve from its original intent into its present form? An appendix includes brief biographies of eight people who had significant impacts on the series.

Synthesis

The desire to establish an industrial arts teacher education yearbook predated the 1939 formation of the AIAA. In the late 1930s, for example, R. Lee Hornbake “used to complain that industrial arts was not well thought of among other educators largely because we had no yearbook” (Coover, 1964, p. 1). Hornbake would later help shape the ACIATE series. DeWitt T. Hunt, a founder of the ACIATE and president of the AIAA, agreed: “perhaps one of the basic criteria of a profession is the existence of literature found only in the group’s yearbook” (1949, as cited in Kinzy, 1973, p. 40).

The ACIATE was organized in 1950 as the first special-interest section of the AIAA. The annual convention of the AIAA would also include the ACIATE’s yearly meetings. According to Hunt, head of industrial arts at Oklahoma A&M College, “The officers were not long in achieving their number one goal – of producing a ‘Yearbook’ for the Council” (1960, p. 104).

The 70 attendees at that first meeting agreed that the yearbooks would be topical, and that each would be scheduled several years in advance (e.g., Hunt, 1950). Each September or October, the next year’s volume would be sent to the printer so that copies would be available for distribution at the AIAA conference the following April or May.

Early Yearbooks

The ACIATE's first president was Walter R. Williams, Jr. (not to be confused with his son, Walter R. Williams III (1933-2007), the 17th ACIATE president), professor of education at the University of Florida and immediate past president of the AIAA. On August 9, 1951, Williams visited the offices of McKnight & McKnight Publishing, where he discussed the production of the yearbook with William McKnight, Jr. and Wesley D. Stephens. Under the agreement they reached, the publisher would "underwrite the entire costs of producing and disseminating [the] yearbooks… profits received from the sale of these volumes will be forwarded to the Council Treasury by the publishers who have agreed to absorb any annual losses which may arise" (Williams, 1952, n.p.). When McKnight sold the company in 1983, he was able to influence the new ownership to continue the arrangement, which continued through the first 57 volumes (see Seymour, 2009).

The ACIATE's responsibility was "the development of material and the editorial phase of this project," which McKnight said would "rest entirely with the officers and the editorial committees of your Council" (1951, p. 1). Unlike McKnight, the organizers and early leaders of the ACIATE made little distinction between "the officers and the editorial committees;" the original constitution referred only to a "Publications Committee" ("Proposed Constitution," 1951, p. 9). Williams became chairman of this committee in 1950. In this capacity, he oversaw the first three volumes of the yearbook series and the planning phases of the next two (See Table 1, Next Page).

Table 1

ACIATE Yearbooks Approved During Walter R. Williams, Jr.'s Term as Chair of the Publications and Yearbook Planning Committee (1950-54)

Volume	Title	Editors and Institutions
1952 (1st)	*Inventory-Analysis of Industrial Arts Teacher Education Facilities, Personnel, and Programs*	Walter R. Williams, Jr.; Harvey K. Meyer, Jr. (U. Florida)
1953 (2nd)	*Who's Who in Industrial Arts Teacher Education*	Williams; Roy F. Bergengren, Jr. (U. Florida)
1954 (3rd)	*Some Components of Current Leadership; Techniques of Selection and Guidance of Graduate Students; An Analysis of Textbook Emphasis*	Williams†
1955 (4th)	*Superior Practices in Industrial Arts Teacher Education*	R. Lee Hornbake; Donald P. Maley (U. Maryland)
1956 (5th)	*Problems and Issues In Industrial Arts Teacher Education*	C. Robert Hutchcroft (U. Michigan)

†Williams, listed as "Editor-in-Chief, Yearbook Series," later identified himself as the book's editor.

To get the series started, Williams oversaw data collection for what would become yearbooks 1 and 2. The following year, Hornbake started work on the next volume. Williams and the other officers faced the first crisis of the new series when it became evident that Hornbake's *Superior Practices in Industrial Arts Teacher Education*, scheduled as yearbook 3, would not be completed on time. Without a backup yearbook in progress, and without time to create a new book, Williams sent McKnight & McKnight the dissertations of three of his students to constitute the volume (Kinzy, 1973).

Formation of the Yearbook Planning Committee

John A. Whitesel of Miami University of Ohio, who had done much of the work to establish the ACIATE, was especially concerned that the council nearly missed publishing the 1954 yearbook. But when he became the council's president in September 1954, he discovered that a second potential crisis loomed. No plan was in place for yearbook 5, which would be due to the publisher in a year (Whitesel, 1956); yet the ACIATE publications committee was not scheduled to meet until April 1955. The possibility of skipping a volume in a “yearbook” series was real; it had happened to the National Art Education Association in 1950 (by 1954 the NAEA series probably appeared to be back on its feet. But in 1957 the series became a biennial publication, and the group’s last “yearbook” *per se* was published in 1959). Regarding the root of the problem as poor planning (e.g., 1956), Whitesel assembled a ten-member *ad hoc* yearbook committee and called “an emergency meeting of a sub-committee” of five members, including Williams as chair, at the end of September (Whitesel, 1954a, p. 11).

Whitesel published a report of this meeting in the next edition of the *Industrial Arts Teacher*, the AIAA’s journal. Although he made it clear to ACIATE members that the leadership was acting to assure that the series would “be able to continue in a high professional tone” (p. 11), there is no evidence that the membership at large had exhausted its patience after the first three yearbooks. But at least some pressure was being applied from another quarter. As Whitesel later recalled,

> The McKnight and McKnight Publishing Co. [had] asked that a Yearbook Planning Committee be a continuous thing so that there will not be a break with the changing of officers. The Executive Committee has concurred and has developed a plan of having ten members on the Yearbook Planning Committee – two of whom are to be replaced each year. …The president of the Council will [by] virtue of his office act as Chairman for the Committee. (Whitesel, 1956, p. 1-2)

Although McKnight and Stephens had agreed to a very generous publishing arrangement, they apparently wanted some influence over the planning model. The ACIATE responded, and in less than a year, Whitesel and the committee had lined up topics, editors, and authors for 1956, 1957, and 1958, and had selected the 1959 topic. This began a four-year period in which the committee maintained a cushion of at least three future books (See Table 2, Next Page).

Table 2

ACIATE Yearbook Committee Chairs, 1950-1964, and the Number of Future Yearbooks Approved and Accrued at the Time of Each Annual Conference

ACIATE Yearbook Committee chair[†]	Year	*n* future yearbooks 1	2	3	4	5	6
Walter R. Williams Jr.	1951	1	2				
	1952	2					
	1953	3					
	1954	4					
John A. Whitesel	1955	5	6	8			
	1956	6	8	7	9		
R. Lee Hornbake*/	1957	7	8	9			
	1958	8	9	10			
John A. Fuzak	1959	10	9				
	1960	10	11				
Donald Maley	1961	11	12	13	14	15	16
	1962	12	13	14	15	16	
	1963	13	14	15	16		
	1964	14	15	16	17		

KEY ***v***: yearbook accepted and scheduled at this conference; ***v***: yearbook accepted and scheduled some time before the conference; ***v***: volume number. Notes: Does not include *Who's Who in Industrial Arts Teacher Education 1969*, an unnumbered supplement to the series. [†]Not a formal position until 1955. *Hornbake resigned when he became Associate Dean at Maryland. ACIATE Vice-president Fuzak succeeded him, then was elected to a 2-year term.

The planning committee approved four yearbooks while Whitesel was its chair (See Table 3, Next Page). As all were in process when he left the office, he left his successor with a comfortable margin.

Table 3

Yearbooks Approved During John A. Whitesel's Term (1954-56) as ACIATE Yearbook Planning Committee Chair

Volume	Title	Editors and Institutions
1957 (6th)	*A Sourcebook of Readings in Education*	Carl Gerbracht; Gordon O. Wilbur (SUNY–Oswego)
1958 (7th)	*The Accreditation of Industrial Arts Teacher Education*	Verne C. Fryklund (Stout State College); H. L. Helton (Northeast State College, OK)
1959 (8th)	*Planning Industrial Arts Facilities*	Ralph K. Nair; Paul L. Scherer; Lynne C. Monroe (U. California–Santa Barbara)
1960 (9th)	*Research in Industrial Arts Education*	Raymond Van Tassel (New York U.)[†]

[†]Original editor Robert L. Thompson (NYU) died in 1958.

Limits of Committee Decision-Making

When John A. Fuzak assumed the dual role as ACIATE president and yearbook planning committee chair in 1958, he wrote an open letter to the council's membership, reminding his readers that any ACIATE member could propose a yearbook topic and meet with the committee to discuss it. The message, unstated in Fuzak's letter but clear from memos and meeting notes, was that the committee itself had become an insufficient source of ideas for future yearbooks; the letter was part of a strategy to solicit proposals from outside the committee. But a few months later, Fuzak's coordination of this effort was postponed by more immediate problems.

Late in 1958, Fuzak wrote to the committee about the death Robert L. Thompson, who was to be the editor of the 1960 book. Furthermore, he added, no topic or editor(s) had been chosen for the 1961 book. Ultimately, a replacement was found for Thompson, and at the convention in April, the committee selected *Graduate Study in Industrial Arts* as the tenth yearbook (1961), to be edited by Herber Sotzin.

About a year later, history repeated when Sotzin died on January 6, 1960. By the end of the month, Fuzak informed the committee via mail that he had found a possible replacement. Referring to the lack of a plan for the 1962 book, he enclosed several proposals for that publication, at least five of which contained detailed outlines. He asked the committee to "please react immediately" on the "selection of our next Yearbook topic" (1960a, p. 1).

About five weeks prior to the AIAA convention at which the yearbook meeting would be held, Fuzak wrote to Donald Lux on behalf of the committee, sending him an "outline … intended only to suggest ideas to an editor who might accept responsibility for the Yearbook." The book, *Curricular Approaches in Industrial Arts*, would be "due at the publishers on October 1, 1961" (1960b, p. 1). Lux, of the University of Illinois, responded with a one-page proposal on an entirely different topic, *The Pre-Service Preparation of Industrial Arts*. At their 1960 meeting, the yearbook committee accepted the Lux proposal. This was the first time a yearbook planning committee approved a yearbook without exercising substantial input.

Fuzak was able to leave his successor with a backlog of two yearbooks (Table 4). He also left a precedent that would be regularly observed for the next fifty years; future yearbook committees would consider package proposals, which would include the yearbook topic, editor, chapter topic, and (in most cases) chapter authors.

Table 4
Yearbooks Approved During John A. Fuzak's Term (1957-60) as Chair of the ACIATE Yearbook Committee

Volume	Title	Editors and Institutions
1961 (10th)	*Graduate Study in Industrial Arts*	Ralph P. Norman; Ralph C. Bohn (San Jose State U.) †
1962 (11th)	*Essentials of Preservice Preparation*	Donald G. Lux (U. Illinois)

†Original editor Herber A. Sotzin (San Jose State) died in 1960.

Convention Emerges

At the end of 1960, Fuzak wrote to incoming ACIATE president and yearbook chair Donald Maley. Fuzak referred to his attempts to solicit yearbook proposals from the membership at large:

> It was our hope that individuals and small groups would be coming forward with proposals to the Yearbook Committee which might be screened by the committee… I am afraid that it has not worked out as well as we thought it might. …while this is an ideal way to operate[,] and members should be encouraged to forward proposals to the committee, the committee itself must be active in developing ideas. I would suggest that several of the members of the Yearbook Committee who are in your vicinity get together and work out some rough outlines for future yearbooks. …I am sure that you must be getting somewhat nervous about future selections. (1960c, p. 2)

Whether or not Maley was getting nervous, it seems that the executives at McKnight & McKnight had again become concerned about the ACIATE's management of the series.

In November, Wesley Stephens wrote to Maley, urging him to consider a yearbook idea from John Rowlett of Eastern Kentucky University. Maley wrote the committee a month later, saying, "As an item of special concern to this committee, I would like to have your reaction to the following suggestion which I received from Wes Stephens" (1960, p. 1).

About three months later, Stephens wrote directly to the yearbook committee, indicating that, at the company's expense, McKnight & McKnight would host a dinner for them prior to their meeting on April 5. Potential editors and editors of books in progress would also be invited. Stephens also repeated the possibility of a yearbook edited by Rowlett, ending the memo with, "I am informing him of the planning committee meeting and *inviting him to attend* [emphasis added] if he wishes to outline this matter for committee consideration" (1961, p. 1,).

At the post-dinner meeting the committee approved the topics and editors for five yearbooks (Table 5). Rowlett was chosen to edit yearbook 15.

Table 5
ACIATE Yearbooks Approved on April 5, 1961

Volume	Title	Editors and Institutions
1963 (12th)	*Action and Thought in Industrial Arts Education*	Ethan A. T. Svendsen (Indiana State U.)
1964 (13th)	*Classroom Research in Industrial Arts*	Charles B. Porter (Illinois State U.)
1965 (14th)	*Approaches and Procedures in Industrial Arts*	G. S. Wall (Stout State U.)
1966 (15th)	*Status of Research in Industrial Arts*	John D. Rowlett (Eastern Kentucky U.)
1967 (16th)	*Evaluation Guidelines for Contemporary Industrial Arts Programs*	Lloyd P. Nelson; William T. Sargent (Ball State College)

Under the previous arrangement, Maley's term as yearbook committee chair should have ended at the close of the 1962 AIAA convention. But during the council's business meeting at the convention, he made a motion "that the immediate past President will automatically become Chairman of the Yearbook Committee for a two year term" ("Minutes," 1962).

The motion carried. Some private debate followed after the convention as to whether Ralph Gallington, the new ACIATE president, should chair the committee despite Maley's motion (e.g., Wall, 1962; Gallington, 1962), but the ACIATE constitution did not clearly specify who had oversight of the yearbook series. Maley served two more years as committee chair, and the constitution was amended to institutionalize the motion. The structure of the committee has not changed since.

Analysis

Between 1925 and 1950, several national education associations had inaugurated yearbook series, including the National Council of Teachers of Mathematics, the National Council for the Social Studies, and the National Art Education Association. But the yearbook program with perhaps the most marked influence on the ACIATE's founders was the 48-year-old series of the National Society for the Study of Education (NSSE). John Dewey, David Snedden, and Frederick Bonser were among the NSSE participants who would have been recognized by the founders of the ACIATE as important figures in the history of industrial arts in the US.

The Original Conception of Yearbook Planning

In addition to the inspiration of the NSSE books themselves, it seems that the ACIATE's founders envisioned yearbook *committees* similar to those of the NSSE. Members of these committees, who would possess expertise in the subject of the yearbook, would serve as the chapter authors. And each would represent some diversity of philosophy—thus the need for a chairperson to ensure balance in the final volume.

In the original operational model of the ACIATE yearbook series, open meetings would facilitate debate and eventual consensus on future yearbook topics and contributors. At the same meetings, the authors and editors of in-process yearbooks would report on their progress. Ideally, drafts of the chapters would be distributed and discussed (Whitesel, 1954b). Through such measures, council members could influence the yearbooks without being elected to a committee—or perhaps more precisely, the ACIATE members would collectively *be* the yearbook planning committee. This conception is clear, not only from private correspondence, but from items published in the *Industrial Arts Teacher* (e.g., "American Council Meeting," 1950; Hunt, 1950; Whitesel, 1954b) and from programs of early ACIATE meetings.

It is also evident that the council's organizers wished to make progress quickly. They formed a publications committee and hoped to publish their inaugural yearbook even before the group adopted a constitution. Reconciling such *in camera* decisions with the published ideal of democratic, group decision-making suggests that the early yearbooks were to be transitional volumes until a critical mass of topics and personnel could be achieved.

Accordingly, the four-member publications committee was more focused on the technical aspects of publishing than on the content of the yearbooks.

Meanwhile, virtually all-important decisions regarding the first four yearbooks were made by the ACIATE executive committee, a group of four or five men. On one hand, the yearbook series may not have survived its fledgling stage if all decisions, trivial or critical, had to be postponed until the next annual meeting. On the other, it was during this stage that the council's leadership and membership became accustomed to yearbook decisions being made in executive session.

The story of yearbook 3, *Superior Practices in Industrial Arts Teacher Education*, is a pertinent example. Each ACIATE member would likely have been aware of this volume before it was to be published in 1954. R. Lee Hornbake and Donald Maley had begun collecting data for the book in 1952 by contacting personnel representing all 203 industrial arts teacher education programs in the US. Announcements about the upcoming book were made at the AIAA conferences in 1952 and 1953, and were also reported in the *Industrial Arts Teacher*.

But, in February 1954, this notice was printed in the *Industrial Arts Teacher*:

> Because of late returns by members, publication of what was to be Yearbook III had to be postponed until next year. Fortunately, work on the 1955 yearbook was sufficiently advanced so that it could be completed by the publisher's deadline, and will be released as Yearbook III. ("Los Angeles," p. 11)

This was the first published mention of a "1955 yearbook," and no further details were provided. Nearly every *Industrial Arts Teacher* since 1950 had included a discussion of upcoming yearbooks, so the existence of a 1955 yearbook, or plans for one, must have been a surprise to many ACIATE members.

At the April 1954 convention, William McKnight, Jr. presented the book, *Leadership, Graduate Preparation, and Textbook Analysis in Industrial Arts Teacher Education,* stating that "the authors … produced the Yearbook by each writing a part" ("ACIATE Membership," 1954).

The idea that the three dissertations assembled to constitute yearbook 3 were parts of a whole, or that such a collection had been planned as the 1955 yearbook, appears to be completely false. Correspondence among Williams and the executive committee during this time contained no such references, and just months after its publication, the yearbook planning committee adopted a general policy not to reprint dissertations. Williams and Stephens later explained to Kinzy that yearbook 3 was an eleventh-hour "stopgap" measure, "necessary to provide continuity" (p. 108).

A year later, Whitesel expressed “no doubt [that] the membership is aware of the double emergency situation which faced the officers last September” (1955, p. 24). Yet at least in terms of official publications, it seems that the ACIATE leadership had tried to keep the membership unaware of the Yearbook 3 situation (Whitesel was not a member of the ACIATE executive committee during the 1952-53 and 1953-54 academic years and may not have been involved in this episode. During his subsequent term as president he twice acknowledged, in print, awkward “emergencies” which had befallen the yearbook series), then explained that the last-minute substitution was “because of late returns by members.”

The ideals of the four-year-old group had yet to be met. Group decision-making remained untried. The books themselves—essentially the results of studies—had fallen short of the ambition of a series of topical collections of the best thinking in the field. Those who worked to produce the volumes must have more closely resembled a tight-knit group (Table 6) than a meritocracy. Despite this close association, this group represented an ideological diversity which would become apparent over the next decade.

Table 6
Chief Contributors to ACIATE Yearbooks 1 through 4 and Their Institutional Affiliations.

Yearbook Contributor	Vols.	Doctorate	Advisor’s Doctorate	Primary Employer
Walter R. Williams, Jr.	1, 2, 3	Ohio State	Ohio State	Florida
Harvey K. Meyer, Jr.	1	Florida	Ohio State	Florida
Roy F. Bergengren, Jr.	2, 3	Florida	Ohio State	Florida
George F. Henry	3	Florida	Ohio State	Colorado A&M
Talmadge B. Young	3	Florida	Ohio State	Berry College
R. Lee Hornbake	4	Ohio State	Columbia	Maryland
Donald P. Maley	4	Maryland	Ohio State	Maryland

Note: “Primary employer” is where the contributor worked the longest.

Nominally, the profession had a yearbook program, but the aspiration of a series that would demonstrate the intellectual *bona fides* of industrial arts—or at least make the field, in Hornbake’s words, “well thought of”—had yet to be realized.

Yearbook Planning Committee(s): From Supervision to Franchising

Something had to be done about "the whole Yearbook situation," Whitesel (1954b, p. 11) acknowledged in his report of the yearbook planning committee's September 1954 emergency meeting. The five participants "decided to start by first developing a statement of principles governing all decisions in yearbook planning" (p. 11). Among these was a reaffirmation of the privilege and intent of the ACIATE's officers to name the "special committee" responsible for each yearbook. Another was to clarify the role of the membership. Whitesel (1954b) wrote,

> A yearbook session will be held at the convention next spring [1955] at which time the entire membership will participate in suggesting and discussing various topics as possibilities for future yearbooks. (p. 11)

The ACIATE leadership appears to have hoped to accomplish two goals, involving the general membership in yearbook decisionmaking and addressing the shortage of agreeable topics for future volumes. Open sessions of the yearbook planning committee were held on the first full day of the AIAA conferences in 1955 and 1956. The following year Hornbake noted that

> The Yearbook Committee … has proposed a series of publications through the ninth yearbook and the several editors have been designated. At the last two national conventions a prospectus for each forthcoming yearbook has been presented to and discussed by the Council members. (1957, p. iv)

As Fuzak noted in his November 1960 letter to Maley, efforts like these did not increase the active participation of ACIATE members in selecting yearbook topics. In any event, these open sessions ended in 1956. In their place, Stephens and McKnight began hosting a breakfast meeting for the yearbook planning committee. To keep costs reasonable, admission was "by invitation only." Whether intentionally or not, the officers of McKnight & McKnight, who had persuaded the ACIATE to institute a permanent yearbook committee, now cemented another brick in the wall separating the ACIATE membership from yearbook decision-making. After four years, the breakfast meeting was replaced by the dinner, mentioned earlier, that Stephens arranged in 1961. The practice of the publisher hosting such a dinner continued until 2008.

By the late 1950s, two factors were converging. The yearbook planning committee was encountering difficulty identifying topics it could pair with suitable editors, and the official channels through which an individual member could influence yearbook decisionmaking had been restricted to either presenting a formal proposal to the committee in a closed-door session or getting named to the committee (between 64% and 100% of these seats were held by people who had already contributed to a yearbook as a writer or editor). If there was a watershed moment, it was the committee's acquiescence to Lux's package proposal in 1960. In a sense, Lux became a franchisee of the committee.

Once institutionalized, the practice of approving package proposals would *per se* reduce the direct influence of the yearbook committee on the contents of yearbook chapters. Two reasons that this committee would voluntarily relinquish such control are apparent from the record. First, committee members—and especially Fuzak—were in a dilemma. On one hand, they were responsible for the council's signature product; on the other, it had become difficult to organize and supervise editors and writing groups. This was partly because yearbook editorship, hamstrung as it was by this process, was often not sufficiently rewarding to those able to carry it out. The second reason was that, by attracting seasoned editors with the promise of more autonomy, the committee was able to surrender responsibility for each individual volume without abdicating its fundamental function to supervise the yearbook series.

The NSSE experienced a similar shift at the same time:

> Many early NSSE Yearbooks were actually the result of committees created to study a particular issue; findings were then written up and published. … In 1963, the title "chairman" was replaced by "editor," marking a shift in the organization of yearbook work away from committee-led efforts. In the 1970s, the yearbooks began to be organized more as a group of authors contributing chapters under the direction of an editor who tended to be recruited by a Board member. ("The History," n.d.)

For the ACIATE yearbook series, the emergence of the "strong editor" model was swift. The editors of at least four of the five volumes approved in 1961 appear to have been given as much latitude as Lux enjoyed. After that, yearbook topics were only rarely scheduled with unspecified editors; even in these cases, the editors, once chosen, were permitted to select their own authors and topic outlines.

Recapitulation

An inspection of the early yearbooks of the American Council on Industrial Arts Teacher Education reveals surprisingly few hallmarks of the series it would become a decade later. Whereas all but two yearbooks since 1958 have been edited collections of chapters, five of the first seven were reports of studies. For each volume from 1955 through 1961, the yearbook planning committee selected a topic and outlined a general approach before assigning an editor to carry out the plan. This is a very different system from the committee's current consideration of package proposals.

Since the early 1960s, the yearbook series has been remarkably stable in terms of decision-making structure and the management and organization of individual volumes. How this tradition evolved from the initial conception of the series—in which the membership at large would determine the topics of books, which would be produced by committees answerable to the council as a whole—was the central question of this study. To Kinzy (1973), the answer was relatively straightforward:

> The yearbook series was a need felt by the profession and one of the main, if not the main, objectives of the Council when it was formed. It was made financially possible by a generous offer from McKnight & McKnight Publishing Company. It was made a reality by Walter R. Williams, Jr., who made the proposal to McKnight & McKnight and edited the first two yearbooks and provided for the stopgap third yearbook to keep the series going.
>
> Problems of yearbook planning made evident by Yearbook 3 were solved when John A. Whitesel appointed a Yearbook Planning Committee and developed guidelines. The yearbook program has operated smoothly since that time. (p. 138-139)

Kinzy's three primary sources for his history were Williams, Whitesel, and Hunt. Hunt wrote in 1960 that "the story of the origin and development of the ACIATE Yearbook program reads almost like a fairy tale" (p. 104). But a broader examination, albeit one without new interviews of these men, suggests otherwise. Whereas in a fairy tale the hero surmounts extraordinary challenges, the protagonists in this story battled institutional homeostasis, competing egos, and divergent management styles—formidable, but nonetheless ordinary, challenges. Kinzy's characterization notwithstanding, these extended beyond the yearbook 3 problems, beyond the formation of the planning committee, and beyond the adoption of the first guidelines.

In fact, Whitesel's institutionalization of a yearbook planning committee did not alter the "whole Yearbook situation"—at least at first. It did, however, signal the eventual demise of the concept wherein an active membership would select topics of yearbooks. The execution of each yearbook would be the responsibility of a special committee appointed by the council's officers. Nonetheless, as Fuzak noted, the yearbook series could not be carried out solely by the planning committee itself.

A degree of stability was achieved by counterbalancing strong editors of individual volumes with a new model of the yearbook planning committee as an oversight or quality control board. With Maley's successful maneuver to extend his term as committee chair, the transition to modern yearbook decisionmaking was complete.

Suggestions for Further Research

At least three approaches to the continuation of this research appear to be potentially fruitful.

Impacts of Inertia

How has the stasis described here impacted the yearbooks since the mid-1960s—and in turn, how has it affected the larger profession, both in and beyond the US? In his review of yearbook 44, *Foundations of Technology Education*, Petrina (1998) supports the premise that ideological homogeneity constrained yearbook decisionmaking, at least through the mid-1990s. Did the concentration of influence, which began in the 1960s, ultimately give control of the yearbook series to a handful of likeminded men who protected the yearbook series from competing ideologies? How has the yearbook-selection process, and the stability of that process, impacted the range of acceptable topics and authors?

Delayed Democracy

Once the ACIATE yearbook series was begun, democratic decision-making was sacrificed to promote efficiency and consistency. Perhaps this sacrifice was temporary, or, after 60 years, the yearbook decision-making structure has ceased to be an effective tool in promoting specific ideologies. Demographic changes in the profession, including the closure of once-dominant doctoral programs and an increase in the number of teacher educators whose professional preparation is in engineering or other fields, may have diluted the "old boy network," resulting in yearbooks that better represent the profession.

Over the past two decades, more yearbook authors have been women, and more have held office in the National Association of Industrial and Technical Teacher Educators, a group sometimes viewed as a rival to the ACIATE. Of authors in higher education, fewer have been full professors. And the number of authors from outside the US is growing, though slowly. Furthermore, it seems unlikely that in any earlier 10-year stretch in the profession's history, four yearbooks would appear with titles like *Diversity in Technology Education* (Rider, 1998), *Appropriate Technology for Sustainable Living* (Wicklein, 2001), *Ethics for Citizenship in a Technological World* (Hill, 2004), and *International Technology Teacher Education* (Williams, 2006). [Regarding the last title, it should be noted that C. Robert Hutchcroft advanced the first serious proposal for an "international" yearbook in 1959. Four years later Marshall L. Schmitt of the U.S. Office of Education unsuccessfully sought to have the yearbook committee consider a similar topic.]

Impacts of Individuals

This article discusses the influence of individuals, such as Walter R. Williams, Jr., Wesley D. Stephens, and William McKnight, Jr., on the yearbook series in its formative years. Further investigation should also focus on the longer-term impacts of Donald Maley on the yearbook series. In his term as chair of the yearbook planning committee, he exerted more influence over the series than anyone had before. It also appears that both directly and indirectly, Maley served to stabilize the series into the 1990s.

Including four years as chair, Maley's yearbook-committee service totaled 16 years between 1959 and 1992. Two other committee members whose long service suggests that their influence should be studied are R. Thomas Wright (13 years between 1982 and 1995, including 8 years as committee chair) and G. Eugene Martin (20 years between 1981 and 2007).

Final Thoughts

To some degree, the ACIATE's founders were unaware of the logistics of producing the kind of series they desired, and, at the same time, they seem to have overestimated their collective ability to manage the series without such a structure. It is well worth noting that they ultimately succeeded in their task of having a yearbook for their profession. But what of R. Lee Hornbake's concern that his profession's lack of respect was due to its lack of a yearbook? Morris Freedman, a former chair of the University of Maryland's English department, who considered Hornbake to be "the spiritual creator of the University of Maryland," remarked after Hornbake's death in 2000: "I was stunned when I learned that his academic field had been industrial education. The obituary solved this mystery, reporting that he spent a year at Harvard studying the humanities" (p. B-8).

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Appendix: In Order of Appearance

Ralph Lee **Hornbake** (1912-2000): Received his doctorate from The Ohio State University, but appears to have had fundamental differences with AIAA founder and Ohio State Professor William E. Warner. After twelve years, he left the Industrial Education Department at the University of Maryland in 1957 to join the upper administration. The university's Hornbake Library was named in his honor.

DeWitt Talmadge **Hunt** (1889-1988): As AIAA President, 1949-51, he headed the drive to create the ACIATE. In 1955, he retired after forty years at Oklahoma A&M College to become the Specialist for Industrial Arts for the U.S. Office of Education. He had begun his teaching career in 1908, before most of the other figures in this story were born, and received his doctorate at age 50.

Walter Rollin **Williams,** Jr. (1909-1989): The first President of the ACIATE, he was largely responsible for its constitution and for its first three yearbooks. Preceded Hunt as AIAA president. Left the University of Florida at the end of 1953 to become that state's Director of Vocational Education. The son of Quaker missionaries, Williams spent most of his first fourteen years in China.

William Warren **McKnight,** Jr. (1913-2006): After World War II, he began to assume leadership of McKnight & McKnight Publishing, which his father had founded in 1895. On August 1, 1951, he agreed that McKnight & McKnight would underwrite the ACIATE yearbook series. He sold the company in 1983.

Wesley Delmar **Stephens** (1921-2009): William McKnight, Jr.'s "right-hand man," he eventually became the company President of McKnight Publishing. He often acted as a liaison between the company and the ACIATE, at one point becoming the council's parliamentarian. He remained active in the industrial-arts field for more than a decade after retiring in 1978.

John Allen **Whitesel** (1903-1993): Assigned in 1948 by the AIAA executive committee to organize the ACIATE, he called the May 10, 1950 meeting at which the council was formed. Whitesel, a Professor at Miami (Ohio) University from 1941, was the third president of the ACIATE and formed the first Yearbook Planning Committee in 1954.

John Alexander **Fuzak** (1914-2007): A graduate of the University of Illinois, Fuzak was ACIATE President from 1957-1960. Among his posts during 31 years at Michigan State University were Dean of Students and Vice-President for Student Affairs. In a brief professional baseball career, he batted .194 in 20 games for Class D Sioux Falls in 1936. He later served as the President of the National Collegiate Athletic Association (NCAA).

Donald **Maley** (1918-1993): As the 1960-64 Chair of the ACIATE Yearbook Planning Committee, he oversaw the committee's transition to its modern form. Like Hornbake, whom he replaced as department chair at Maryland in 1957, he was often philosophically at odds with Warner. Maley was originator of the influential Maryland Plan for junior high school industrial arts.

Looking Back, to Look Forward: Using Traditional Cultural Examples to Explain Contemporary Ideas in Technology Education

Although the term *technology* means different things to different people, most would generally agree that it is about "stuff." For some it may be more complex than this, and for others it may simply involve using or studying high-tech gadgetry, such as computers and iPhones. Whatever your view, technology cannot occur without people, and therefore, values and culture are inherent influences on and features of technology. Understanding this interdependence between design and culture is a critical part of technology education. In order to know what one wants and needs for the future, it is important to have a good historical and cultural understanding of technological change. Although many countries include historical, societal, cultural, and environmental emphases in their technology curriculum, these can be lost in the drive to design, make, and create. The following article will provide justification and examples for these notions to be key parts of a technology program.

Over the last decade, the one thing that has been constant in education is change. Teachers are expected to cover more concepts, whilst addressing the ever-increasing diversity amongst their pupils. Technology education is no exception (de Vries, 2006). However, providing justification and examples for the inclusion of historical, societal, cultural, and environmental emphases may help teachers and teacher educators to see the validity of and ease with which they can include this crucial material. Including these approaches will allow students to utilise the wisdom of other generations and cultures in order to contemplate contemporary technological developments.

Technology Education

The term *technology*, although part of everyday language, means different things to different people. The majority of people identify technology with products such as computers, iPods, and iPhones (Jarvis & Rennie, 1996; Lawson, 2008). Advertisements referring to the "latest technology" reinforce this interpretation of the term. Upon contemplation, most people "can describe technology in general as the means by which human beings have sought and provided for their survival and enjoyment of life on this planet" (Burns, 1997, p. 16). People use technology, create technology, and do technology. It can be a noun, adjective, or verb. Undertaking technology can be seen as an age-old task of innovation and adaptation, which focuses not only on the product, but includes the processes by which technological products are developed and used (Lindgren, 2005).

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However technology education is perceived, it always involves something that people have made or done, and therefore, is inherently situated within a culture and its values. The place of values in technology education has been argued for decades (Layton, 1991; Pavlova, 2006; Prime, 1993). *Culture*, in this paper, is defined as the "relationship between a given group of people and their environment. It includes patterns of production and consumption and the beliefs, values and structures that maintain these patterns" (Kokko & Dillon, 2010). Foucault (2002) writes that understanding of the world is influenced by socio-cultural factors and discourses prevalent in each society, with an individual's actions being a response to their experience-based disposition and their specific surroundings.

Many technology curricula throughout the world acknowledge the importance of the relationship between history, society, and culture and technology. In an international study of six countries' technology curricula, the "history of technological developments" was found the most significant common content across all curricula (Rasinen, 2003).

The Swedish technology curriculum requires students to "be able to describe important factors in technological development, both in the past and present, and give some of the possible driving forces behind this" (Skolverket, 2000, as cited in Hallström & Gyberg, 2009, p. 4). The South African technology curriculum requires a third grade learner to "find out about the historical context when given a problem, need or opportunity related to structures, processing or systems and control" (Department of Education, Republic of South Africa, 2002, p.4 as cited in Hallström & Gyberg, 2009, p. 4). The New Zealand curriculum requires students to "to appreciate the socially embedded nature of technology and become increasingly able to engage with current and historical issues and to explore future scenarios" (Ministry of Education, 2007, p. 32). Despite many countries including cultural and societal aspects in their technology curriculum, for a variety reasons (time, lack of knowledge, and interest) these are frequently not covered (Mawson 1999).

Internationally, the last 20 years have been very turbulent for technology education (de Vries, 2006). There has been a great deal of change, and, for the most part, teachers have been expected to change both what and how they teach. For some this has been a breath of fresh air, but for many it has been an arduous undertaking (Lee, 2003a). Teachers often lack subject knowledge and understanding of the nature of teaching and learning involved in new subjects (Elton, 2006). Teachers have been expected to master a plethora of new terms and jargon, as well as translate their new curriculum into implementable classroom activities, often with limited access to resource materials (Rasinen et al., 2009; Stevens, 2006). This article demonstrates the ease with which contemporary technological notions can be linked to topical, local, and cultural products and issues.

The Need for Culturally Appropriate Resources

Two of the most frequent opening statements made in Australian public speeches are “we live in times of rapid social change” and “we are a multicultural society” (Jamrozik, Boland, & Urquhart, 1995). These phrases are not unique to Australia, as the cultural diversity of cities and nations is rapidly changing (Inglehart, 1997). And yet, we must question whether our teaching reflects these changes.

Providing historical and cultural examples will not only value students’ cultural capital, but will also develop a broader understanding of technology (Lee & Waqavanua, 2008). An authentic learning environment allows students to construct knowledge using real world contexts and examples. In doing so, teachers will “close the gap between technology in the real world and technology education in schools” (Stein, McRobbie, & Ginns, 2001, p. 241). Children will be able to link news articles and items they see every day with concepts presented in the technology curriculum. Rather than seeing technology as something that is high-tech and foreign, e.g. the latest iPhone application, they can see that it is an age-old tradition of problem solving, adaptation, and modification to meet needs, whilst considering the consequences of one's actions.

The following section shows how traditional cultural and historical examples can be used to support contemporary technological concepts. A brief justification will be provided to validate use of the material.

Using Traditional Cultural and Historical Examples to Support Contemporary Technological Concepts

Students are usually very keen to construct (make or do) something when learning about technology and can become quickly frustrated when asked to think, discuss, and write (Lee, 2003b). Providing current topical examples, which highlight adverse consequences if this process is ignored, may help students see the value of undertaking more than just the practical nature of technology.

The students of today need to look at yesterday in order to design a better tomorrow (de Vries, 2006; Starkweather, 2006). Given that the majority of technology teachers and teacher educators are not educated as historians (Hallström & Gyberg, 2009), gathering historical cultural examples may need to be a shared responsibility. It is important, however, to “avoid the technological version of the ‘Whig theory of history’ in which the past is read as a sequence of steps leading inevitably to the accomplishments of today” (Winner, 1993, p. 370).

Being aware and researching the impact of historical events and the values placed on these by certain cultures ensures that contemporary designs are more viable. An example of the importance of this occurred in 2001, when a Chinese actress/fashion model on a New York assignment wore an outfit that looked like the Japanese imperial flag from World War II. This caused an international incident, as people in China, particularly those in Nanjing (who had suffered greatly during World War II), were deeply offended.

The difference between wisdom and out-of-date knowledge is often more a case of perspective; thus, much of the knowledge held by our forebears is lost. Decisions about which skills and information are valued enough to be passed on are always hotly debated, especially by those teachers close to retirement. The well known story of hunting the sabre-tooth tiger, where children were taught the fundamental skills of how to grab fish, club woolly horses, and scare sabre-tooth tigers even when (due to climate changes) these were no longer food sources, is a good example of this. (Peddiwell, 1939). On the other side of the argument, history is full of lost knowledge and skills, that, if "(re-)discovered" at a later time, prove to be very valuable. One such example is that of the skull trepanation, which occurred in Neolithic times about 7,000 years ago. This is the oldest known surgical procedure that involves drilling a circular hole into the skull. In Neolithic times flints or obsidian would have been used as the cutting edge of the tool, specific mushrooms may have provided antibiotic actions, and poppies served as analgesics (painkillers). Surgeons knew enough about the anatomy to know how far into the cranium they could operate, and they developed processes so that the patient remained still and the drilling procedure was so quick and precise that part of the skull could be removed but the brain matter below (dura) not penetrated. Archaeological evidence has shown that patients survived months or years after these operations, with skull fractures showing healing without evidence of inflammation and infection (Weber & Wahl, 2006). Trepanation also occurred 3,000 years ago in Egypt (El-Zawahry et al., 1997) and 2,000 years ago in Peru (Rifkinson-Mann, 1988). It appears, however, that this wisdom was not passed from culture to culture, but rather has been a process of lost knowledge, discovery, and rediscovery over the millennia.

Transferring, valuing, and financially benefiting from cultural knowledge leads to rich discussion points such as bio-piracy and bio-prospecting. Rich philosophical discussions can occur about the ethics of intellectual property (IP) and transference of sacred tribal wisdom. With the rapid increase in “charges of misappropriation or theft of traditional knowledge of the uses of plants” (Mgbeoji, 2001, pp. 163-164), examples are easily found. One is that of the Samoan Nonu plant, which is now being grown in numerous countries for its medicinal and anticancer properties.

Knowledge about power relationships lead to other philosophical and ethical discussions about how human actions and "developments" can have positive and negative influences on the social and natural world. For example, a boat with an outboard motor providing links between two islands may be seen as a much faster alternative to a traditional outrigger canoe. Trade, travel, and communication will be faster, but the tradeoff is noise, small oil slicks, and erosion caused by wakes. A once quiet, secluded island may now have a constant buzz, as boats with outboard motors move around islands. Is and/or should money be the deciding and driving force for adoption of technologies? This leads to discussions and debates about stakeholders' needs, perspectives, and rights.

Culture and design are always interwoven "as design does not take place in isolation but is embedded in its user's culture" (Moalosi, Popovic, & Hickling-Hudson, 2010, p. 1). Designers who focus on the intelligence and values of the users, rather than the intelligence and values placed on the technology, will produce meaningful innovations. "Innovation starts with people, not with enabling technologies, and the designers' main role is to mediate between technology and culture and to get ethics and aesthetics to technology" (Ross 2002, as cited by Moalosi, et al., 2010, p. 3).

Culture gives objects meaning and provides the rituals within which these objects are used and the values that are often reflected in their form and function (Press & Cooper, 2003). It has a large influence on how items are valued and used. It has been said that "technology is not a good traveller unless it is culturally calibrated" (Kaplan 2004, as cited in Moalosi, et al., 2010, p. 177). An example of this is a fofo`e, which is a traditional wooden Samoan tool used to peel bananas. Samoans use this tool to slit and remove the skin in seconds, and it has become an implement used as frequently as a knife and fork; yet, similar tools are rarely seen in countries where bananas, although eaten, are not peeled in vast numbers.

Figure 1
Fofo`e being used to peel bananas

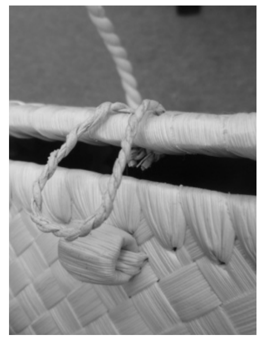
When using a thesaurus to find synonyms for the word *man-made*, the following words can be found: counterfeit, ersatz, factitious, false, manufactured, not genuine, plastic, synthetic, and unnatural. Although these terms are accurate it is surprising how many create a negative emotion. Technology can be likened to Frankenstein's monster, grown beyond control (Ellul, 1965), or as the latest "must have" (gadetphilia) (Lee, 2009). Drengson (2010) identifies these emotions as being part of the four stages of technological development, these being *technological anarchy*, *technophilia*, *technophobia*, and, finally, *appropriate technology*.

Technology is often personified by the media. We read how "machines steal jobs" and "cell phones cause car accidents." Although these phrases appear quite harmless, they give the impression that society is powerless. These media reports create the opportunity for discussions as to whether society has the power "to modify technology to fit people, rather than modifying people to fit technology" (Marshall, 1996, pp. 65, as cited in Oudshoorn, 2003, p.335). This leads to notions of haecceity (Collinson, 1988), hylomorphism, technocracy, phenomenology, existentialism, techno-determinism, post-modernism, post-structuralism, social construction, somnambulism, social constructivism, deconstruction, and actor-network theory which are just a few technology related philosophies able to be "googled" and debated. Writings by Aristole, Hegel, Husserl, Ihde, Heidegger, Ellul, Winner, Wittgenstein, Mumford, Pinch, Biijker, Derrida, Latour, Mitcham, Vincenti, and deVries form a reference basis for technology philosophy.

With over 30 million Google results for the word *sustainability*, it is clear that this is a popular and well used concept. Triple bottom line philosophies (Elkington, 2004) and *Agenda 21*, which developed from the Brundland Report (WCED, 1987), have made sustainability not only the responsibility of individuals, but also of nations. Many new curricula expect teachers to incorporate aspects of sustainability within classroom practices. Traditional craft items are often excellent examples to show how products can be sustainably designed, as they are often made from the primary resources of their local environment (Kokko & Dillon, 2010). When one raw material is no longer available, another can be sourced and processes altered accordingly. In Samoa a very hard seed called a pu'a was traditionally used to form latches on bags. With increased tourism, alternatives were needed. A new technique developed that utilised the more commonly used pandanus leaf (as in Figure 2 on next page), thus saving the treasured pu'a resource.

Figure 2a
Latch using a pu'a

Figure 2b
Latch using the pandanus leaf



In 2007, 50% of the global population lived on less than $2 a day (income level has been adjusted for purchasing power) (Kaplinsky, 2011). Since the recent financial crisis the numbers living in absolute poverty has risen by over 60 million (United Nations, 2009). In trying to address this issue a number of different strategies relating to technology have been developed, these include *hard* and *soft technologies*, *intermediate technology*, *alternative technology*, *green technology*, and *appropriate technology*. Investigating appropriate technology requires a thorough understanding of the culture for which the product is to be manufactured, used, and, if possible, repaired or reused. In this way, the solution is an appropriate piece of technology that is designed to take into consideration social, cultural, ethical, and environmental, as well as, political and economic aspects of the community for which it is intended to be used. An example of this is a pump that can provide water for 100 Indonesian village families and is able to be cheaply made from locally bought components with spare parts able to be sourced from everyday items such as old tire tubes (http://www.youtube.com/watch?v=l_SwFN3z9lg). YouTube videos such as the one provided are excellent visual examples for students to see the impact this type of technology can have on people's lives.

Conclusion

Historical, societal, cultural, and environmental knowledge should enrich contemporary design theory and underpin creativity and innovation in technological practice. Providing relevant, topical, and cultural examples will allow students to link their everyday lives to new areas of learning. This article has provided a variety of international examples to explain contemporary concepts in technology education. These have been justified to highlight the practical relevance of this material for today's multicultural classes. Although there may be large cultural diversity within a class, utilizing the historical, societal, cultural, and environmental knowledge available from the community and media will enable a teacher (at any stage of their technology career) to make technology education come alive.

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Collaborative Information and Multimedia to Assess Team Interaction in Technology Teacher Preparation

Technology influences elemental communication methods, results, and artifacts (Rogers & Thomas, 1997). Technological innovation obliges educators, students, and consumers to alter approaches to a variety of issues spanning from the way hierarchal relationships are perceived to the manner and means that individuals use to communicate. The utilization of information technology to assist communication and collaboration has become a central theme in information systems research and practice (Olesen & Myers, 1999). Rising information and communication technologies could considerably enhance interaction and collaboration.

A situation is identified as collaborative in nature when three conditions are met: "if peers are (i) more or less at the same level and can perform the same actions, (ii) have a common goal, and (iii) work together" (Dillenbourg, 1999, p.9). Communication and decision assembly are the two most prevalent actions executed by groups (Fisher, 1974; Mills, 1967, as cited in Baker, 2004). Multifaceted tasks and assignments that necessitate various proficiencies and abilities have been identified as most efficiently performed by a group. The logic and associated evidenced-based findings identify that a group's problem-solving skills and knowledge exceed those of any single contributor (Neilson, 2002). Edmondson, Roberto, and Watkins (2003) identify that team-based approaches and structures further the origination of innovative ideas and satisfactory alternatives, enabling diverse considerations to satisfy complex tasks and functions.

There are distinct advantages and disadvantages in operating with electronically linked groups. Structural and member advantages refer to groups' abilities to communicate virtually anytime and support active participation by each member (Brown, 2000). However, individual member and group-level conditions exist primarily due to scaled down exposure to visual and auditory contact, as well as lessened synchronous contact, although many contemporary information and multimedia technologies permit visual, auditory, and synchronous contact.

Information and communication technology practices and uses have developed into progressively more successful approaches in addressing individualistic learning needs, although meeting the needs of learning groups

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remains a challenge (Soller, Ogata, & Hesse, 2007). Initiated in the early 1980s, research about the method and approach of peer interaction assisting the development of understanding and learning has been pursued (Littleon, 2000). Collaborative learning research identifying specific educational effects has been illustrated in conditions of conceptual change or increased self-regulation (Amigues, 1987; Blaye, 1988; Gilly, 1989; Roschelle, 1992; Pea, 1993, cited in Dillenbourg, 1999). However, documentation of the understanding of true team dynamic and associated knowledge formation has not been clearly considered and accounted for.

Communication Collaborative Technologies

Regardless of the degree of learner preparedness, subsequent knowledge is based on how well students understand the learning process, with feedback, achievement, motivation, and expertise as acting elements. Team-based learning naturally incorporates each of these facets through its structure (Hills, 2001). Hills (2001) further identifies that, in an actual group structure, these naturally occurring facets must take on varied dynamics encompassing team planning, internal actions, relationships with others outside the group, and self measures of progress. Collaborative information technologies are broadly defined as electronic communication means that enable cooperation amid individuals engaged in a common mission or specific task (Khosrow-Pour, 2002). Through the incorporation of visual elements, communication technologies can further stimulate learning (Hamm & Adams, 1992). Targeted research by Andres and Akan (2010), examining the effects of technology-mediated learner collaboration, found that technology tool specification and incorporation, although not solely, promotes knowledge formation and application in team problem solving. In a study on innovations in remote learning design through collaborative online learning activities, Armellini and Aiyegbayo (2010) identify, through the use of web-based media tools (wikis, blogs, GoogleDocs, etc.), that activity design led to instantaneous instructor adoption and incorporation into the classroom. The study attributes this incorporation to learners being provided a mechanism to take part in, and benefit from, active knowledge construction.

For the purposes of this research study, applications that permit documents and imagery transfer, video communications, audio communication, and text-based communication (whether synchronous or asynchronous) are universally identified as collaborative information and multimedia technologies. This study introduced students to Google Documents, Skype, Wikis, Elluminate, Doodle, and Ning as information and multimedia technology applications to collaborate with classmates/peers (see Table 1 next page). Although course sections had traditional face-to-face meetings and laboratories, one section of participating students utilized the selected information and multimedia technology applications.

Table 1
Information and Multimedia Technology Applications

Application	Description
Google Documents	Documents, spreadsheets, forms, and presentations can be created, shared, and/or exported within Google Documents. Google Documents automatically saves files with a revision history view option.
Skype	Skype is an internet protocol audio and video communication provider.
Wikis	Wikis permit web pages to be formed for the purpose of editing collaboration.
Elluminate	Elluminate has a wide range of uses, spanning from social networking to video conferencing.
Doodle	Doodle is a group meeting scheduler to efficiently identify common availability among team members.
Ning	Ning serves as a place for social networking categorized by issues, topics, and initiatives.

Research Questions

A technology and teamwork study conducted by Palit and Stein (2008) identified that effective use of technology in a collaboration requires contextual knowledge and skills. One limitation acknowledged in their investigation was that student participants were deficient in information and communication technology proficiency. Palit and Stein recommend the inclusion of lessons/exercises to demonstrate how skills may be transferred into the context of their group experiences. They also identified that maintaining an operational knowledge of technological innovations (e.g. Information and Multimedia Technology Applications) should be paired with foundational skills and competencies associated with teamwork and collaboration. Further, developing practical teaming knowledge through experiences permits students to properly select and utilize technological applications in academic and professional settings. These findings and recommendations invoke lines of examination associated with technology teacher preparation and the potential uses of information and multimedia technology application, not only to extend student interactions outside of class, but also to promote knowledge formations associated with teaming and collaboration.

This research study was designed to investigate and identify the impacts, if any, that web-based information and communication collaborative technologies have on team-established interaction and team knowledge formation. Considering the Palit and Stein (2008) recommendation, four research questions were posed to specifically guide this study.

1. Are there identifiable differences in how students interact with group members before and after being presented with collaborative information and multimedia teaming technologies?
2. Is there an identifiable difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies interact with group members?
3. Are there identifiable differences in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies form team knowledge?
4. Is there an identifiable difference in students' team knowledge formation before and after being presented with collaborative information and multimedia teaming technologies?

Associated investigational hypotheses were derived to provide specific evaluation of research questions 1, 2, 3, and 4.

- There is no difference in how students interact with group members before and after being presented with collaborative information and multimedia teaming;
- There is no difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies interact with group members;
- There is no difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies form team knowledge; and
- There is no difference in students' team knowledge formation before and after being presented with collaborative information and multimedia teaming technologies.

Study Participants

Students enrolled in university advanced digital media sections were selected to participate in this team interaction and knowledge formation study based on enrollment and willingness to participate. The advanced digital media course serves as a required course in the re-visioned Technology, Engineering, and Design Education curriculum for Technology Education licensure. This course provides students with advanced knowledge and skill in the digital and interactive media industry. Emphasis is placed on advanced audio and video design. This course fulfills the communication technology requirement, while also targeting competencies in the Trade and Industrial endorsement area of Digital Media. The advanced digital media course is designed to build upon foundational knowledge and skill, gained in the introduction to digital media course, through advanced media study and application. Technology education at North Carolina State University has both a teacher licensure option, as well as a concentration option in graphic communications. However, both options are categorized as preservice technology and trade and industrial teacher education designations. The advanced digital media course for this study included both preservice teacher education options. Tables 2 and 3 provide the participant demographics of the advanced digital media sections participating in this team interaction and knowledge formation study.

Table 2
Digital Media Section One Demographics

Gender *n* – (%)	Male	16 – (94%)
	Female	1 – (6%)
Age Range *n* – (%)	18-20	10 – (59%)
	22-29	5 – (29%)
	30-39	0 – (0%)
	40-49	0 – (0%)
	50+	1 – (6%)
	Not Specified	1 – (6%)
Major *n* – (%)	Technology Education	7 – (41%)
	Technology/Graphics Educ.	7 – (41%)
	Science, Tech., & Society	1– (6%)
	Parks, Rec. & Tourism	1– (6%)
	Mechanical Engineering	1– (6%)

Table 3
Digital Media Section Two Demographics

Gender *n* – (%)	Male	16 – (76%)
	Female	5 – (24%)
Age Range *n* – (%)	18-20	12 – (57%)
	22-29	9 – (43%)
	30-39	0 – (0%)
	40-49	0 – (0%)
	50+	0 – (0%)
Major *n* – (%)	Technology Education	14 – (67%)
	Technology/Graphics Educ.	7 – (33%)

Methodology

The research team submitted a research proposal and was granted Institutional Review Board administrative study approval. Advanced digital media course instructor permission was acquired for the only two course sections offered. The advanced digital media course offering is limited to spring semesters, resulting in an annual offering of two simultaneous sections in the spring. One of the two digital media course sections was designated the control group, implementing the non-supplemented course curricula. The remaining digital media course section was designated as the treatment group. The treatment group was offered an identical course curriculum with the exceptions of a pretest and presurvey administered in week four of instruction, a one hour teaming technology orientation in week five of instruction, and a thirty-minute follow-up on specific uses of teaming technologies in week six of instruction. The one-hour teaming technology orientation consisted of a professional instructional technology and media specialist introducing the selected information and multimedia technology applications (identified and described in Table 1). The specialist created a single web-based resource for student access to applications and associated tutorials pertaining to the selected collaborative technologies. One week after the initial one-hour teaming technology orientation, the specialist hosted an in-class thirty-minute follow-up that included specific student questions and demonstration-based answers. Additionally, the control group and the treatment group were administered a teaming survey and a teaming test in week 15 of instruction. The treatment group was issued an additional team dynamic supplemental survey.

Both the treatment and control groups met a total of 23 times over the course of the semester using a standard lecture/laboratory course format. The course cognitive evaluations consisted of four periodic examinations and a cumulative final examination. The performance assessments were separated into team-based assignments, projects, and laboratories. Assignments consisted of two video projects that challenged students to brainstorm, formulate ideas, storyboard, and produce 30-second video solutions given defined criteria associated with viewing audience, time constraints, and intent.

Course projects, all of which were team-based, included storyboarding, instructional still video, documentary photography, and documentary video. The storyboard project introduces students to a variety of preproduction methods, which are widely used in today's audio and video production markets. At the conclusion of this project, students encountered much of the preproduction process in the completion of a storyboard. The Instructional Still Project introduced students to a variety of preproduction, production, and postproduction processes and methods important in achieving directed viewer effect. This project required students to utilize existing knowledge and skill to plan sequences, originate imagery, and generate audio. The Documentary Photography Project introduced students to a method of image capture that provides a record of social and political situations. This project required students to utilize existing knowledge and skill to convey a message through digital still photography. Similarly, the Documentary Video Project introduced students to a method of video capture that also provides a record of social and political situations. There were two primary approaches to documentary video—anthropological and historical. The anthropological approach shows people, institutions, and cultures as they are. The historical approach tries to bring to life significant people and events from the past. This project required students to utilize one of these documentary approaches, existing knowledge, and existing skill to convey a message through video.

Team-based laboratories consisted of a live video assignment, a live audio assignment, an original audio assignment, and a satellite communications assignment. The live video production laboratory gave students an opportunity to create, develop, and produce a live news television program. The laboratory was designed to allow the students to think and work in a "live television" environment. After completing the laboratory, the intent was for students to have gained a better appreciation for the technical requirements involved in producing a news television program. The live audio production laboratory provided students with an opportunity to create, develop, and produce a live radio program. After completing the laboratory, the intent was for students to have gained a better appreciation for the input and technical functions associated with creating and producing a live radio program. The audio development laboratory introduced students to technologies, which included audio composition, alteration, enhancement, and sweetenings, in a practical application used in today's industry. The Satellite Communications laboratory gave students a chance to learn about one aspect of satellite communication through the use of global positioning systems (GPS). Students were given the opportunity to use a synched digital camera GPS in order to complete a photography scavenger hunt.

Instrumentation

The Team Perception of Collaboration (TPC) assessment measures team interaction among group participants. The assessment is composed of 21 statements where participants are instructed to choose an option (ranging from never to always) that most accurately categorizes the description of their team. The option scale consists of 5 choices, 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Frequently, and 5 = Always. Instrument procedure requires subjects to be placed into groups and presented with collaborative tasks to capture team interaction specifics pertaining to listening, differences/conflicts, decision assembly, criticism, communication, group structure, and efficiency. Powers, Sims-Knight, Topciu, and Haden (2002) identified, through instrumentation analysis of the TPC of Arizona State University engineering undergraduates, that the sub-scales demonstrate adequate reliability evidenced by alpha's of .72 for both pre- and posttesting.

The Team Knowledge Test (TKT) assesses team knowledge formation in participants (Palit & Stein, 2009).

> The TKT is a measure intended to assess individual team members' general knowledge of team issues and concepts. The current test was designed for use with an undergraduate college population rather than a corporate population. Its 21 items are designed to sample students' understanding of four domains -- team process, decision-making, communication, and conflict resolution. This test presents a series of hypothetical situations in which the respondent is asked to choose the best [response of four multiple choice] options. (p.309)

A limitation of the TKT instrument design is that it contains carryover and, in some cases, duplicate concepts, although, not for all items. Also, TKT items are in many cases situational and are not always indicative of productive teaming elements. Sims-Knight et al. (2002), as cited in Palit & Stein (2009), state that TKT scale reliability is high as evidenced by a developmental study having a pretest scale Cronbach's Alpha of .78 and a posttest scale Cronbach's Alpha of .76. This is resultant in TKT scale developers recommending a valued overall calculation score.

Data Analysis and Findings

The first evaluated hypothesis was: There is no difference in how students interact with group members before and after being presented with collaborative information and multimedia teaming technologies. This hypothesis was evaluated in Table 4 using the nonparametric Mann-Whitney test. As indicated by Sheskin (2007), the Mann-Whitney test was selected for this study based upon its assumptions, sampling, non-parametric basis (non-Gaussian population), and the TPC's rank order data set. The test statistic for the Mann-Whitney test was compared to the designated critical value table based on the sample size of each student participant sample. The participant data for both sample sizes was less than 50, denoting that no normal approximation with continuity correction was necessary and the reported p-value is exact. The critical alpha value was set at 0.05 for this investigation. The p-value for the test (0.526) was determined to be larger than 0.05, therefore, the null hypothesis failed to be rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation has no statistically significant impact on how students interact with group members in this sample.

Table 4
Treatment Group Pretest and Posttest Team Interaction (TPC)

Treatment Pre- (*n*)	Treatment Post- (*n*)	Diff. Est.	Test Stat.	P-value
21	20	0	416.5	0.526

The second evaluated hypothesis was: There is no difference in how students presented with, and those no presented with, collaborative information and multimedia teaming technologies interact with group members. This hypothesis was evaluated in Table 5, again using the nonparametric Mann-Whitney test. The p-value for the test (1.00) was determined to be larger than 0.05, therefore, the null hypothesis failed to be rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation has no measurable impact on how students interact with group members in this sample.

Table 5
Treatment Group Posttest and Control Group Posttest Team Interaction (TPC)

Treatment Post- (*n*)	Control Post- (*n*)	Diff. Est.	Test Stat.	P-value
20	17	0.0186	2	1.00

The next hypothesis to be evaluated was: There is no difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies form team knowledge. This hypothesis was evaluated in Table 6 using the Kruskal-Wallis Test. The Kruskal-Wallis Test ranks designated elements from lowest to highest in the two designated samples. Kruskal-Wallis was selected over the Mann-Whitney non-parametric test based on the nature of the TKT instrument and resultant data set.

The sampling distribution for the H statistic was used to test the null hypothesis. The calculated values for the H statistic were evaluated in comparison to the critical values to determine if the null hypothesis is rejected or if there is evidence that fails to reject the claim. The H statistic is less than the critical value so the null hypothesis is not rejected. The p-value for the test (< 0.0001) was determined to be smaller than 0.05, therefore, the null hypothesis was rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation had a measurable impact on student team knowledge formation, when framed as treatment control study given the student population and sample.

Table 6
Treatment Group Posttest and Control Group Posttest Team Knowledge Formation (TKT)

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Treatment	21	1	18	25.325	15.139137	< 0.0001
Control	17	1	14	11.558824		

The fourth hypothesis to be evaluated was: There is no difference in students' team knowledge formation before and after being presented with collaborative information. This hypothesis was evaluated in Table 7 using the Kruskal-Wallis Test. The p-value for the test (0.5174) was determined not to be smaller than 0.05, therefore, the null hypothesis failed to be rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation has no measurable impact on student team knowledge formation when measured in a pretest/posttest format given the student sample.

Table 7
Treatment Group Pretest and Posttest Team Knowledge Formation (TKT)

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Pre-Treatment	21	1	18	22.225	0.41899058	0.5174
Post-Treatment	20	1	17	19.833334		

Supplemental hypothesis testing was conducted for each item of both the TPC and TKT instruments. This was done to specifically identify TPC and TKT item-based differences, not only between the treatment and control groups, but also between the treatment pretesting and post testing. Mann-Whitney results identify that TPC Item 8, “My team ignores conflicts among team members,” exhibited a statistically significant difference between team interaction outcomes between the treatment and control groups, where Items 11, “My team tends to start working without an explicit plan,” and 14, “My team is able to generate potential solutions and evaluate them in an effective and systematic fashion,” exhibited a statistically significant difference between team interaction outcomes between the treatment pretest and posttest. Table 8 displays the supplemental Mann-Whitney results for TPC Item 8, and Table 9 displays the supplemental Mann-Whitney results for TPC Item 11 and the supplemental Mann-Whitney results for TPC Item 14.

Table 8
TPC Item 8 - Treatment Group and Control Group Team Interaction

Treatment (*n*)	Control (*n*)	Diff. Est.	Test Stat.	P-value
20	17	1	396	0.0226

Table 9
TPC Items 11 and 14 - Treatment Pretest and Posttest Team Interaction

TPC Item #	Pre-Treatment (*n*)	Post-Treatment (*n*)	Diff. Est.	Test Stat.	P-value
11	21	20	-0.5	363	0.025
14	21	20	1	541.5	0.0039

Kruskall-Wallis results identified that Items 1, 3, 8, 13, and 21 (see Appendix A) exhibit statistically significant differences between outcome teaming knowledge formation between the treatment and control groups. Item 13 also shows a statistically significant difference between outcome teaming knowledge formation between the pretest and posttest of the treatment groups. TKT Item 1 addressed appropriate action when a disagreement occurs in a group: “When there is a disagreement or difference of opinion in your team, it is generally best to…”. Table 10 (next page) displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 1.

Table 10
TKT Item 1 - Treatment Group and Control Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Treatment	17	1	1	22.075	6.904716	0.0086
Control	20	1	1	15.382353		

TKT Item 3 questions actions or responses to the unpreparedness of group leadership: "Your team leader comes to your scheduled meeting without an agenda. What should you do?" Table 11 displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 3.

Table 11
TKT Item 3 - Treatment Group and Control Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Treatment	17	1	1	21.65	4.7210083	0.0298
Control	20	1	1	21.65		

TKT Item 8 addresses the review of peer groups' work: "You have been asked to review another team's process check. Which of the following would be the best response?" Table 12 displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 8.

Table 12
TKT Item 8 - Treatment Group and Control Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Treatment	17	1	1	21.575	4.7210083	0.0207
Control	20	1	1	15.970589		

TKT Item 11 is designed to identify productive actions when angry in a group setting: “You have gotten quite angry in a team meeting. Which of the following is the least productive thing you could do?” Table 13 (next page) displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 11.

Table 13
TKT Item 11 - Treatment Group and Control Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Treatment	17	1	1	21.875	4.0859523	0.0432
Control	20	1	0	15.617647		

TKT Item 13 questions about strategies to engage removed members of the team: “The opinions of quiet members of a team are often not heard. If you were meeting leader, what would you do about it?” Table 14 displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 13.

Table 14
TKT Item 13 - Treatment Group and Control Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Treatment	17	1	1	22.6	6.653262	0.0099
Control	20	1	0	14.764706		

TKT Item 21 questions about action that lead to problem resolution after disagreements among team members: “Two members of your team have a genuine disagreement (not just miscommunication or personality conflict). Which of the following would be most likely to lead to a resolution?” Table 15 (next page) displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 21.

Table 15
TKT Item 21 - Treatment Group and Control Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Treatment	17	1	1	21.575	5.349076	0.0207
Control	20	1		15.970589		

Again, TKT Item 11 is designed to identify productive actions when angry in a group setting. Table 16 displays the treatment group pretest and posttest Kruskall-Wallis supplemental results for TKT Item 11.

Table 16
TKT Item 11 - Treatment Pretest and Posttest Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Pre-Treatment	17	1	0	17.880953	4.0859523	0.0432
Post-Treatment	20	1	1	24.275		

As previously described, TKT Item 13 questions about strategies to engage removed members of the team. Table 17 displays the treatment group pretest and posttest Kruskall-Wallis supplemental results for TKT Item 13.

Table 17
TKT Item 13 - Treatment Pretest and Posttest Group Knowledge Formation

Group	*n*	DF	Median	Avg. Rank	Chi Square	P-value
Pre-Treatment	21	1	0	16.428572	9.002198	0.0027
Post-Treatment	20	1	1	25.8		

Discussion and Conclusions

Given the significant results for this sample, using the TPC and TKT instruments, several conclusions can be made. Considering the Palit and Stein study (2008), it was determined that the inclusion of specific instruction on the use of relevant information and multimedia communication technologies as a component of the treatment has definite potential to influence associated team-based knowledge. The flexibility that collaborative teaming technologies permits allows for a heightened level of shared group knowledge that extends beyond the task at hand (Abbott, 1998). Secondly, in this study involving knowledge formation between groups, students exhibited progression in functioning in a team structure. However, incorporating collaborative information and multimedia technologies did not enhance team interaction. Supplementary to the primary investigation, this study identified differences in treatment and control groups, as well as pretests and posttests, that relate to a lack of understanding and acceptance in handling conflicts, group planning, and overall review and evaluation of group work at the undergraduate level within technology education.

While information and multimedia technology can be considered useful for group collaboration and communication, as this study identified, it is limited by the level of interactivity and the amount of control of group dynamic when using collaborative tools. Teacher education programs must heavily consider direct student knowledge, as well as group qualities and characteristics, to create functional team dynamics through the successful introduction of multimedia team-based integrative technologies. Preservice teacher knowledge of exemplar team structure and function is invaluable, considering that the information can be transferred into direct classroom practice to enhance learner experience. In conclusion, teaming is a pivotal skill and knowledgebase for future educators, as effective inclusion of teacher applications and 21st century skills integration are no longer considered exceptional teacher practice, but are now among minimal expectations for all teachers.

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Appendix A:
TKT items

TKT items exhibiting a statistically significant difference

TKT item 1:	When there is a disagreement or difference of opinion in your team, it is generally best to a. find some way to downplay it so as not to draw attention to it. b. address the disagreement directly and supportively, even if there is a risk of conflict. c. try to ignore it altogether. d. point out that dissention is harmful to a team.
TKT item 3:	Your team leader comes to your scheduled meeting without an agenda. What should you do? a. Make your first agenda item developing an agenda as a team. b. Let the meeting proceed without an agenda. c. Tell the team leader to write out an agenda right now and take the rest of the team for coffee until s/he is done. d. Suggest the meeting be postponed until the team leader gets his act together.
TKT item 8:	You have been asked to review another team's process check. Which of the following would be the best response. a. All excellent ratings, because that would show they know what they are doing. b. Excellent ratings on task-related questions; the touchy-feely questions don't matter. c. Excellent ratings on the touchy-feely questions, because if they got their processes correct, task excellence is sure to follow. d. A variety of responses, some high and some low, because that would give pointers to improvement.
TKT item 13:	The opinions of quiet members of a team are often not heard. If you were meeting leader, what would you do about it? a. Set up a specific order for everyone to speak and then follow it. b. Leave it be. If they don't want to talk, they shouldn't have to. c. Ask them to adopt roles in the meetings, such as time-keeper and facilitator. d. Ask them to write down their positions and give it to you anonymously after the meeting.

TKT item 21:	Two members of your team have a genuine disagreement (not just miscommunication or personality conflict). Which of the following would be most likely to lead to a resolution? a. Ask questions to try to understand each person's position and look for solutions that both might like. b. Ask each person to give up something. c. Have the other team members come up with a third position they can agree on. d. Take a vote among all the team members—winner takes all.

The Development of Technological Competence from Adolescence to Adulthood

Finland has a well-known reputation in technology, but technology is still not taught as a separate subject in the national curriculum. The position of technology education in Finland is quite different from that in most other European countries, even Finland’s Nordic neighbours. Technology education is incorporated within the scopes of other subjects such as physics, chemistry, biology, home economics, and craft education. Craft education is, in practice, further divided into technical work and textile work.

No special differences exist between Finnish schools’ curriculums and usual international practices. At the primary level (grades 1-6) pupils are 7 to 13 years old, at the secondary level (grades 7-9) 14 to 16, and upper secondary 17 to 19. In grades 1 to 7, craft and technology education is a compulsory subject taught 2 or 3 hours a week, although in grades 1 and 2 its contents are closer to those of hobby crafts. In grades 8 and 9 there is no compulsory technology education, but pupils can take elective studies for about 2 to 4 hours per week. Nowadays, it is possible to take elective courses in technology education even in upper secondary school, but this was not typical in Finland 15 years ago. Perhaps the main difference in the Finnish education system, as compared to usual international practice, is that University level studies are free of charge. This means that demanding entrance exams are the norm.

This article builds on earlier research that defined and assessed technological competence among adolescents. It tracks students who took part in a measurements of technical abilities study fifteen years ago. The researcher had no previous knowledge of the test subjects’ current employment status, but in favorable circumstancs, these test subjects are now professionals in the field of technology.

The aim of this research was to examine how technological competence was attained during the test participants’ lives. In addition, we tried to determine the elements accounting for the participants’ technological competence. The main research questions were as follows:

1. How was the test participants' technological competence developed over the course of their lives?
2. What were the main elements in technology education that affected the test participants’ competence?

This follow-up study was carried out as a qualitative case study. Data from interviews with three participants were tape-recorded and translated. The research data were then analyzed using content analysis. The analysis was

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carried out by assessing which of the essential elements in the participants technological competence contributed to success in their lives. These findings were later classified in terms of themes or factors and, finally, reported in the conclusions. The results from each participant interview are shown in a competence curve, which will later be explained in more detail. The competence curves indicate each person's development in technological competence during their life.

Theoretical background

Technological competence is fundamental to human existence (Burke & Ornstein, 1995; White, 1962). At each stage within the cycle of life, humans continuously strive to acquire new skills, or to refine existing ones, in the hope that productivity and quality of life will be enhanced. Despite the fact that skilled behavior underlies nearly every human activity, our understanding about the factors that contribute to the attainment of expertise in technology education is far from complete. However, some attempts to define technological competence have been made. For example, based on Dyrenfurth's (1990) and Layton's (1994) work, Autio and Hansen (2002) defined *technological competence* as an interrelationship between technical abilities in psychomotor, cognitive, and affective areas.

Defining and measuring technological competence as a construct was achieved by extending the work of Dyrenfurth (1990) and Layton (1994). They identified three components that correspond with what the authors considered to be the dimensions of technological competence. The first is *technological knowledge*. Citizens in a democratic society, according to Dyrenfurth (1990), know something about technological concepts, principles, and connections, as well as the nature and history of technology. This kind of knowing is often referred to in the educational sciences literature as the cognitive domain. Common examples include troubleshooting and understanding a circuit diagram.

The second dimension of technological competence is *technological skill*. Technical and technological skills are part of most human activities and are essential for the survival of humankind. These skills are often labeled by psychologists as psychomotor skills and are an important component of technological competence. They involve tactile or kinesthetic ability, as well as practical intelligence. Such skills include manual coordination and steadiness when using welding or soldering equipment, for example.

The third dimension is *technological will*, or being active and enterprising with regard to technology. Technology is determined and guided by human emotions, motivations, values, and personal qualities. Thus the development of technology in society is dependent on citizens' technological will to participate in, and have an impact on, technological decisions (individual and/or societal). This is the affective or emotional aspect of technological competence. Technological competence, in short, involves a balance between knowledge, skill, and emotional engagement. In its fullest sense, it is the act of using human ingenuity, or, being ingenious (Hansen, 2008).

In the present study, technological competence was defined as an aggregate of the three aforementioned measurements: knowledge, skill, and emotional engagement. This definition has been criticized because it seems to be too simple for defining the complex interrelationship between psychomotor, cognitive, and affective areas. It is also true that in every psychomotor action a certain amount of cognitive thinking and emotional engagement is involved; in addition, every cognitive action always includes an affective element. Despite the difficulty involved, it is worth trying to determine if it is possible to predict student potential for career success with this instrument. A simplified model of technological competence is described in Figure 1.

Figure 1
Technological Competence

TECHNOLOGICAL COMPETENCE		
Technical Abilities In		
Cognitive Area Examples:	Psychomotor Area Examples:	Affective Area Examples:
• Spatial Reasoning	• Coordination	• Motivation
• Troubleshooting	• Dexterity	• Attitude

During the interviews typical elements affecting technological competence were identified. These were classified according to the Peltonen and Ruohotie (1992) model of school learning, which consists of four factors or themes: *personality*, *environment*, *social relations*, and *subject content*. Personality includes a person’s character, needs, interest in technology education, talent, and hobbies. Environment includes the classroom environment, home environment, tools and machines in the classroom, material used in lessons, and class size. Social relations include teacher-student interaction, classroom atmosphere, parental opinion, and friends. Finally, subject content includes school curriculum; items to be made in class; freedom to choose items, materials, and techniques; student’s internal feedback; and evaluation. As the Peltonen and Ruohotie (1992) model was originally designed for general school learning, following the interviews, we changed the classification slightly to better fit the context of technology education.

Study Method

The research was carried out as a qualitative case study (Merriam, 1988) and the data was collected from individual theme interviews. The interviews were first tape-recorded and transcribed. Themes were identified, and portraits of each subject were established (Lightfoot, 1983). Later the data were analyzed using the content analysis methodology (Anttila, 1996; Baker, 1994). The analysis was carried out by assessing which of the essential elements in the participants technological competence contributed to success in their lives. These findings were later classified according to the themes and were reported in the conclusions. Prior to the interviews, the researcher had a short discussion with each test participant about the concept of technological competence. Each understood that technological competence was defined in the study as an aggregate of three areas: knowledge, skill, and emotional engagement. In addition, they understood that a competence curve is a self-report having no absolute value, and they drew competence curves indicating how their technological competence was developed over the course of their lives. The competence curves were later discussed in more detail during the interviews. The curves indicated each person's competence in technology during his life.

Study Participants

The study group consisted of three individuals now in their late twenties (two aged 28, one aged 29) who, when tested for technological competence 15 years ago as students, achieved the best results in terms of the three abovementioned measurements—cognitive, psychomotor, and affective. Technological competence was defined as an aggregate of these measurements. Therefore, the test subjects were selected according to overall accomplishment in all three areas. In the original test group 15 years ago, comprising 267 participants, a number of individuals performed better in certain areas (e.g. psychomotor), but did not succeed as well in the others. More information about the research group, test instruments, etc. in the original study is available in Autio (1997) and Autio and Hansen (2002).

The researcher had no previous knowledge of the test subjects' current employment status. Fortunately, the background of each test subject was somewhat different, but there were enough similarities in the elements behind their technological competence to make some conclusions. The test participants were difficult to trace, but with the help of their old teachers and the internet this was done after three weeks of investigation. Although 267 students were tested 15 years ago, coincidentally, two of the test participants attended the same school in a small rural village. The third participant came from Helsinki. The participants' school curriculums did not differ from those of other Finnish comprehensive schools.

Two participants had studied at the University of Technology. The first was quite sure of his decision to choose a technology career already after secondary school, but the second was interested in several other areas as well. He could have chosen a number of other careers. The third test subject was equally talented in technical matters and was not particularly interested in other subjects when in comprehensive school. So, he began to study computers and automation technology in vocational school, instead of continuing in a more academic direction. The test participants were named characteristically as follows:
Subject 1—academic technology researcher
Subject 2—academic multi-talent
Subject 3—non-academic technology talent

Results

In the following section, the educational path of each test subject is described more precisely and the competence curves are presented in Figures 2-4. The competence curves were first drawn by the test participants, who assigned values from 0 to 100% based on their opinions of their competence, and then discussed in more detail with the researcher during the interviews. No absolute value was given for the strength of the particular competence.

The elements accounting for their competence are described in Tables 1-3, which show the elements that had the greatest effect (shown in bold and underlined text) as well as those that affected the participants' competence less (shown in bold or normal text). The significance of the factors is based on the participants' direct comments, which were documented during the interviews.

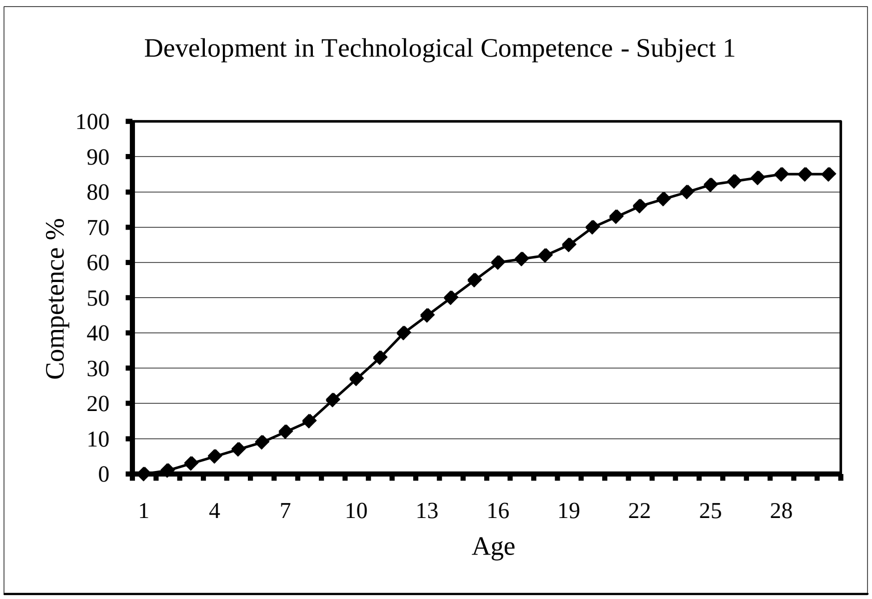
Subject 1—Academic Technology Researcher

Subject 1 was a 28-year-old man who spent his school years in a rural village of about 4,500 inhabitants in southern Finland, approximately 150 kilometers north of Helsinki. He was exposed to technology education in primary and secondary school. In addition, he had an opportunity to take elective courses in technology education in upper secondary school, which was not typical in Finland 15 years ago. He lived with his parents, three brothers, and one sister. His father worked in forestry, and his mother was a homemaker.

Subject 1 was already interested in technology in early childhood, and his competence in technology developed steadily throughout his school years. His first progression occurred when technology education classes began in primary school, when for the first time he received sound instruction from a teacher and could perform tasks himself with tools that he had earlier seen and tried using at home. In secondary school his competence increased when he could concentrate more on electronics, which was his main area of interest. However, for a period of time in upper secondary school he concentrated more on academic subjects.

Subject 1 finished school in 2000 with good grades (average of all school subjects 9.2 / 10.00). After finishing upper secondary school, he started computer science studies at the University of Technology. In 2005 he graduated with a Master of Science in technology and continued to doctoral studies in computer science and engineering. He finished his doctoral thesis in January 2010. He is willing to continue his research career, and he will apply for a scholarship from the Finnish Academy. He assumes that his technological competence will develop further in the projects he undertakes in the future. How test subject 1's technological competence has developed throughout his life is presented in Figure 2.

Figure 2
Competence Curve in Technology Education of Subject 1



Analysis of Subject 1

Subject 1 had become familiar with technology in early childhood, using Legos and constructing huts in the forest with his younger brothers. His father had worked with various tools fixing cars and machines at home. "*My father was a woodsman and there was always something interesting going on. His chainsaw was especially fascinating.*" School was the first identifiable element to affect his competence. Subject 1 responded positively to technology education; already, early in comprehensive school, craft and technology had become his favorite subject. He was also good in other subjects, e.g. mathematics and physics, but technology was of special interest. In particular, electronics and computers provided him with an increasing intellectual challenge.

Subject 1 was also gifted with his hands and so could concretely witness his own development in terms of things he produced (e.g.a metal detector and twilight switch). Yet he received the best encouragement from being able to understand how things work and being able to develop his own ideas. "*Electronics was a new and interesting area and now I even understood how those things work.*" For its part, the entire school environment shaped his competence. According to him, in technology classes, there was always a sufficient supply of materials, and tools and machines were in good condition. The teacher was also a significant element. The teacher did not cause stress and could create an open, intellectually challenging atmosphere. Although his internal feedback was usually enough, he still appreciated the positive and encouraging feedback from his technology teacher, because teachers in other subjects did not do the same.

Once the technology education courses were over, computers became Subject 1's main interest in upper secondary school. This provided him a new kind of challenge after working with wood, metal, and electronics. "*In upper secondary school, when technology classes were over I could fulfill my interest in technology with computers.*" His competence in technology was further developed by these studies in computer science. Later, in his academic career, he concentrated on carrying out research in a supportive and challenging working environment, and, despite relatively low salaries, after finishing his doctoral thesis he remains willing to continue his research career. This is a clear sign that the main source of his motivation has always been intrinsic. The elements accounting for Subject 1's technological competence are described in Table 1 (next page).

Table 1
Elements Behind Subject 1's Technological Competence

PERSONALITY	ENVIRONMENT	SOCIAL RELATIONS	SUBJECT CONTENTS
• Intellectual challenge • Hobbies (Legos, electronics, computers) • Talent	• Machines and tools • Home environment	• Teacher • Father • Atmosphere in technology lessons • Feedback from the teacher	• Internal feedback • Electronics

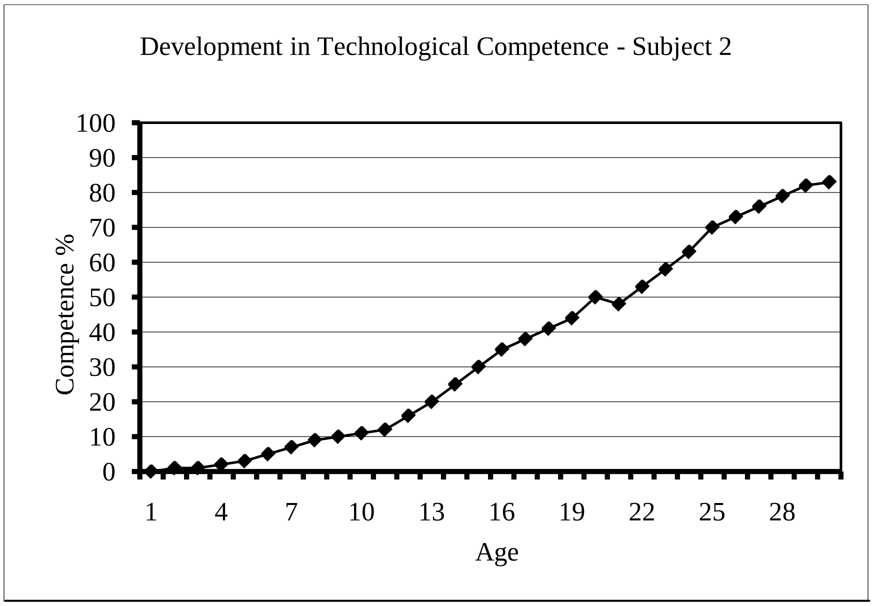
Subject 2—Academic Multi-Talent

The second participant was a 29-year-old man who was born in Helsinki, which is the capital of Finland. His first school years were spent in a normal primary school, but at secondary and upper secondary level he studied at one of the highest ranked upper secondary schools in Finland. He lived with his parents and one younger brother. Both parents had earned Masters of Science in technology and worked at the State Technical Research Centre. Many of his older relatives had also studied at the University of Technology.

Already in early childhood, Subject 2's family was very supportive of his technology-related hobbies. However, in primary school he was not especially interested in technology education. Technology education became more interesting for him in secondary school. In upper secondary school he concentrated more on academic subjects, but his attitude towards technology remained very positive.

He finished upper secondary school in 1999 with good grades (overall 9.4 / 10.00) and was planning to study medicine. However, following his compulsory military service in 2001, he decided to study automation technology at the University of Technology. In 2007 he completed Master of Science in technology and began working for an international company that manufactures hospital automation devices and other products. He feels comfortable in his job, enjoys the innovative working atmosphere, and thinks that his technological competence will still improve in the future. How test subject 2's technological competence has developed throughout his life is presented in Figure 3 (next page).

Figure 3
Competence Curve in Technology Education of Subject 2



Analysis of Subject 2

Subject 2 had become acquainted with technology in early childhood through familiarity with Legos and radio-controlled (RC) cars. His family was competent in technology, and his mother in particular was very supportive, often fixing toys with the children. "*The whole family was interested in technology, although when something was broken, it was my mother who tried to fix toys with me.*" Subject 2's motivation was based on a child's curiosity and he always wanted to know how toys worked. In primary school, however, he was not especially interested in technology education and did not learn many technological skills. Secondary school offered him more freedom of choice in projects, and studying was in general more challenging. According to him, in technology education classes were well organized; there were plenty of different materials, and machines and tools worked well. The teacher was also very competent and could create an open atmosphere, while maintaining rational planning, investigation, implementation, and evaluation processes. "*Working in technology lessons was not just copying. The teacher always guided and convinced us to a rational working process.*" It was easy to talk with the teacher, whose feedback was rewarding, and he developed his skills and technical thinking further.

In upper secondary school Subject 2 had to concentrate more on academic subjects and was not at all sure that he would choose a technology-related profession in the future. "*In our school most of the students were planning ambitious studies at university, but I was not at all sure. I could have been a doctor or something, even being a technology teacher was sometimes in my mind.*" He was interested in physics, chemistry, and mathematics, but still wanted to find a balance between theory and practice. Computers gave him a new chance to develop his technological competence without being too theoretical. This was one of the main reasons why he chose automation technology as his major subject at the University of Technology. Today he sees the inspiring and technically open environment of his work as the main factor in his development. Also, his good friends with a common interest in technology provide him with support and new ideas to develop his competence further. The elements accounting for Subject 2's technological competence are described in Table 2.

Table 2
Elements Behind Subject 2's Technological Competence

PERSONALITY	ENVIRONMENT	SOCIAL RELATIONS	SUBJECT CONTENTS
• Curiosity • Hobbies (Legos, RC, computer) • Interest • Talent	• Machines and tools • Inspiring and technically open environment (school, academic studies, work) • Home environment	• Teacher • Technically oriented and supportive family • Friends with common interest • Feedback from the teacher	• Freedom of choice • Process (planning, investigation, implementation, evaluation)

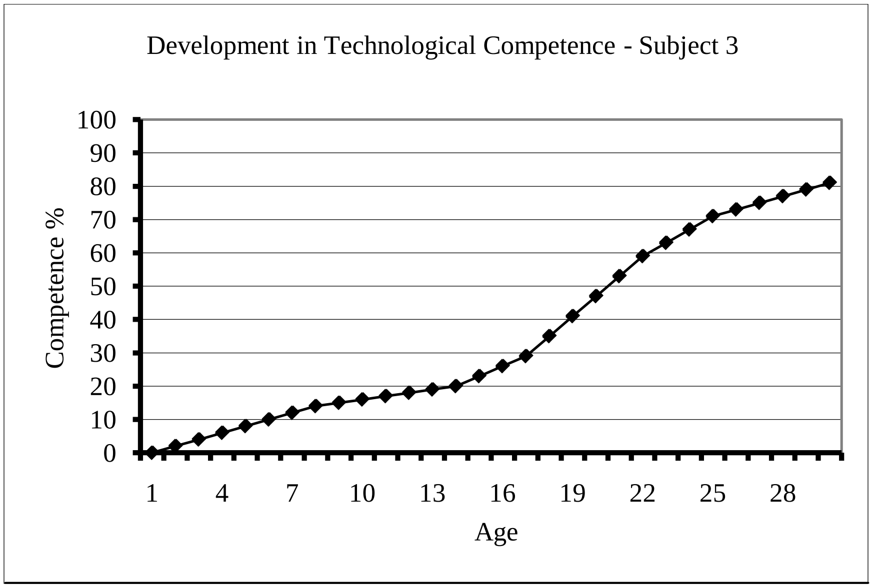
Subject 3—Non-Academic Technology Talent

The third test subject was a 28-year-old man who spent his school years in the same village as Subject 1. Both were exposed to technology education in the same primary and secondary schools. Following secondary school, he moved to a larger city with approximately 100,000 inhabitants to study in vocational school. He lived with his parents and had two elder brothers and two sisters. His father worked as a taxi driver, but was a main owner of a local bus company. His mother worked in a bank.

He was already interested in technology in early childhood, emulating his two older brothers who were technologically oriented. They were skillful mechanics, working with motors and repairing cars. Subject 3 was used to working with his hands and was not especially interested in other school subjects. Technology education provided him at least some form of intellectual challenge in terms of concrete things, but there was no significant increase in his competence during primary school. At the secondary level, however, his competence increased more rapidly when he could concentrate more on his own area of interest, electronics, and when he became aware that his skills were developing.

Subject 3 finished secondary school in 1997. His grades were not particularly good (overall 7.3 / 10.00), and instead of choosing an academic career and upper secondary school, he began to study computers and automation technology in vocational school. After finishing in 2000, he did his compulsory military service, where he had an opportunity to work with optical cables and computers. He also became interested in the mechanics of tanks and other vehicles. His technical competence was thus even higher after military service. Then he began his studies in automation technology in polytechnics. In 2005 he graduated as an engineer and started working in an engineering office as an electrical wiring designer. In his current post at an international mining and construction company, he feels comfortable and enjoys the innovative working atmosphere. How test subject 3’s technological competence has developed throughout his life is described in Figure 4 (next page).

Figure 4
Competence Curve in Technology Education of Subject 3



Analysis of Subject 3

Subject 3 had become familiar with technology in early childhood, using Legos and emulating his older brothers. There was plenty of stimulation at home. His father had good facilities for working on cars, tools of all kinds, and available machines. Thus school was the first identifiable element to affect his competence. He thinks that there was no significant increase in his competence during primary school. "*After I had seen my older brothers working with real cars, there was nothing interesting in making wooden toys.*" In secondary school, however, electronics in particular provided him a challenge, and he generally felt much better, as he had more freedom and his choices were respected; this was not the case with several other school subjects. According to him there was always a sufficient supply of materials, and tools and machines were in good condition. The teacher was also a significant element, as he could create an open, intellectually challenging atmosphere.

Subject 3 was gifted with his hands so he could concretely witness his own development in the products he produced (e.g. an infrared light gate and metal detector). He felt comfortable in technology education classes, but his competence developed even more through his hobbies than through school. When he was older and more skilful, his two older brothers allowed him to repair cars with them. "*I still remember that day when my brothers accepted me as a respected co-worker and not just a pain in the neck.*"

After finishing secondary school Subject 3 went on to study in vocational school. This presented him with a new kind of challenge, as he could concentrate on areas of special interest and develop his technological talent. Later his competence in technology was developed by his studies in automation technology. Although he was not especially good in several school subjects during his earlier school years, he graduated from polytechnic school near the top. "*Maybe I was a bit lazy in school, but I was not stupid. Unfortunately, our Swedish teacher did not know what the difference was.*" In his current post in an international company, he feels he could have learned more languages at school, but his choice of moving straight into vocational school was the best decision in terms of his talent and interests. According to him, how his technological competence develops in the future will depend on interesting and challenging future projects. The elements accounting for Subject 3's technological competence are described in Table 3.

Table 3
Elements Behind Subject 3's Technological Competence

PERSONALITY	ENVIRONMENT	SOCIAL RELATIONS	SUBJECT CONTENTS
• Interest • Own needs • Hobbies (Legos, cars) • Talent	• Home environment • Machines and tools • Inspiring environment (further studies, work) • Technical facilities in military service	• Teacher • Atmosphere in technology education lessons • Parents and brothers • Challenging and inspiring working atmosphere	• Product • Freedom of choice • Internal feedback • Working process

Conclusion

The competence curves indicated how test participants' technological competence was developed over the course of their lives. There seemed to be three crucial phases in the development of technological competence. The first was noticed when technology lessons started in primary school. The second seemed to occur in secondary school when there was more freedom of choice in projects, and studying was in general more challenging. Thirdly, competence in technology was further developed by studies at university or polytechnical school. The secondary school phase seemed to be the most important for all test subjects. Two participants assumed that the increase in their competence was not as significant during primary school.

The most important personality elements that affected test participants' competence in technology were curiosity, interest, students´ own needs, and intellectual challenge. Technology-related hobbies (e.g. Legos, computers, cars, and electronics) were definitely another important element. In the measurement of technical abilities fifteen years ago the test participants were also found to have technological talent, and according to Byman (2002), students usually prefer and choose subjects and tasks in which they are proficient and can show their competence. Research in other life contexts, such as education in general, has also shown that high levels of autonomous motivation toward education lead to high academic performance (Burton, Lydon, D'Alessandro, & Koestner, 2006; Gottfried, Fleming, & Gottfried, 1994).

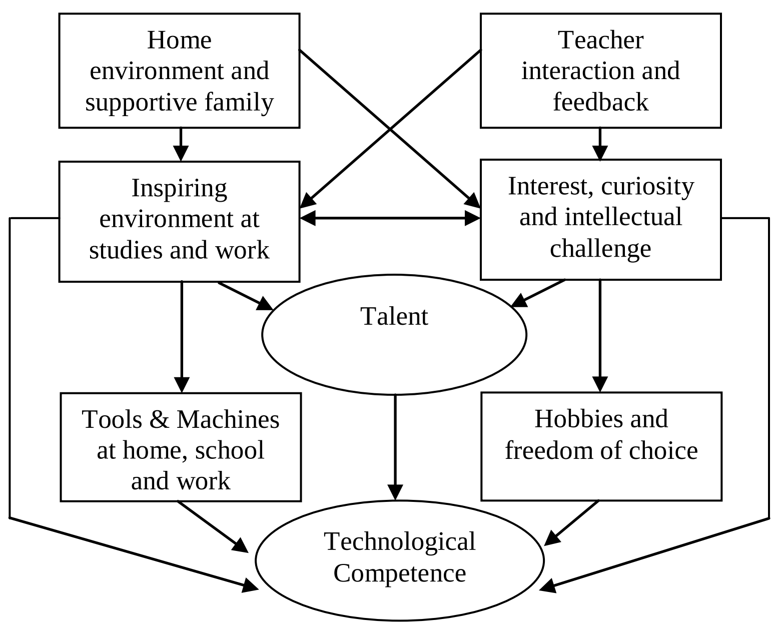
Furthermore, the entire classroom environment appeared to be an important factor in technological competence. According to the test participants, the classroom in technology education always provided enough materials, and tools and machines were in good order. In addition, most of the test subjects could work at home, in further studies, and finally at their present jobs. According to Stipek (1996), it is even more important to pay attention to providing an optimal and suitable learning environment than to concentrate on students' personal problems in terms of motivation. Deci and Ryan (1985) argue that informal learning environments (e.g. hobbies) which offer optimal challenges, plenty of different stimuli, and a chance to be autonomous result in effective motivation. In this study all test participants engaged in many technological activities outside of school in their leisure time. This can be seen as a clear sign of intrinsic motivation.

Social relations—teacher-student interaction, the classroom atmosphere, and the family—were also found to be important elements in creating technological competence. We can suppose that classroom atmosphere and teacher-student interaction were more important in making the whole environment suitable than in directly influencing competence in technology. A suitable learning environment and atmosphere are seen as typical factors for producing a positive affect. A positive affect, for its part, facilitates flexible thinking and problem solving, and enhances performance, even when the tasks at hand are complex, difficult, and important (Isen & Reeve, 2005). Furthermore, Isen and Reeve (2005) indicate that positive affect fosters intrinsic motivation, as well as optimal performance and enjoyment of tasks, but not at the expense of responsible work behavior in uninteresting tasks that must be done.

Surprisingly, technology education's subject content was found to be less important than personality, environment, and social relations. The artifact to be made is usually seen as one of the most important elements in students' motivation (Autio, Hietanoro, & Ruismäki, 2009). In Autio's (1997) factor analysis, the practical advantage gained from having produced an artifact is emphasized more than the process of doing so, which for its part would have emphasized the external motivation or situational interest. In this study, the test participants placed greater value on the working process and freedom of choice as elements that generated their technological competence, which certainly refers to intrinsic motivation in their behavior.

Figure 5 shows the interaction between the main elements of technological competence based on the empirical data from the interviews with the test subjects'. The interaction is not self-evident, and obviously there are certain limitations in this generalized figure. Hence, from the interviews with test subjects' we can conclude that the interaction was based on a supportive environment at home, in studies, and at work. The environment also provided suitable tools and machines to be used. The significance of the teacher was noticeable in all test participants. These elements effected interest, curiosity, and intellectual challenge—which were further developed in hobbies and in freedom of choice in several different formal and informal learning situations—and finally generated technological competence.

Figure 5
Interaction Between the Main Elements Behind Technological Competence—Summary of Test Participants.



Discussion

In this study, the three students who had the best overall results in the measurement of technical abilities fifteen years ago were followed. The researcher had no previous knowledge of how these three test participants were currently employed. In addition, the researcher tried to determine if is it possible to predict student potential for career success in the technical professions with the instrument used in the measurement. Although we must be cautious about the final conclusions, the study shows that, at least among these participants, it was possible to predict student potential for career success in the technical professions. The study had obvious limitations; the research group was small, and we can't be sure how well the participants remembered their pasts. Furthermore, we did not determine the effect of other school subjects on technological competence.

In the original measurement of technical abilities, all test participants proved to be technologically talented. However, their subsequent circumstances were somewhat different. Two participants had studied at the University of Technology. The first was sure of his decision to do so quite early on, but the second was talented and interested in several other areas as well. He could have chosen a number of other options, but ultimately went for a technological career. The third test subject was equally technologically talented, but he was not especially interested in other school subjects in secondary school. So he began to study computers and automation technology in vocational school instead of continuing in upper secondary school and aiming for an academic career.

In Finnish schools it appears to be the case that some students value neither crafts nor vocational education. In their opinion, a university is definitely a better and more respected place in which to study than a vocational school. These views usually reflect values and attitudes originating from the home, attitudes that are adopted already at an early age (Autio et al., 2009). An academic career is usually more valued than practical work, but in reference to the case of Subject 3 (non-academic technology talent), we can suggest that there should have been a better balance between practical and academic subjects, at least in the primary and secondary school.

It is obvious that, among the test participants, curiosity and intellectual challenge had affected even intrinsic motivation by expanding the amount of internal feedback. According to Deci and Ryan (1985), one way to achieve intrinsic motivation is to expand students' feelings of autonomy. This occurs when work is based on students' own curiosity and there is freedom of choice in materials, techniques, and in things to be made. A feeling of autonomy is especially important for older students who want and need more autonomy when making decisions.

Furthermore, according to Hidi and McLaren (1990) individual interest develops slowly and tends to have long-lasting effects on a person's knowledge and values, whereas situational interest is an emotional state that is evoked suddenly by something in the immediate environment and may have only a short-term effect on an individual's knowledge and values. This phenomenon seemed also to be true in this study, as the test subjects' individual interests had long-term effects even on their career decisions.

Social factors, as discussed, were also found to be important elements in creating technological competence. Although it seems that these elements were more important in making the whole environment attractive than in directly influencing technological competence, Reeve, Bolt, and Cai (1999) have shown that teachers who support students' freedom of choice and autonomy in decision-making create more intrinsic motivation than those who intend to control their students. Support of autonomy is evident when an authority figure respects and takes the subordinate's perspective, promotes choices, and encourages decision-making (Ratelle, Larose, Guay, & Senecal, 2005).

Motivation has been viewed for a long time as the primary determinant of students' learning and school success. Motivation is critical, not only to academic achievement, but also to students' beliefs in their future success as professionals. This study seems to agree. Students' own interests and intellectual challenge, combined with a favorable environment at home and in further studies, is the key to success in the field of technology education as well. However, the question is how can we find these intrinsically motivated technologically talented students, especially those who are not interested in academic subjects, before they lose their natural potential by becoming bored at school? This is a real challenge, and we are continuing our efforts in this regard in related projects. Further, it would be interesting to learn how the best girls have progressed. Are they working in technology as well, or did they end up in other professions?

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Book Review

Creativity in Technology Education: A Review of Explaining Creativity: The Sciences of Human Innovation

Pao-Nan Chou

Sawyer, R. K. (2006). *Explaining creativity: The sciences of human innovation*. New York: Oxford University Press. $39.95 (paperback), 368 pp. (ISBN: 0195304454).

According to a recent study (Johnson & Daugherty, 2008), creativity is an emerging research topic in the field of technology education. Many technology educators will find this attention brought to creativity promising, like this reviewer does. Today, classroom instruction has started to shift from teacher-centered to learner-centered learning. As teachers in technology education programs, we all expect that students can think and behave in creative ways after completing our classes. The most difficult challenge technology educators confront is that creativity cannot be easily acquired. However, Sawyer's book, *Explaining Creativity: The Sciences of Human Innovation*, unveils the nature and mystery of creativity.

This book contains five topics: conceptions, individualist approaches, contextualist approaches, artistic creativity, and everyday creativity. The first topic, conceptions (Chapters 1-2), presents readers with an introduction to the history of creativity research and conceptions of creativity. The second and third topics, individualist and contextualist approaches (Chapters 3-9), are theoretical foundations that clearly delineate how scholars from different scientific disciplines engage in creativity research. The fourth topic, artistic creativity (Chapters 10-13), provides an example unit that describes the operation of creativity in various fields. On the last topic, everyday creativity (Chapters 14-16), Sawyer offers a clear path to understanding how to increase creativity in everyday life.

Sawyer begins by describing the relationship between creativity and art in history. In this discussion, Sawyer provides insight into two conceptions of creativity, rationalism and romanticism. The former is "the belief that creativity is generated by the conscious, deliberating, intelligent, rational mind" (p.15). The latter is "the belief that creativity bubbles up from an irrational unconscious, and that rational deliberation interferes with the creative process" (p.15). Sawyer

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argues that romanticism strongly affects thinking models, which leads to many "creativity myths." For example, one of these myths is that creativity relates to unconscious minds. However, current scientific studies have dispelled this myth and confirmed that creativity mostly arises from "conscious, hard work rather than a sudden burst of insight" (p.18).

Next, Sawyer discusses several scholarly works that focus on creativity from two approaches, individualist (four disciplines) and contextualist approaches (three disciplines). In the individualist approach, personality psychology was the first trend for examining human creativity in the academic world. Personality psychologists attempted to employ measurements to assess an individual's creativity. However, Sawyer contends that the methods personality psychologists used were unsuccessful, which in turn led to the emergence of cognitive psychology. As a cognitive psychologist, Sawyer proposes a four-stage creative model: preparation, incubation, insight, and verification. A challenging idea of Sawyer's is that "creativity involves both problem solving and problem finding" (p.73). In addition to personality and cognitive psychology, the other scientific disciplines Sawyer mentions are biology and computer science. Although biologists use human brain functions to analyze creativity, Sawyer still considers that "biology is the smallest level at which we could explain creativity" (p.95). Regarding computer science, Sawyer argues that artificial intelligence technologies cannot imitate the human creative process.

Sawyer proceeds to examine, from a contextualist perspective, three scientific disciplines. First, sociologists contend that social groups strongly influence human beings' creativity. Sawyer elaborates that "groups are more creative than individuals when they have worked together for a while; when they share a common set of conventions and knowledge" (p.121). Second, since cultural backgrounds guide thinking processes, anthropologists stress the importance of cultural creativity. Sawyer adds that "culture's conceptions of creativity influence how you see creative works" (p.149). Last, historians use a technique called historiometry to identify specific creative patterns in historical events. Sawyer states that historiometry allows viewing "numeric relationships across historical periods" (p.158). For instance, historiometric data show that "each domain has a typical peak age of productivity, the age at which the most significant innovation of a career is typically generated" (p.162).

In later chapters, Sawyer's analysis moves toward a practical discussion with less emphasis on abstract ideas. Sawyer discusses artistic and everyday creativity and attempts to apply theories into practical contexts. By using theories from individualist and contextualist approaches, Sawyer explains in detail the creativity phenomenon in the fields of visualization, writing, music, acting, science, and business. In the last chapter, Sawyer concludes the discussion by providing advice for those who seek to be more creative. For example, Sawyer suggests developing "a network of close colleagues" (p. 310) with whom to share ideas; he also suggests exiting comfort zones.

Overall, this well-organized book is worth the investment of money and time. For technology educators, reading the book may provoke further interest in creativity, especially for creativity training. For researchers in the field of technology education, the theoretical foundations reviewed in the book may offer a clear understanding of what has been done in creativity research for different scientific disciplines. Additional research and discussion of creativity research will undoubtedly appear as a result of Sawyer's work.

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Miscellany

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