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From the Editor

Applied Latin and a Caveat on Virtual Problem Solving

When I was an undergraduate student in industrial arts in the early 1960s, nearly every practical course required the preparation of three items before proceeding to build a “project.” First, a complete set of plans had to be prepared. Second, a bill of materials was required. Third, the order of procedure, a listing of each of the steps necessary to complete the project, had to be submitted. This triumvirate was the *sine qua non* of instruction. Incidentally, the notion of a required project, where every student followed the same set of plans, was abhorred in those earlier days just as it is today.

Having attended a private, parochial high school that emphasized Latin and other classical studies over more practical pursuits, I was ill-equipped to prepare the three requisite documents. I did the best that I could, but most of the problems that I solved were done, *ad hoc*, as the project was being built, rather than in forethought. What I actually did to complete the project and how it looked in the end were quite different than what my trio of documents had indicated. In the eleventh hour I decided to prepare a new set of plans, order of procedure, and bill of materials to reflect what I actually did to complete the project. I explained to the professor what I had done. Judging by the particular glint in his eyes, I was confident that I was not the first student to do my planning, *ex post facto*.

New computer graphics software has recently become available to technology education from several companies that enables the student to model ideas in three dimensions on the screen of the computer. The software is much easier to learn than the computer assisted design packages with which the field has become familiar. This software is much more intuitive and is based upon a “sketching” sort of algorithm in which students can quickly move a design idea from their head to the computer, worrying about the exact sizes and proportions of the parts and components at a later point in the development process. The objects created can be effortlessly rotated and viewed from any angle. Mechanisms can be simulated and tested virtually in far less time than the construction of prototypes or mockups requires. The iterative process whereby designs can be developed, evaluated, and redesigned requires little effort and students do not become bored and frustrated as they often do when building and revising a prototype over and over.

The new software significantly reduces compromises in designs, resulting in an increase in the quality of technological problem solutions that is analogous to the editing advantages of word processing software and the higher quality prose that has resulted. The conventional orthographic and isometric views can be quickly generated from the solid model when required. In short, this new genre of software enables students to develop nearly final solutions to technological problems before they actually begin to build the solutions. They confront many of the same design constraints and problems in the virtual world of the computer that they would confront when working with real materials. The reduction of material waste alone should garner the attention of even the more computer-wary teachers.

The new software enables students to design practically anything that might be built within a technology education laboratory. Traditional wooden products, solar collectors, structures, as well as the ever-pervasive CO_2 powered vehicle, can all be designed with relative ease. In addition, the software allows students to design products that could never be built in a typical laboratory, opening up many new opportunities for learning. Examples are limitless, ranging from nano-machines to jumbo jets. I can personally attest that this software is engaging and fun to use!

Nonetheless, there are some potential unintended consequences, akin to Tenner's (1997) treatise on the subject. In the wake of this new design software, the problem-solving process might never go beyond the virtual world of the computer. Even modeling systems like Lego blocks have crossed the line into the virtual world, as evidenced in the article by Kurt Michael in this issue. Students can now virtually model a modeling system that, itself, is intended to model the real world.

There are compelling reasons to move technology education into the virtual world. The expense of the learning facility is reduced significantly since a computer lab requires far less space than a facility with real tools and materials whereby students can actually build what they design. Student management problems might be reduced as well, providing that students remain engaged with what they are doing in their virtual world. Concerns about student injuries and the resultant liability by the school system would be on par with most other school subjects. The environment in which the students learn might be considered more consistent with the advanced world outside the school. Certainly, the virtual world is "cleaner" than the world in which real tools, machines, and materials are used.

So what might some of the trade-offs be in ending the design process at the virtual stage? What do students learn in the design phases of solving a technological problem compared to what they learn in actually building the solution? What role does building a solution play in psychomotor development? What are the affective outcomes of the design-and-build experience? Is there something unique that occurs when students bend, push, feel, smell, and see real materials and how tools interact with them? What are the unique contributions that technology education offers to the teaching-learning process? Most experienced teachers would agree that both designing and building are essential in the education of the child. Yet this assertion and the questions posed before it beg for research evidence.

Calls are increasingly being heard, especially from outside the field, for evidence of what students learn from their experiences in technology education. This has been a perplexing demand on my psyche for some time now. My thoughts consistently lead me back to the same, simple conclusion, as naïve as it may be. That is, are not the solutions to the technological problems that students design and build the defensible evidence we are seeking? Would not this evidence be parallel to measures of achievement in other subjects that focus on *doing*, such as solving a mathematical problem, playing a musical instrument, and throwing a clay pot on a potter's wheel? If the evidence is acceptable, then we need to focus our efforts on the nature of the problems that we engage our students in solving, how they can best be sequenced and articulated, how they can be assessed with reliability and validity, and how they can be made universally exciting and challenging with respect to gender and ethnicity. Or, on the other hand, is the evidence we seek in the form of filled-in blanks on a worksheet or a quiz? *Et sententia tua, conlegium meum?*

JEL

Reference

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Articles

Comparing Computer Usage by Students in Education Programs to Technology Education Majors

Aaron C. Clark and Eric N. Wiebe

Introduction

The 1990s have been an era of growth in computer usage for campuses across the United States. A national survey of information technology use in higher education indicated an increasing integration of computing related activities into college courses (Campus Computing Project, 2000). This survey reported that three-fifths of undergraduate courses utilized electronic mail and two-fifths made use of World Wide Web (WWW) resources. Parallel to this trend is the growing number of colleges and universities instituting requirements for student computer ownership ("Growing number of colleges require…," 2000). This article reported that many of the schools implementing the requirement did so to guarantee that all students had access to the same computing resources. Research by Brown (1999) indicated that at schools without a computer ownership requirement, only half the students are likely to own one.

National surveys of teacher education programs seem to show trends that are similar to other higher education programs (Moursund & Bielefeldt, 1999; Rosenthal, 1999). While some statistics are available for teacher education programs as a whole, little research has been done in this area that focuses on technology education. For example, does the strong emphasis on technology in general in technology education teacher preparation programs make it more likely that majors in these programs would own a computer (in the absence of required ownership) than, say, a social studies or mathematics pre-service teacher? Apart from the actual ownership of the computer, are students in other education majors likely to utilize their computers differently in the course of their studies? These become important questions when assessing whether different teacher education programs are meeting local and national mandates for computing literacy. While nearly all national teacher education organizations have called for some elements of computer competency, technology education has logically put computing and information technology literacy front and center (International Technology Education Association, 2000). Though this study focuses on a technology education program at a single institution, the

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researchers believe that it offers some fundamental findings to inform the field and can serve as a comparative baseline to the conduct of more comprehensive research.

The College of Education at North Carolina State University (NC State) has been consistently upgrading its technology infrastructure and integration of computing into the curriculum as a response to campus-wide and national trends as well as new technology competency requirements for current and future teachers (Technology Assessment Project, 1999). Though every faculty member in the College has a computer and four computer labs are available for both student use and instruction, there are still unanswered issues concerning reasonable expectations faculty members can make concerning student computer access and familiarity of different software tools when developing instructional materials for use by students.

In the Fall of 1999, the College of Education at NC State undertook a survey of its majors in all disciplines, including technology education, to gain an accurate look at many of these issues surrounding the use of computers and information technology. The researchers were not only interested in the level and type of computing activity going on in the college and within the technology education program, but also whether it was justifiable to treat all logical groupings of students as having equivalent access and experience with computing tools. The faculty and administration wanted to know if computing needs differed with respect to certain demographic elements such as gender, age, and ethnicity. The researchers identified three principal areas on which to focus the study. First was the extent to which students owned computers and how they used these computers for school, work, and leisure activities. For the purpose of the study, “work” was defined as receiving pay for using a computer. Second, the researchers wanted to find out the variability among majors in the use of computing tools such as e-mail, word processing, spread sheets, statistical analysis, presentation graphics, and technical graphics (i.e. CAD). Third was to compare technology education majors to other majors in their computer ownership and use.

Methodology

A survey instrument was designed to gather information on the computing issues of interest. Computer ownership was determined by asking whether the respondents owned their own computer and, if so, how old it was. The age of a computer can be roughly equated to its capability. Determining the age of the computer was thought to be a simpler and seemingly more reliable way to determine the capability of a computer than asking about specific features of the machine about which the responding students may not be knowledgeable (i.e., RAM, hard drive capacity, CPU model and speed, etc.).

The instrument also measured computer usage. Frequency and duration are the most common scales used to measure usage (Deane, Podd, & Henderson, 1998). Previous observations of student computer usage in the College revealed that the duration of individual sessions on the computer were highly variable. Therefore, frequency would not likely to give a good measure of usage. For that reason, duration was used as the operational definition of usage.

The respondents were also asked to report on specific types of activities for which they used the computer. These computer-based applications were considered to reflect basic computer competencies. They included electronic mail, the World Wide Web (WWW), word processing, presentation graphics, databases and spreadsheets, and statistical analysis.

Sample

As of the Fall of 1999, the College of Education (then called the College of Education and Psychology) had 1695 undergraduate and graduate majors. The instrument was mailed to a stratified, random sample of one third of these majors (565). Since several of the programs had small numbers of students, the stratification was by department rather than program. A second stratum was class level. Of the 565 surveys mailed, 23 were returned as undeliverable. A total of 190 surveys were returned by students, for an effective return of 35.1% of the original mailing.

A second survey instrument was developed that mirrored the college-wide instrument. This instrument was sent to majors in the technology education program after the college-wide assessment was completed. A total of 54 (63%) of the 86 technology education majors in the College responded to the survey. In order to compare between technology education majors and other education majors within the College, information on other undergraduate education-related majors was abstracted from the initial college-wide survey. Breaking down the College majors by class and area, 417 of the 1695 majors were in undergraduate teacher education programs. About one third of the total (139) of these undergraduate teacher education majors were part of the original survey sample. Of these, 111 were teacher education majors in areas other than technology education. Thirty-five (31.5%) of the 111 non-technology education majors in the initial survey sample had responded.

Findings

Table 1
Key Demographics Data by Major

	TED		Other Ed.	
Factor	*n*	%	*n*	%
Female	8	15.7	28	82.4
Male	43	84.3	7	17.6
White	40	80.0	30	88.2
Non-White	10	20.0	4	11.8
Full-time	50	98.0	30	85.7
Part-time	1	2.0	5	14.3

The instruments collected demographic data from the respondents. Table 1 shows the key demographic variables: gender, race, and student status (i.e. full-time or part-time). The majority of respondents from undergraduate technology education majors were white males attending college full-time. The majority of undergraduate respondents from other education majors within the college were white females attending college full-time. The majority of respondents were between ages 19-21. Among the technology education respondents, not one reported being 18 or younger, while 37% of other education majors responding were 18 or younger. Also, more technology education respondents reported being 22 or older (35.1%) than other education majors (22.9%) within the College. Figure 1 presents a synopsis of the age of the respondents.

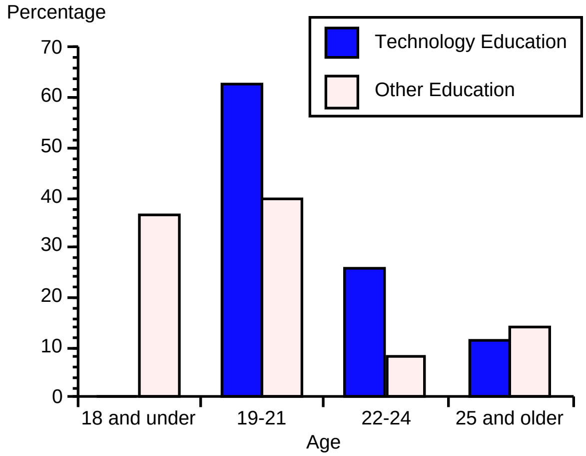

Figure 1. *Comparison of age between technology education and other majors.*

Overall, 87% percent of all education majors indicated they have a personal computer they own and use. Eighty four percent of technology education respondents own a personal computer, compared to 91% of the students from other education majors within the College. Most computers owned by both sets of respondents were between one and three years old. Figure 2 shows a comparison of the age of the computers among the respondents.

Computer ownership levels were analyzed to see if any significant difference or interaction existed relative to the variables of academic major, gender, or race. Using an ANOVA test (alpha = .05), no significant differences nor interactions were found.

Likewise, the researchers found no significant interaction between technology education majors as a group and those in other majors. No interaction was found between computer age and either gender or race. Also, no significant difference in computer age based on major, gender, or race was found. However, a significant positive correlation ($p < .0065$) was found between the age of student and the age of the computer for the total population that participated in the study.

The second part of the instrument assessed the number of hours each week the students spent using a computer for school, work, and leisure and the extent to which they used their own computer or one available elsewhere. As mentioned earlier, computer use for work meant that the students were being paid for the time they were using a computer. Figure 3 presents computer use by major.

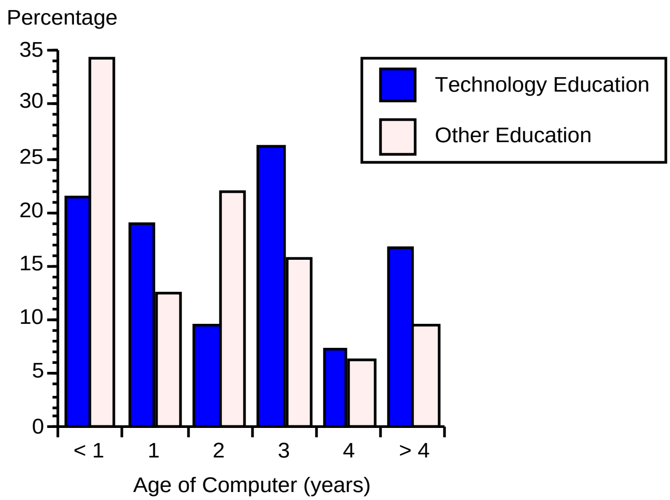

Figure 2. *Comparison of computer age between technology education and other majors.*

The second part of the instrument assessed the number of hours each week the students spent using a computer for school, work, and leisure and the extent to which they used their own computer or one available elsewhere. As mentioned earlier, computer use for work meant that the students were being paid for the time they were using a computer. Figure 3 presents computer use by major.

The researchers wanted to see if computing needs and time spent using a computer differed among class level (i.e. freshman, sophomore, junior, senior) and how much time, on average, students in each year classification spent at school, work, and, leisure computing activities. Table 2 shows the average (mean) hours spent per week by class level for each of the three computing activities for both technology and other education majors. Note that freshmen were not a part of the statistical analysis for this study since there were no freshman technology education majors.

The researchers compared differences in total computer use between major and class level using an ANOVA test (alpha = .05). No significant differences or interactions were found in total computer usage between major and the class level (e.g. sophomore, junior, senior). Likewise, there was no significant difference in total use by gender or race. Computer usage was then regrouped into the three component parts of school, work, and leisure and the ANOVA applied again. No significant interaction or difference was found based on major or class level for either school or work computer usage. Although there was no significant interaction in leisure usage by major nor class level, a significant

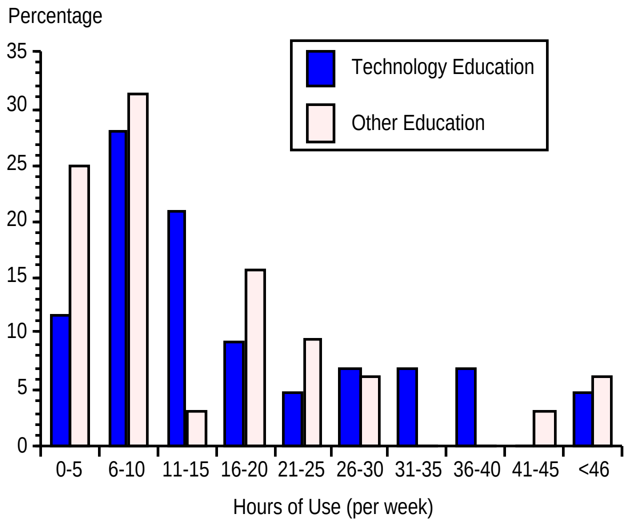

Figure 3. *Duration of computer use between technology education and other education majors.*

main effect ($p < .036$) was indicated for leisure usage by class level (F (3, 63) = 3.02). Post-hoc analysis showed that this was between seniors and the other years. The results of the ANOVA are reported in Table 3. This trend also revealed itself in a significant negative correlation between leisure usage and age ($r^2 = -.322$, $p < .0075$). No significant difference in leisure usage was found based on race or gender, nor was there any interaction with gender and class level or major.

Table 2
Average Hours Per Week Spent on Computing Activities

	Average Hours Per Week.		
Computing	Class Level	Tech. Ed	Other Ed
School	Sophomore	8.75	9.33
	Junior	8.50	5.25
	Senior	10.8	4.58
Work	Sophomore	3.57	1.83
	Junior	2.60	0.00
	Senior	2.27	1.66
Leisure	Sophomore	10.26	9.83
	Junior	7.75	1.50
	Senior	2.81	0.91

Seven computing areas were identified in the initial study as being regularly used within the College: e-mail, world wide web, word processing, databases/spreadsheets, statistics, presentation graphics, and technical graphics(CAD). This study compared the time per week that technology education majors spent in these seven areas compared to students in other majors. Table 4 shows the average number of hours each week technology education and other education majors spent in the seven computing areas selected for the study.

Table 3
ANOVA for Class Level - Leisure Usage

Test	SS	*df*	MS	*F*	*P*
Class Level	715.958	3	238.652	3.02	0.036
Error (Leisure Usage)	4980.004	63	79.047		

Using the ANOVA, no interaction or significant difference was found in the use of e-mail, the World Wide Web, or word processing by class level, major, or gender. Although no interaction was found for the hours spent each week using presentation graphics between class level and major, a significant main effect in use of presentation graphics was found between majors ($p < .0011$) with technology education majors using presentation graphics software more hours per week than other education majors ($F\ (1, 63) = 11.73$). See Table 5 for the results of the ANOVA. Though this two-way ANOVA did not reveal significance for class level, a one-way ANOVA on class level by itself did show a significant difference ($p < .0439$, $F\ (3, 66) = 2.85$). The results of the ANOVA are reported in Table 6. Seniors had significantly higher usage ($m = 2.77$) than freshmen ($m = 0.42$) and sophomores ($m = 0.77$) for this computing area.

Table 4
Average Hours per Week Spent in Selected Computing Areas

Computing Area	Tech. Ed. Majors	Other Ed. Majors
E-mail	3.90	3.77
WWW	7.73	5.48
Word Processing	3.66	4.81
Presentation Graphics	2.24	0.25
Database/Spread Sheet	1.50	0.53
Statistics	0.12	0.32
Technical Graphics (CAD)	6.41	0.03

Table 5
ANOVA Between Major and Class Level for Presentation Graphics Usage

Test	SS	*df*	MS	*F*	*p*
Major	66.561	1	66.561	11.73	0.0011
Class Level	29.837	3	9.945	1.75	0.1654
Class Level * Major	13.041	2	6.520	1.15	0.3235
Error (Pres Graphics Usage)	357.552	63	5.675		

No significant interactions or differences were found between majors or class level for database/spreadsheet, or statistics usage. Although, no interaction in CAD usage between major and class level was found, a significant main effect in CAD usage between technology education majors and other education majors ($p < .0001$, (F (1, 63) = 23.46) was found. See Table 7 for the results of this ANOVA. Also of note was the fact that seniors (m = 7.26) used CAD more than juniors (m = 5.26) who, in turn, used it more than sophomores did (m = 2.14).

In looking at the patterns of usage between applications, significant positive correlations were found between WWW usage and e-mail ($r^2 = .457$, $p < .0001$), as well as between WWW and CAD ($r^2 = .293$, p < .012). The study compared the age of the participants to see if age correlated with any of the seven computing areas. A significant negative correlation between age and E-mail use was found using the Spearman Correlation Coefficient procedure ($r^2 = -.355$, $p < .001$). Using this same test, positive correlations between age and presentation graphics ($r^2 = .337$, $p < .004$) and between age and CAD usage ($r^2 = .354$, $p < .002$) were also found.

Table 6
ANOVA Between Class Level and Presentation Graphics Usage

Test	*SS*	*df*	*MS*	*F*	*p*
Class Level	53.591	3	17.863	2.85	0.0439
Error (Pres Graphics Usage)	413.400	66	6.263		

Table 7
ANOVA Between Major and Class Level for CAD Usage

Test	SS	*df*	MS	*F*	*p*
Major	684.038	1	684.038	23.46	0.0001
Class Level	182.181	3	60.727	2.08	0.1114
Class Level * Major	79.675	2	39.837	1.37	0.2625
Error (CAD Usage)	1837.065	63	29.159		

Conclusions and Recommendations

The results of this study showed surprisingly similar trends in computer ownership and usage between technology and non-technology education majors. These similarities were maintained when the education majors were broken down based on gender or race. From the demographic data, it is clear that males continue to dominate technology teacher education at NC State. This is in contrast to a majority female population in the other education majors. At the same time, females tended to own and use computers at the same level as male students.

Interestingly, there was a considerably higher level of computer ownership among the respondents in this study compared to what Brown (1999) reported. Even though computer ownership was not required, a large majority of students in general owned computers and the proportion was even higher among technology education majors (though the difference was not significant). The lack of consistency between this study and the Brown study might be explained by socioeconomic differences between the two samples or by differences in support within the institutions. Understanding the barriers to ownership is important since ownership improves access to computer resources and this, in turn, influences the computing literacy of pre-service teachers (Kellenberger, 1997).

The age of the computer is related to what students can achieve with it and the extent to which their experience is positive. The computers that technology education majors used were, in general, older than those of non-majors. Older students tended to own older computers. This is likely due to the fact that students purchase a computer when they first enroll in the university and keep this computer until they graduate. The fact that technology education majors are often transfers from other majors may explain why they are older, on the average, than non-majors. Correspondingly, this likely would cause them to spend more years earning their degrees and thus might explain why their computers are older.

The age of a computer provides a relatively good benchmark to judge the readiness of the machine to run current software. Given the hardware demands of the latest graphics, CAD, and multimedia software that technology education majors are expected to use, these students are likely to be disadvantaged if their computer is more than two years old. A new computer ownership plan is being implemented by the College of Engineering at NC State that will have students lease computers and be able to trade them in after two years. A similar plan should be considered for technology education students.

This study revealed little difference in total computer usage between technology education majors and other majors within the College. Likewise, there was little difference in usage among class levels. While there seemed to be greater overall usage by technology education majors than by other education majors, and by sophomores compared to other class levels, these differences were not significant. Only when specific applications were analyzed did significant differences occur.

The fact that education majors in non-technical areas were making use of computers as much as technology education majors is indicative of the pervasiveness of computing activity in all curricular areas and in the work performed by students outside of school. On the other hand, it could be argued that the technology education program at NC State has failed to integrate computers to the extent that one would think, considering the nature of the of the discipline.

A closer look at the differences in computing usage among major, class level, and type of activity might explain some of these findings. For both technology and other education majors, sophomores were clearly the heaviest users of computers. This difference was in large part due to the high amount of leisure time spent with the computer. Sophomores and juniors from all majors engaged in significantly more leisure activity than seniors. While the interaction was not significant, the drop-off of leisure time spent using a computer between the sophomore and junior year for non-technology education majors was much more precipitous than it was for technology education majors. What is unclear is whether this drop-off was due to changing curricular demands as students move through school or whether, in fact, it might be revealing a micro-generational change in lifestyle. That is, younger students tend to integrate the computer more fully into all aspects of their daily life, including their (self-defined) leisure activity. A significant negative correlation between leisure usage and age seems to support this latter theory. Another element of support for this notion comes from the significant negative correlation that was found between e-mail usage and age, since e-mail can be used for a wide range of non-academically-related activities.

Also of note, though not significant, is the reverse trend in use of the computer for school activities between technology education and other majors. While the amount of school-related activities increased between the sophomore and senior years for technology education majors, it dropped for other education majors. A closer look at the curriculum content of all the education programs might reveal the root of this differential trend. For example, the computer literacy instruction for all students could have been concentrated during the sophomore year.

When looking at specific types of software used by education majors, some interesting differences in usage emerged between technology and other education majors with respect to class level. Technology education majors used presentation graphics and CAD (computer-aided design) software significantly more than other education majors. This difference would be expected regarding CAD since it is such an integral part of a technology education curriculum. An explanation for the increased use of presentation graphics software among technology education majors is, however, is less obvious. Unlike CAD, presentation graphics software is meant to be used as a general communication tool. As such, one would expect to find similar use among virtually all majors. It appears that students in other majors should be given increased encouragement and opportunity to use presentation software as part of classroom assignments. Certainly presentation graphics software would be an essential element of computing literacy initiatives for pre-service teachers (e.g., Moursund & Bielefeldt, 1999). Clearly, the use of these software tools and their integration into assigned activities would be a significant influence to their use in the future by an aspiring teacher (Gibson & Nocente, 1998). Technology education does seem to be doing a better job in this area than the other teacher education programs at NC State University.

In addition to showing differential levels of usage between majors, the use of CAD and presentation graphics differed by class level. Seniors were more likely to use CAD and presentation graphics than were lower level students. Not surprisingly is a parallel, significant positive correlation between CAD and presentation graphics and age. In this instance the researchers were less inclined to point to the generational influence mentioned earlier as an explanation. Instead, the increased use was due to the fact that project-based activities and the presentation of their outcomes are more common in upper level courses at NC State and many other universities.

Looking at other application usage patterns, it is worth noting that technology education students seem to be making more use of the WWW, while other education majors were using word processing more. These differences were not significant, however. More important may be the synergistic use of Internet-based activities as shown in the significant correlation of WWW and e-mail usage for all education majors. Also significant is that e-mail and WWW usage is not significantly different between male and female students, regardless of major or class level. For those students who are connected to the Internet, these tools go hand in hand. Whether increased usage of Internet-based tools such as the WWW and e-mail is good or bad is highly dependent upon how individual instructors integrate these tools into their courses and how students apply them in the course of their studies. The Internet is a rich source of information exchange, but all information sources both electronic and paper-based must be used and evaluated based on their quality and their relevance to the academic tasks at hand.

The results of this study clearly indicate that computer ownership and computer usage was pervasive in the College of Education and Psychology in the Fall of 1999. This pervasiveness was independent of major, class level, gender, or race. The predominantly white male technology education majors did not differ from other majors in terms of their overall usage of computing resources. It was only in the more specific analyses that differences were found between technology education and other education majors. Overall it appears that differences in computing use may be due more to the age of the student than to their major or gender.

It is risky to generalize the results of this study beyond NC State University in the year 1999. Computers and their application by students continue to evolve at a rapid pace. Institutions of higher education differ dramatically from one another, as do the programs within them. What was found at NC State may not hold true in other technology education programs due to a myriad of factors that were not controlled in this study. However, the regular conduct of national surveys of technology education and other education programs are needed so that longitudinal trends can be observed. Such studies can be key elements in helping the technology education profession provide for the computing needs of its students and to set benchmarks for comparison. The computer has become a tool that is essential for all educators and this is especially true for technology education.

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Online Learning Needs in Technology Education

Jim Flowers

Introduction

The number of distance education courses, degree programs, and enrollment in the US nearly doubled from 1995 to 1998 (US Department of Education, 1999). As universities provide more courses online, possibly to a different population of students, it is important to assess the perceived needs of learners and potential learners. In the field of technology education, some (e.g. Davis, 2000, Ndahi, 1999) have studied university distance education programs, but a characterization of potential learners and their needs has not been performed. The goal of this article is to inform those considering offering online technology education, especially at the graduate level, of the perceived need for and appeal of online educational opportunities in technology education, as discovered through a needs assessment survey.

An educational needs assessment "has been increasingly recognized as a necessary part of curriculum design" (Pratt, 1980, p.79). Stewart and Cuffman (1998) noted that, "the integration of needs assessment as part of a total distance education system should benefit all stakeholders (e.g., faculty, administrators, students)."

> [A] limited use of needs assessment is valid, and it is likely to result in better program design, development, and delivery than otherwise might occur. However, needs assessment can do more than that. [Those providing continuing education] can use it to optimize their service to clients and to enhance the organizations and institutions they represent. (Queeney, 1995, p. 261)

Needs assessments in other areas, such as engineering education (Rutz, 2000), have provided direction for the design of distance learning. As university level technology education programs begin to offer more online classes and degree programs, some current face-to-face technology education professors may be in the position of developing online offerings. Because online education can overcome some traditional barriers related to time and place, there may be special interest in the development of online graduate programs that could serve professionals who might find it a better option than leaving their work and home

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to establish residency at a university. Planning instruction for a new group of students using a new delivery method should be informed by the perceived needs and preferences of the target population.

Methods

Because of the ability to provide information from a large number and wide variety of respondents, the survey technique was chosen over other typical needs assessment data gathering methods, such as interviews, focus groups, and on-site observations (McClelland, 1995). A survey instrument was developed consistent with the five typical stages of needs assessment survey development noted by McClelland (1995): content definition, composing the survey, pilot testing, revision, and gaining approval to distribute the survey. Some of the instrument's content was developed based on the technological literacy standards released by the International Technology Education Association (ITEA, 2000) only weeks before the survey. A preliminary questionnaire was then developed, following recommendations by Gupta (1999) on the writing of training needs assessment instruments (i.e., Determine the types of data to be collected. Determine data sources. Involve experts. etc.)

During the development of the instruments, content and survey specialists were consulted. Content consultants included technology teachers, undergraduate and graduate technology education students, and professors in technology education. Two technology education professors from universities other than the hosting university were consulted specifically because they had recently conducted national surveys in technology education. Two instructional technologists were also consulted, one of whom had recently used the survey software for dissertation research. Finally, two survey specialists from the hosting university's assessment office were consulted regarding the format of the instruments and coding of the results. Pilot testing occurred throughout the development period. Subjects included one undergraduate technology education student, one graduate technology education student, and five technology teachers. During the final round of pilot testing, all subjects seemed to interpret the meaning of the questionnaire's items and the formatting of their response as intended.

After pilot testing, a revised instrument was prepared for delivery by mail and online. In May, 2000, following human subjects protocol approval, 3,203 questionnaires were mailed with a cover letter and a postage-paid return envelop to all professional and student members of the International Technology Education Association (ITEA). A parallel online version of the questionnaire was available as an alternative, and cited in the mailing. The questionnaire included items on demographics, computer use, learning needs, and the educational appeal of online instruction.

Results and Discussion

Respondent Characteristics

As of July 20, 2000, 923 usable questionnaires were received (including 111 submitted online) for a response rate of 29%. This was nearly double the response rate from a needs assessment survey of engineering educators (Rutz, 2000). Most of the respondents (88%) indicated they were professional members of ITEA, with only 8% indicating they were student members (the remainder did not respond to this item.)

The most typical occupations of respondents were high school technology teacher (38%) and middle school or junior high school technology teacher (29%); ten percent noted they were university technology teacher educators, and 5% and 2% were undergraduate and graduate technology education students, respectively. Most respondents (57%) indicated that the master's was their highest degree completed; 25% indicated the bachelor's, and 12% indicated the doctorate. Only 145 respondents (16%) had ever taken a course online. Thus, the results of this survey must be seen as describing the perception of online education, rather than experience with online education.

When asked about their use of the Internet, 829 respondents (90%) noted that they personally used the Internet to learn about some aspect of technology. This indicated a high level of readiness to engage in non-formal distance learning.

Computer Resources. Developers of online offerings should be aware of the computer resources available to their distance education students. Selected hardware and software technologies reported by the respondents as being used regularly are shown in Table 1. Many more respondents reported using a PC regularly both at work and at home, than a Macintosh (though some reported using both computer platforms). Many respondents reported using Microsoft Office and using the Internet. The use of digital still and video technology was not as common, and was greater at work than at home, probably due to the cost of the equipment and its presence in many technology education laboratories. Most respondents (63%) indicated that they used a 56K modem at home and most (57%) used T1 Internet connection at work.

These responses may seem to indicate that the majority of respondents have access to typical computer resources, including at least a 56K modem. However, online educators are cautioned against developing online instruction that is only appropriate for a fraction of potential students, even if that fraction does constitute a majority. Instead, accommodations for students with lesser technological resources should be devised.

Table 1.
Percent of respondents reporting regular use of selected technology (n=923).

	Location	
Technology	Home	Work
Email	82%	85%
Internet	82%	86%
PC	76%	81%
MS Office	74%	81%
Digital Camera	30%	53%
Macintosh	27%	38%
Online Chat	14%	6%
Digital Video	12%	25%

Perceived Learning Needs

Future Coursework Required. Is there a job-related need for future coursework? Sixty-five percent of the respondents indicated such a need. The greatest need (36%, n = 336) was for continuing education credits. Such credits are not necessarily graduate or undergraduate college credits but typically include approved workshops and other training opportunities. Ten percent of the respondents indicated a requirement of one course or less per year, and seven percent indicated the need to finish another degree.

Provision was made on the instrument for respondents to write their requirements for continuing education. A wide variety of required coursework was indicated, due largely to the variability in state requirements. Examples included, “100 workshop credits every 3 years minimum;” “2-4 courses / 5 yr for MA recertification;” and “1 class every 5 years.” This variety can be seen as an opportunity for online education that spans geographic boundaries.

Content Areas of Interest. Several questions were included on the survey to determine the respondents’ interests in different content areas. The first of these asked the respondent how much interest he or she has in taking a course or workshop (not necessarily online) on each of the five topics shown in Table 2. A five-point Likert-type scale was used with the following scale category descriptions: None – Little – Moderate – Much – Great. The mean level of interest was between “moderate” and “much” for all five areas, with the greatest reported interest in courses or workshops dealing with “activities to teach about technology.” For each topic, moderate to great interest was indicated by 71% to 90% of the respondents.

However, this level of interest varied by the educational level of the respondent. For example, “Teaching methods and student management” ranked the lowest of the five, but for respondents whose highest degree was an associate’s, (n = 17), it ranked third; for respondents indicating high school as their highest level (n = 29), it ranked first. Is there a need to provide education on teaching methods and student management? Yes, but with the current survey sample this need is more acute with pre-baccalaureate teachers, as might be expected.

Table 2.
Respondents' interest in taking a course or workshop in selected areas.

	Level of Interest						
Area	None (1)	Little (2)	Moderate (3)	Much (4)	Great (5)	*n*	Mean
Activities to teach about technology	5.3%	5.1%	22.6%	34.0%	33.1%	909	3.85
New and emerging technologies	5.3%	5.2%	31.7%	34.3%	23.4%	900	3.65
Technology education curriculum	6.9%	9.9%	27.5%	33.4%	22.4%	902	3.55
Using the Internet to teach about technology	7.5%	9.8%	31.0%	28.7%	23.0%	904	3.50
Teaching methods and student management	10.2%	19.2%	35.5%	20.0%	15.0%	889	3.10

The questionnaire also assessed respondents' interests in educational enrichment in regard to the newly released ITEA content standards (ITEA, 2000). The newly identified content areas within technology education such as medical technologies and technology assessment were expected to spark much interest since there have been few educational opportunities in these areas. Interest in these areas were expected to be higher than manufacturing and construction which have long been a part of the curriculum. To assess this interest, some of the twenty areas identified by the ITEA standards document were combined, resulting in a sixteen-part survey question. A seventeenth content area related to usability was added to this list.

As indicated in Table 3, the areas related to ITEA content standards that received the most interest were "information and communication" (3.52) and "technological design" (3.50). Those ranking the lowest were "agricultural and biotechnologies" and "medical technologies," with means of 2.84 and 2.74, respectively. This indicates an interest among the respondents between "little" and "moderate." The overall mean for all seventeen items related to ITEA content standards, indicate a moderate interest in all content areas, warranting attention by those providing courses and workshops. Technology education professionals who are potential students would be well served if ITEA coordinated and facilitated access to education in these areas. This would also serve the needs of this association in ensuring that the content standards are understood and applied.

Some of the more traditional areas received greater interest than some of the newer areas, as seen by comparing means for "manufacturing technologies" and "construction technologies" with those of "agricultural and biotechnologies" and "medical technologies." However, there are multiple reasons why a respondent might indicate a relatively low need. If an area is thought to be important, but the individual is well versed in the area, there might be little perceived need. Likewise, if an area is thought to be unimportant or irrelevant, whether or not the individual has studied the area, there might be little perceived need. Furthermore, although survey research assumes that respondents reply honestly, it is possible that regardless of a respondent's expertise or need, this list of seventeen items was seen as an opportunity to "cast a vote" regarding the importance of certain content areas in technology education.

A rather large number of respondents seemed to recognize no personal learning need that could be met by taking a course or workshop. This is surprising considering that the respondents were professionally involved in education. This view, which was most prevalent in respondents with doctorates, those that have fulfilled job requirements for education, and those near retirement, is contrary to the notion of life-long learning and continued professional development.

Need for Online Technology Education. Two Likert-type questions asked respondents for their general opinion on the need for online technology education. The first question in this area asked: "How much of a need do you think there is for online education in technology education (above the high

Table 3.
Mean interest levels for courses or workshops based on content areas included in the ITEA standards. (n = 869 to 891.)

Content Area of Interest	Mean
Information and communication	3.52
Technological design	3.50
Manufacturing technologies	3.40
Construction technologies	3.34
Transportation technologies	3.30
Learning to use technology	3.28
Energy and power technologies	3.25
Technological connections and integration	3.24
Technology and the environment	3.20
Technology assessment	3.15
Technology and history	3.02
The core concepts of technology	3.00
Technology and culture	3.00
Learning about usability	2.95
The characteristics and scope of technology	2.90
Agricultural and biotechnologies	2.84
Medical technologies	2.74

Note: 1 = none, 2 = little, 3 = moderate, 4 = much, 5 = great

school level)?" The points on the scale were coded with numbers 1 representing "no need" to 5 representing "great need." From the responses to this item, a mean of 3.81 resulted. Sixty-three percent chose the top two levels, and 30% chose "great need," whereas only 1% chose "no need."

This level of perceived need is noteworthy and indicates an opportunity for universities considering offering online education. Possibly contributing to this perceived need is the current shortage of technology teachers and the perception that distance education can overcome previous obstacles.

A similar question asked respondents, "How much of a need is there for online technology education for students in grades K-12?" The mean of 891 responses was 3.49, based on the same 5-point scale. This could indicate further opportunities for online curriculum developers interested in reaching K-12 students.

Likelihood of Taking a College Course. When asked, "How likely are you to take college courses over the next 3 years?", 37% (339 of 916) of the respondents indicated they were "certain" to take a college course, and 19% indicated this was "likely." Although these figures (from this self-selected survey sample) may not be generalizable to a larger population, there is a distinct indication of the need for college courses, whether online or not.

As illustrated in Table 4, there is greater likelihood that a respondent will take a continuing education course or workshop rather than a college course at any of the three levels listed. Respondents were least likely to take an undergraduate class. This is not surprising, considering only 5% of survey respondents indicated that high school or an associate's degree was their highest level of education.

Table 4.
Likelihood of taking a course over the next three years, by course level.

		Likelihood				
Course Level	*n*	Very Unlikely	Unlikely	50/50	Likely	Certain
Undergraduate	673	59%	14%	10%	9%	10%
Master's	786	29%	9%	16%	21%	26%
Doctoral	718	45%	18%	16%	13%	8%
Continuing Educ/ Workshop	836	6%	4%	18%	34%	37%

Educational Appeal

The next group of questionnaire items attempted to determine the appeal of different structures for online courses, perceived obstacles and benefits, advertising opportunities, and the appeal of teaching online.

Relative Appeal of Online and On-Campus Classes. Respondents were asked, “How appealing is each of the following to you?” They were then presented with two items, each with its own 5-point Likert-type scale. The items were “Taking a standard on-campus class” and “Taking an online class.” The Likert-type scale headings, coded 1 to 5, ranged from “very unappealing” to “very appealing.” On that scale, the average appeal of taking an online class (3.54, n = 909) slightly exceeded the average appeal of taking an on-campus class (3.15, n = 901). Both means were situated between “50/50” and “appealing.” Respondents who had previously taken an online course reported greater appeal of online classes (3.32, n = 136) than did those who had not. Although the reader is cautioned against generalizing these survey results to a larger population, it is worth noting that at a minimum, 505 ITEA members (or at least one in seven) found the idea of taking an online course appealing or very appealing.

Preference for Different Course Logistics. Educational opportunities can be structured in a variety of ways. It might be that the traditional, three-credit, fifteen-week college course on a fixed calendar is not always the best structure for online educational offerings. It was suspected that shorter, 1-credit courses might be more attractive due to decreased demands on a student’s time. Using a format similar to the previous questionnaire item, respondents were asked to rate the appeal of a 1-credit and a 3-credit class.

Within this survey sample, 3-credit courses seemed to be slightly more appealing (mean = 3.62, n = 900) than 1-credit courses (mean = 3.23, n = 886), although the means for both were situated between “50/50” and “Appealing.” The flexibility of 1-credit offerings was anticipated to increase appeal, but this was not found to be the case. The greater appeal of 3-credit courses might be due somewhat to tradition but also to the need of teachers to take courses that fulfill their districts or degree’s requirements.

Course length is another factor to consider in structuring online courses. Respondents were asked to “indicate the ideal number of weeks you would suggest for a 3 credit online course (between 1 and 15 weeks).” Presenting the mean recommended course length (mean = 8.84 weeks, n = 852) does not adequately describe responses. The top choice was 10 weeks (145 respondents), followed by 15, 6, 8 and 12 weeks. Yet, 194 respondents indicated an ideal time less than six weeks. Universities should consider offering online courses that differ from the length of their traditional courses.

Another logistical factor in course design concerns the course calendar. A questionnaire item asked the following: "Some distance education classes require students to complete the assignments according to a fixed calendar, while others are self-paced. Which would you prefer?" They were then presented three choices: "Fixed calendar," "Self-paced," and "Undecided/ Depends on Content." The number of respondents selecting "Undecided/ Depends on Content" was the greatest (338, 37% of n = 906), just greater than the number choosing "Self-paced" (325, 36%). The third option, "Fixed calendar," was selected by 243 respondents (27%). This does not mean that the preference does not matter, or that these discrepant views cancel each other. Rather, educational providers should be cognizant of the diverse preference of learners.

The final question in this area was an attempt to determine preferences for group or individualized learning structures. When asked to select one of four possibilities, the majority of respondents (564, n = 913) reported having a preference for "a mixture of independent and group learning." More respondents preferred learning on their own (184) than preferred "learning by interacting with other students" (116). An implication for instructional designers and teachers of online courses is to include a variety of individualized and group learning activities in online classes.

Obstacles to Taking an Online Course. An attempt was made to determine perceived obstacles to taking online courses. Respondents were asked, "For you, what is the biggest obstacle to taking an online course?" The item with the most responses (228) was "no opinion / don't know." This might seem like a response with little semantic impact. However, it parallels many of the comments made in the attached "comments" portion of the instrument. There, several respondents indicated that they had never considered online education before, so they were not aware of obstacles. Ironically, this may be the most telling data concerning obstacles: "lack of awareness" or no consideration of online education as a viable alternative could be the biggest barrier between many technology education professionals and online educational opportunities. To overcome this obstacle, educational providers would be wise to take on the responsibility of informing the public and their potential clients of the services they offer, paying special attention to describe what it is like to take an online course.

The second and third ranked obstacles were "time requirements" (227) and "I can't find a course I'm interested in or need" (192). For these, and other obstacles, solutions may be possible. Varying course length and timing may successfully overcome some individuals' "time requirements" obstacles, while better publicizing online course offerings may help overcome the inability of potential students to locate a course they want.

Other obstacles noted in a comments section tended to be related to: ignorance ("Never given it much thought!"); apathy ("Need no longer exists. I have enough credits"); personal characteristics ("Need structure of classroom"); computer issues ("I am slow at keyboard"); and questions of quality ("Poor quality of instruction"). However, it should be noted that these are perceived obstacles, and students who enroll in online education may soon overcome a previously perceived obstacle. For example, Wells (2000) found that by the midpoint of an online course, "the anxiety surrounding the course requirements and gaining the necessary enabling skills were mitigated."

Degree Program Interest. A survey item asked, "If you were to begin an online college degree program, in which level would you be most interested?" Respondents chose the "master's" level (287 respondents, 38% of n = 761) as most appealing, followed by the "doctoral" level (30%) and "continuing education credit" (27%). As would be expected from the educational level of respondents, relatively little interest was shown in an undergraduate degree.

A second question (n = 686) in this area asked, "If you were to begin an online college degree program, in which area would you be most interested?" A clear favorite here was "Technology Education" (69%), over the alternatives of "Educational Administration" (25%) and "Curriculum and Instruction" (20%).

Most Attractive Aspects on Online Courses. In an open-response question, respondents were asked, "What is the most attractive aspect of taking an online course?" The quantity of responses to this item was high (n = 765), but the variety of responses was not. By far, the most common responses concerned convenience, which seemed to be partitioned between not having to travel, and the flexibility to work at one's own schedule. This corroborates the work of Thompson (1998) who noted that, "Traditionally, distance education has attracted students whose geographic distance from a higher education institution discouraged or prevented enrollment in on-campus classes" (p. 12.). However, some respondents indicated that the self-pacing of online education is appealing. (This points out a preconception among some that online education is necessarily self-paced, in spite of examples to the contrary.)

Least Attractive Aspects of Online Courses. In a parallel item, respondents were asked, "What is the least attractive aspect of taking an online course?" The number of responses to this item was once again great (n = 726), but the variety was greater than the previous item. The most common response expressed the belief that there would be little human interaction, either with the instructor or with fellow students. This confirms the findings of Schmidt and Gallegos (2001), who surveyed four technology classes at Purdue University to determine issues and concerns of distance learners. Other common responses from the present study concerned low interaction ("No interaction with instructor/classmates"); low quality ("Quality is near -0-."); time, work, and cost requirements ("Cost / time"); personal characteristics ("Motivation"); computer concerns ("Not being totally comfortable with using the Internet"); ignorance and fear ("Unsure of what it is all about"); and availability ("Finding one to take.")

Strategies should be devised to minimize each of these "least attractive" aspects. For example, designers of online instruction might consult newly published standards and principles for online education in their effort to ensure quality (Innovations in Distance Education, 1998; The Institute for Higher Education Policy, 2000). Most significantly, however, is the need to overcome the belief that online courses do not include interpersonal contact.

Ignorance and misconceptions about what an online course entails may pose a problem in analyzing the results of this item. Anderson (1997-1998) noted that typical students who take their first online course are often unaccustomed to the instructional techniques and mistakenly assume a passive role. It is not feasible to use an online course to overcome such misconceptions if they pose a significant obstacle to enrolling in an online course. Instead, universities and others should educate potential students about what it is like to take an online course. Because there is much variety in both student needs and possible educational offerings, universities should provide sufficient information to potential students that would allow them to wisely choose courses or programs that meet their content needs and learning styles.

Locating Online Offerings. Respondents were asked the following question: "If you decided to take an online course or begin an online degree, where would you look to see what is available? Where should universities advertise?" Many stated they had no idea where to look. Others listed ITEA's website and publications. A surprisingly large number of respondents noted that they would look toward local (geographically) sources to find information about online courses. They most commonly included nearby universities, the Web pages of those universities, state organizations affiliated with ITEA, and state departments of education.

The implications for the technology education profession are clear. First, there should be a free, centralized clearinghouse that facilitates easy listings of, and easy searches for, online education in technology education. ITEA is the logical choice within the US for this clearinghouse, though other associations may be more appropriate elsewhere. A second implication is that universities should use a variety of strategies to disseminate information about online offerings. These include Web-based sources, mailings, organizations, bulletins, and partners. The Web addresses (i.e., URLs) of courses should be submitted to search engines so that keyword searches will find the necessary information about the online offering.

Willingness to Teach Online. Respondents were asked, "Would you like to try teaching online (even if that means getting training in online teaching)?" A large number (437, 47%) answered, "Yes." This was higher than had been expected, considering the observation of Williams, Paprock, and Covington (1999). They stated, "When teaching and training professionals are asked to participate in open and/or distance learning projects, many have an underlying resistance to change" (p. 75). Those without prior experience as online students were more likely to answer "Yes" than those who had been online students.

The implications for universities and the technology education profession are not certain, here. Should universities recruit online technology teachers? Should they specifically offer training in "how to teach technology education online"? Should technology teachers provide online K-12 education?

Conclusion and Recommendations

Perceived Online Learning Needs

A variety of views emerged concerning online learning needs. While some people indicated a need for individual courses, others preferred continuing education credits, or entire degree programs. Although the greatest job-related educational need was for continuing education credit, a higher level of interest was expressed for online programs in technology education and at the master's level than in other alternatives.

Interest was evident in courses and workshops covering a variety of topics, including activities to teach about technology, new and emerging technologies, technology education curriculum, and using the Internet to teach about technology. Teaching methods and student management were also of interest, but more among those who had not yet completed a bachelor's degree. Furthermore, interest was expressed in topics related to the ITEA content standards. Of these areas, the most interest was expressed for "information and communication" and for "technological design." "Medical technologies" and "agricultural and biotechnologies" were of least interest.

Several barriers to meeting online learning needs emerged. Among these were a lack of perception of need, a lack of awareness of online opportunities, a perception that online education is too impersonal, and a perception that online education is of inferior quality. Yet, universities can help overcome some of these barriers if they advertise online offerings that have been designed to ensure both high quality and personal interaction.

A number of preconceptions emerged that may not accurately describe online education. For example, a perceived lack of inter-student contact in online courses seems to be contrary to the use of collaborative online strategies and technologies (See Mason, 1999; Verdejo and Cerri, 1993.) Other preconceptions that should be scrutinized include a perceived lack of contact with the instructor, a self-paced calendar for an online class, and lower quality of online education compared to traditional education.

Recommendations for Educational Providers

The following recommendations are made to potential providers of online technology education:

1. Take advantage of the perceived need for online education in technology education by offering more online courses and workshops. Areas such as "information and communication" and "technological design" may meet a greater need than other areas and may yield greater enrollments. Courses that are part of complete online degree programs, especially at the master's level, may be useful to those seeking credit only and to those seeking degrees.
2. Ensure high quality in the online learning experience. This concerns the depth of content, accommodations for significant interpersonal interaction, and the facilitation of a wide variety of learner needs and capabilities.
3. Advertise and promote online opportunities using a variety of techniques

to reach near and distant technology education professionals. Where possible, note where online courses and workshops meet individual re-certification requirements for teachers from a variety of geographic locations. Help dispel misconceptions about what it is like to take an online course.

Finally, future needs assessments should be performed to gain information on the changing needs of a changing population. Stabb (1995) noted that “there is near universal recognition of needs assessment as an ongoing, dynamic process that responds to shifts in the local context” (p. 53).

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The Effect of a Computer Simulation Activity versus a Hands-on Activity on Product Creativity in Technology Education

Kurt Y. Michael

Computer use in the classroom has become a popular method of instruction for many technology educators. This may be due to the fact that software programs have advanced beyond the early days of drill and practice instruction. With the introduction of the graphical user interface, increased processing speed, and affordability, computer use in education has finally come of age. Software designers are now able to design multidimensional educational programs that include high quality graphics, stereo sound, and real time interaction (Bilan, 1992). One area of noticeable improvement is computer simulations.

Computer simulations are software programs that either replicate or mimic real world phenomena. If implemented correctly, computer simulations can help students learn about technological events and processes that may otherwise be unattainable due to cost, feasibility, or safety. Studies have shown that computer simulators can:

1. Be equally as effective as real life, hands-on laboratory experiences in teaching students scientific concepts (Choi and Gennaro, 1987).
2. Enhance the learning achievement levels of students (Betz, 1996).
3. Enhance the problem solving skills of students (Gokhale, 1996).
4. Foster peer interaction (Bilan, 1992).

The educational benefits of computer simulations for learning are promising. Some researchers even suspect that computer simulations may enhance creativity (e.g., Betz, 1996; Gokhale, 1996; Harkow, 1996), however, after an extensive review of literature, no empirical research has been found to support this claim. For this reason, the following study was conducted to compare the effect of a computer simulation activity versus a traditional hands-on activity on students' product creativity.

Background

Product Creativity in Technology Education

Historically, technology educators have chosen the creation of products or projects as a means to teach technological concepts (Knoll, 1997). Olson (1973), in describing the important role projects play in the industrial arts/technology classroom, remarked, "The project represents human creative achievement with materials and ideas and results in an experience of self-fulfillment" (p. 21).

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Lewis (1999) reiterated this belief by stating, "Technology is in essence a manifestation of human creativity. Thus, an important way in which students can come to understand it would be by engaging in acts of technological creation" (p. 46). The result of technological creation is the creative product.

The creative product embodies the very essence of technology. The American Association for the Advancement of Science (Johnson, 1989) stated, "Technology is best described as a process, but is most commonly known by its products and their effects on society" (p. 1). A product can be described as a physical object, article, patent, theoretical system, an equation, or new technique (Brogden & Sprecher, 1964). A creative product is one that possesses some degree of unusualness (originality) and usefulness (Moss, 1966). When given the opportunity for self-expression, a student's project becomes nothing less than a creative product.

The creative product can be viewed as a physical representation of a person's "true" creative ability encapsulating both the creative person and process (Besemer & O'Quin; 1993). By examining the literature related to the creative person and process, technology educators may gain a deeper understanding of the creative product itself.

The Creative Person

Inventors such as Edison and Ford have been recognized as being highly creative. Why some people reach a level of creative genius while others do not is still unknown. However, Maslow (1962), after studying several of his subjects, determined that all people are creative, not in the sense of creating great works, but rather, creative in a universal sense that attributes a portion of creative talent to every person. In trying to understand and predict a person's creative ability, two factors have often been considered: intelligence and personality.

Intelligence

A frequently asked question among educators is "What is the relationship between creativity and intelligence?" Research has shown that there is no direct correlation between creativity and intelligence quotient (I.Q.) (Edmunds, 1990; Hayes, 1990; Moss, 1966; Torrance, 1963). Edmunds (1990) conducted a study to determine whether there was a relationship between creativity and I.Q. Two hundred and eighty-one randomly selected students, grades eight to eleven, from three different schools in New Brunswick, Canada participated. The instruments used to collect data were the *Torrance Test of Creative Thinking* and the *Otis-Lennon School Ability Test,* used to test intellectual ability. Based on a Pearson product moment analysis, results showed that I.Q. scores did not significantly correlate with creativity scores. The findings were consistent with the literature dealing with creativity and intelligence.

On a practical level, findings similar to the one above may explain why I.Q. measures have proven to be unsuccessful in predicting creative performance. Hayes (1990) pointed out that creative performance may be better predicted by isolating and investigating personality traits.

Personality Traits

Researchers have shown that there are certain personality traits associated with creative people (e.g., DeVore, Horton, and Lawson, 1989; Hayes, 1990; Runco, Nemiro, & Walberg, 1998; Stein, 1974). Runco, Nemiro, and Walberg (1998) identified and conducted a survey investigating personality traits associated with the creative person. The survey was mailed to 400 individuals who had submitted papers and/or published articles related to creativity. The researchers asked participants to rate, in order of importance, various traits that they believed affected creative achievement. The survey contained 16 creative achievement clusters consisting of 141 items. One hundred and forty-three surveys were returned reflecting a response of 35.8%. Results demonstrated that intrinsic motivation, problem finding, and questioning skills were considered the most important traits in predicting and identifying creative achievement. Though personality traits play an important part in understanding creative ability, an equally important area of creativity theory lies in the identification of the creative process itself.

The Creative Process

Creativity is a process (Hayes, 1990; Stein, 1974; Taylor, 1959; Torrance, 1963) that has been represented using various models. Wallas (1926) offered one of the earliest explanations of the creative process. His model consisted of four stages that are briefly described below:

1. Preparation: This is the first stage in which an individual identifies then investigates a problem from many different angles.
2. Incubation: At this stage the individual stops all conscious work related to the problem.
3. Illumination: This stage is characterized by a sudden or immediate solution to the problem.
4. Verification: This is the last stage at which time the solution is tested.

Wallas' model has served as a foundation upon which other models have been built. Some researchers have added the communication stage to the creative process (e.g. Stein, 1974; Taylor, 1959; Torrance, 1966). The communication stage is the final stage of the creative process. At this stage, the new idea confined to one's mind is transformed into a verbal or non-verbal product. The product is then shared within a social context in order that others may react to and possibly accept or reject it. A more comprehensive description of the creative process is captured within a definition offered by Torrance (1966).

> Creativity is a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficult; searching for solutions, making guesses or formulating hypotheses about the deficiencies, testing and re-testing these hypotheses and possibly modifying and re-testing them, and finally communicating the results. (p. 8)

Torrance's definition resembles what some have referred to as problem solving. For example, technology educators Savage and Sterry (1990), generalizing from the work of several scholars, identified six steps to the problem-solving process:

- Defining the problem: Analyzing, gathering information, and establishing limitations that will isolate and identify the need or opportunity.
- Developing alternative solutions: Using principles, ideation, and brainstorming to develop alternate ways to meet the opportunity or solve the problem.
- Selecting a solution: Selecting the most plausible solution by identifying, modifying, and/or combining ideas from the group of possible solutions.
- Implementing and evaluating the solution: Modeling, operating, and assessing the effectiveness of the selected solution.
- Redesigning the solution: Incorporating improvements into the design of the solution that address needs identified during the evaluation phase.
- Interpreting the solution: Synthesizing and communicating the characteristics and operating parameters of the solution. (p. 15)

By closely comparing Torrance’s (1966) definition of creativity with that of Savage and Sterry’s (1990) problem solving process, one can easily see similarities between the descriptions. Guilford (1976), a leading expert in the study of creativity, made a similar comparison between steps of the creative process offered by Wallas with those of the problem solving process proposed by the noted educational philosopher, John Dewey. In doing so, Guilford simply concluded that, “Problem-solving is creative; there is no other kind” (p. 98).

Hinton (1968) combined the creative process and problem solving process into what is now known as creative problem solving. He believed that creativity would be better understood if placed within a problem solving structure. Creative problem solving is a subset of problem- solving based on the assumption that not all problems require a creative solution. He surmised that when a problem is solved with a learned response, then no creativity has been expressed. However, when a simple problem is solved with an insightful response, then a small measure of creativity has been expressed, when a complex problem is solved with a novel solution, then genuine creativity has occurred.

Genuine creativity is the result of the creative process that manifests itself into a creative product. Understanding the creative process as well as the creative person may play an important role in realizing the true nature of the creative product. Though researchers have not reached a consensus as to what attributes make up the creative product (Besemer & Treffingger, 1981; Joram, Woodruff, Bryson, & Lindsay, 1992; Stein, 1974), identifying and evaluating the creative product has been a concern of some researchers. Notable, is the work of Moss (1966) and Duenk (1966).

Evaluating the Creative Product in Industrial Arts/Technology Education

Moss (1966) and Duenk (1966) have arguably conducted the most extensive research establishing criteria for evaluating creative products within industrial arts/technology education. Moss (1966), in examining the criterion problem, concluded that unusualness (originality) and usefulness were the defining characteristics of the creative product produced by industrial arts students. A description of his model is presented below:

1. Unusualness: To be creative a product must possess some degree of unusualness [or originality]. The quality of unusualness may, theoretically, be measured in terms of probability of occurrence; the less the probability of its occurrence, the more unusual the product (Moss, 1966, p. 7).
2. Usefulness: While some degree of unusualness is a necessary requirement for creative products, it is not a sufficient condition. To be creative, an industrial arts student's product must also satisfy the minimal principle requirements of the problem situation; to some degree it must "work" or be potentially "workable." Completely ineffective, irrelevant solutions to teacher-imposed or student-initiated problems are not creative (Moss, 1966, p. 7).
3. Combining Unusualness and Usefulness: When a product possesses some degree of both unusualness and usefulness, it is creative. But, because these two criterion qualities are considered variables, the degree of creativity among products will also vary. The extent of each product's departure from the typical and its value as a problem solution will, in combination, determine the degree of creativity of each product. Giving the two qualities equal weight, as the unusualness and/or usefulness of a product increases so does its rated creativity; similarly, as the product approaches the conventional and/or uselessness its rated creativity decreases (Moss, 1966, p. 8).

In establishing the construct validity of his theoretical model, Moss (1966) submitted his work for review to 57 industrial arts educators, two measurement specialists, and six educational psychologists. Results of the review found the proposed model was compatible with existing theory and practice of both creativity and industrial arts. No one disagreed with the major premise of using unusualness and usefulness as defining characteristics for evaluating the creative products of industrial arts students.

To date, little additional research has been conducted to establish criteria for evaluating the creative products of industrial arts and/or technology education students. If technology is best known by its creative products, then technology educators are obligated to identify characteristics that make a product more or less creative. Furthermore, educators must find ways to objectively measure these attributes and then teach students in a manner that enhances the creativity of their products. A possible approach to enhancing product creativity is by incorporating computer simulation technology into the classroom. However, no research has been done in this area to measure the true effect of computer simulation on product creativity. For that reason, other studies addressing computer use in general and product creativity will be explored.

Studies Related to Computers and the Creative Product

A study conducted by Joram, Woodruff, Bryson, & Lindsay (1992) found that average students produced their most creative work using word processors as compared to students using pencil and paper. The researchers hypothesized that word-processing would hinder product creativity due to constant evaluation and editing of their work. To test the hypotheses, average and above average eighth grade writers were randomly assigned to one of two groups. The first group was asked to compose using word processors while the second group was asked to compose using pencil and paper. After collecting the compositions, both the word-processed and handwritten texts were typed so that they would be in the same format for the evaluators. Based on the results, the researchers concluded that word-processing enhances the creative abilities of average writers. The researchers attributed this to the prospect that word-processing may allow the average writer to generate a number of ideas, knowing that only a few of them will be usable and the rest can be easily erased. However, the researchers also found that word-processing had a negative effect on the creativity of above average writers. These mixed results suggest that the use of word-processing may not be appropriate for all students relative to creativity.

Similar to word processing, computer graphic programs may also help students improve the creativeness of their products. In a study conducted by Howe (1992), two advanced undergraduate classes in graphic design were assigned to one of two treatments. The first treatment group was instructed to use a computer graphic program to complete a design project whereas the other group was asked to use conventional graphic design equipment to design their product. Upon completion of the assignment, both groups' projects were collected and photocopied so that they would be in the same format before being evaluated. Based on the results, the researcher concluded that students using computer graphics technology surpassed the conventional method in product creativity. The researchers attributed this to the prospect that computer graphics programs may enable graphic designers to generate an abundance of ideas, then capture the most creative ones and incorporate them into their designs. However, due to a lack of random assignment, results of the study should be generalized with caution.

Like word processing and computer graphics, simulation technology is a type of computer application that allows users to freely manipulate and edit virtual objects. Thus it was surmised that computer simulation may enhance creativity. This notion led to the development of the study reported herein.

Purpose of the Study

This study compared the effect of a computer simulation activity versus a traditional hands-on activity on students' product creativity. A creative product was defined as one that possesses some measure of both unusualness (originality) and usefulness. The following hypothesis and sub-hypotheses were examined.

Major Research Hypothesis

There is no difference in product *creativity* between the computer simulation and traditional hands-on groups.

Research Sub-Hypotheses

1. There is no difference in product *originality* between the computer simulation and traditional hands-on groups.
2. There is no difference in product *usefulness* between the computer simulation and traditional hands-on groups.

Method

Subjects

The subjects selected for this study were seventh-grade technology education students from three different middle schools located in Northern Virginia, a middle-to-upper income suburb outside of Washington, D.C. The school system's middle school technology education programs provide learning situations that allow the students to explore technology through problem solving activities. The three participating schools were chosen because of the teachers' willingness to participate in the study.

Materials

Kits of *Classic Lego Bricks* ™ were used with the hands-on group. The demonstration version of *Gryphon Bricks* ™ (Gryphon Software Corporation, 1996) was used with the simulation group. This software allows students to assemble and disassemble computer generated Lego-type bricks in a virtual environment on the screen of the computer. Subjects in the computer simulation group were each assigned to a Macintosh computer on which the *Gryphon Bricks* software was installed. Each subject in the hands-on treatment group was given a container of Lego bricks identical to those available virtually in the Gryphon software.

Test Instrument

Products were evaluated based on a theoretical model proposed by Moss (1966). Moss used the combination of *unusualness* (or originality) and *usefulness* as criteria for determining product creativity. However, Moss' actual instrument was not used in this study due to low inter-rater reliability. Instead, a portion of the *Creative Product Semantic Scale* or *CPSS* (Besemer & O'Quin, 1989) was used to determine product creativity. Sub-scales "Original" and "Useful" from the *CPSS* were chosen to be consistent with Moss' theoretical model.

The *CPSS* has proven to be a reliable instrument in evaluating a variety of creative products based on objective, analytical measures of creativity (Besemer & O'Quin, 1986, 1987, 1989, 1993). This was accomplished by the use of a bipolar, semantic differential scale. In general, semantic differential scales are good for measuring mental concepts or images (Alreck, 1995). Because creativity is a mental concept, the semantic differential naturally lends itself to measuring the creative product. Furthermore, the *CPSS* is flexible enough to allow researchers to pick various sub-scales based on the theoretical construct being investigated, like the use of the Original and Useful subscales in this study. In support of this, Besemer and O'Quin (1986) stated, "... the sub-scale structure of the total scale lends itself to administration of relevant portions of the instrument rather than the whole" (p. 125).

The CPSS was used in a study conducted by Howe (1992). His reliability analysis, based on Cronbach's alpha coefficient, yielded good to high reliability across all sub-scales of the *CPSS*. Important to this study were the high reliability results for sub-scales Original (.93) and Useful (.92). These high reliability coefficients are consistent with earlier studies conducted by Besemer and O'Quin (1986, 1987, 1989).

The Pilot Study

A pilot study was conducted in which a seventh-grade technology education class from a Southwest Virginia middle school was selected. The pilot study consisted of 16 subjects who were randomly assigned to either a hands-on treatment group or a simulation treatment group. As a result of the pilot study, the time allocated for the students to assemble their creative products from 30 minutes to 25 minutes since most of them had finished within the shorter time. Precedence for limiting the time needed to complete a creative task was found in Torrance's (1966) work in which 30 minutes was the time limit for a variety of approaches to measuring creativity.

Procedure

One class from each of the three participating schools was selected for the study. Fifty-eight subjects participated, 21 females and 37 males, with an average age of 12.4 years. Subjects were given identification numbers, then randomly assigned to either the hands-on or the computer simulation treatment group. The random assignment helped ensure the equivalence of groups and controlled for extraneous variables such as students' prior experience with open-ended problem solving activities, use of Lego blocks and/or computer simulation programs, and other extraneous variables that may have confounded the results. The independent variable in this study was the instructional activity and the dependent variable was the subjects' creative product scores as determined by the combination of the *original* and *useful* sub-scales from the *CPSS* (Besemer & O'Quin, 1989).

Subjects in both the hands on and the simulation groups were asked to construct a "creature" that they believed would be found on a Lego planet. The "creature" scenario was chosen because it was an open-ended problem and possessed the greatest potential for imaginative student expression. The only difference in treatment between the two groups was that the hands-on group used real Lego bricks in constructing their products whereas the simulation treatment group used a computer simulator. Treatments were administered simultaneously and overall treatment time was the same for both groups. The hands-on treatment group met in its regular classroom whereas the simulation treatment group met in a computer lab. The classroom teacher at each school proctored the hands-on treatment group and the researcher proctored the simulation treatment group.

The subjects in the hands-on treatment group were given five-minutes to sort their bricks by color while subjects in the simulation treatment group watched a five-minute instructional video explaining how to use the simulation software. By having the students sort their bricks for five minutes, the overall treatment time was the same for both groups, thus eliminating a variable that may otherwise influence the results. Then, the subjects in both groups were given the following scenario:

> Pretend you are a toy designer working for the Lego Company. Your job is to create a "creature" using Lego bricks that will be used in a toy set called Lego Planet. What types of creatures might be found on a Lego planet? Use your creativity and make a creature that is *original* in appearance yet *useful* to the toy manufacturer.
> One more thing, the creature you construct must be able to fit within a five-inch cubed box, that means you must stay within the limits of your green base plate and make your creature no higher than 13 bricks.
> You will have 25 minutes to complete this activity. If you finish early, spend more time thinking about how you can make your creature more creative. You must remain in your seat the whole time. If there are no questions, you may begin.

When the time was up, the subjects were asked to stop working. The hands-on treatment group's products were labeled, collected, and then reproduced in the computer simulation software by the researcher. This was done so that the raters could not distinguish from which treatment group the products were created. Finally, the images of the products from both groups were printed using a color printer.

Product Evaluation

To evaluate the students' solutions, two raters were recruited: a middle school art teacher and a middle school science teacher. The teachers were chosen because of their willingness to participate in the study and had a combined total of 36 years of teaching experience. To help establish inter-rater reliability, a rater training session was conducted during the pilot study. The same teacher-raters used in the pilot study were used in the final study. The training session provided the teacher-raters with instructions on how to use the rating instrument and allowed them to practice rating sample products. During the session, disagreements on product ratings were discussed and rules were developed by the raters to increase consistency. The pilot study confirmed that there was good inter-rater reliability across all the scales and and thus the experimental procedures proceeded as designed. No significant difference in creativity, originality, or usefulness was found between the two treatment groups during the pilot study.

For the actual study, the teacher-raters were each given the printed images of the products from each of the 58 subjects and were instructed to independently rate them using the Original and Useful sub-scales of the CPSS (Besemer & O'Quin, 1989). Three weeks were allowed for the rating process.

Findings

Once the ratings from the two raters had been obtained, an inter-rater reliability analysis, based on Cronbach's alpha coefficient, was conducted. Analysis yielded moderate to good inter-rater reliability (.74 to .88) across all the scales. The stated hypotheses were then tested using one-way analysis of variance (ANOVA).

- No difference in product *Creativity* scores was found between the computer simulation group (M = 41.7, SD = 7.67) and the hands-on group (M = 42.0, SD = 5.58). Therefore the null hypothesis was not rejected, F (5,52) = 0.54, p = 0.75.
- No difference in product *Originality* scores was found between the computer simulation group (M = 20.59, SD = 4.44) and the hands-on group (M = 21.10, SD = 3.10). Thus, the null hypothesis was not rejected, F (5,52) = 1.07, p = 0.39.
- No difference in product *Usefulness* scores between the computer simulation group (M = 21.15, SD = 4.17) and the traditional hands-on group (M = 20.90, SD = 3.20). Once again, the researcher failed to reject the null hypothesis, F (5,52) = 0.49, p = 0.78].

Conclusion

Though there are only a few empirical studies to support their claims, some researchers believe that computers in general may improve student product creativity by allowing students to generate an abundance of ideas, capture the most creative ones, and incorporate them into their product (Howe, 1992; Joram, Woodruff, Bryson, & Lindsay, 1992). Similarly, some researchers speculate that the use of computer simulations may enhance product creativity as well (Betz, 1996; Gokhale, 1996; Harkow, 1996). However, based on the results of this study, the use of computer simulation to enhance product creativity was not supported. The creativity, usefulness, or originality of the resulting products appears to be the same whether students use a computer simulation of Lego blocks or whether they manipulated the actual blocks.

Because the simulation activity in this study was nearly identical to the hands-on task, one might conclude that product creativity may be more reliant upon the individual's creative cognitive ability rather than the tools or means by which the product was created. This would stand to reason based on Besemer and O'Quin's (1993) belief that the creative product is unique in that it combines both the creative person and process into a tangible object representing the "true" measure of a person's creative ability. With this in mind, when studying a computer simulation's effect on student product creativity, researchers may want to focus more attention on the creative person's traits and the cognitive process used to create the product rather than focusing on the tool or means by which the product was created. This approach to understanding student product creativity may lend itself more to qualitative rather than quantitative research.

If quantitative research is to continue in this area of study, researchers may wish to consider using a different theoretical model and instrument for measuring the creative product. For example, if replicating this experiment, rather than using only the two sub-scales of the Creative Product Semantic Scale (Bessemer & O'Quin, 1989), the complete instrument might be used, yielding additional dimensions of creativity. Additional research regarding the various types of simulation programs is needed, along with the different effects they might have on student creativity in designing products. The use of computer simulations in technology education programs appears to be increasing with little research to support their effectiveness or viable use.

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Teacher Knowledge and Understanding of Design and Technology for Children in the 3-11 Age Group: A Study Focusing on Aspects of Structures.

Eric Parkinson

Introduction

Teacher background knowledge and understanding has probably been an issue for providers of initial as well as in-service teacher education for as long as teachers have been formally prepared for their profession (Bennett, Summers, & Askew, 1994; Reynolds, 1989). In the UK a wealth of training documentation concerning background knowledge for teachers underpins this concern (Department for Education and Employment, 1998). The issue of teacher background knowledge in curriculum areas such as science and technology is an intense one. Matters such as teacher confidence and perceptions of a relevant knowledge base (Holroyd & Harlen 1996; Kruger, Palacio, & Summers, 1990) and the sheer pace of change in our technological and scientific environment, serve to challenge all existing and intending teachers (Rannikmäe, 1998).

This article is concerned with issues surrounding the depth and level of detail of knowledge that teachers of children in the age range of three to eleven years may need in order to teach certain aspects of design and technology with confidence and accuracy. The study is focused on aspects concerning student teachers' understanding of structures and associated scientific ideas on force. The article thus attempts to determine to what extent those who aspire to become teachers are aware of the role of certain scientific concepts in underpinning aspects of Design and Technology activity in English and Welsh schools. The article then raises questions about the implications arising for future professional and curriculum development.

The place of structures in the curriculum: Professional concerns

Design and technology can be seen as having a considerable body of knowledge with which skills interact and from which product outcomes may duly arise. Within the National Curriculum for England and Wales (Qualifications and Curriculum Authority and Department for Education and Employment, 1999), this body of knowledge and understanding of materials and components can be classified broadly within areas such as the working characteristics of materials and combinations of materials; use of mechanism including control, and switching with electric circuits.

These areas embrace an ocean of conceptual matters and real-life experience

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and are founded on the inter-relationships between the great scientific abstractions of matter, energy and force. The knowledge-based dimension of this article, which is focused on the understanding of structures, thus embraces the conceptual domains of force and matter.

Structures are necessarily encountered in many aspects of children's activity in designing and making. Activities involving the arrangement of materials so they retain their shape when subjected to forces will have a structural dimension. This applies as much to modeling a house in card or paper as it does to the baking of bread or the building of a car or tower with a construction kit: all these products retain their shape despite the influence of say, gravitational or frictional forces. The publication of a subject-specific Design and Technology guidance scheme of work by the UK government agency, the Qualifications and Curriculum Authority of the Department for Education and Employment. (QCA/ DfEE) underpins the relevance of this broad influence of structures on designing and making activity. Within this scheme, nine out of the range of 24 classroom planning units feature some aspect of structures as the main or shared focal point. It is worth noting however, that the QCA/ DfEE scheme of work was founded upon a pre-1999 (Department for Education, 1995) version of the national curriculum for England and Wales and does not reflect the revised, relatively low density level of knowledge and understanding now required of children aged 3-11 engaged in design and technology in English and Welsh schools (DfEE/QCA, 1999).

For comparison from an American perspective, a set of Standards now define and detail content for the study of technology to significant depth. Areas specific to the understanding of structures (for children in Grades 3-5) can be found under Core Concepts, Standard 2, where it is noted that "The properties of a specific material determine whether it is suitable for a given application" (ITEA, 2000, p. 35), and in Standard 20, (children in Grades K-2) Construction Technologies, where "The type of structure determines how the parts are put together" (ITEA, 2000, p. 192).

The QCA/DfEE guidance materials have been widely adopted by schools for children in the age range 3-11 in England and Wales. It is this widespread adoption of a government-approved scheme of work that would appear to bring with it a considerable classroom commitment to the teaching of structures.

Concern for teacher understanding in the area of structures has become evident with the publication of formal teacher education and self-study materials by higher education and UK government agencies (Kruger, Palacio, & Summers, 1991). These materials have been intended for use by teachers in schools, often using classroom ideas from children as links to the misunderstanding of concepts relating to forces held by adults, and thus of course, teachers. A self-study guide on Forces (National Curriculum Council, 1992) has within it a dedicated section on structures to assist teacher understanding. This resource is prefaced by a carefully worded caveat to the effect that the purpose of the material is to extend teacher knowledge and understanding and that it is not suitable for direct use in the classroom. Clearly, some degree of background knowledge beyond the working level of children is seen as desirable.

Teacher understanding specific to design and technology has been highlighted by the UK Teacher Training Agency (1998) with the publication of self-assessment texts intended to provide diagnostic feedback for serving teachers.

Recent changes in the requirements for the qualification of teachers in England and Wales have further underpinned this subject-specific deepening of teacher knowledge. All student teachers in England and Wales now have to comply with certain specified Standards regarding background knowledge in subject areas if they are to gain qualified teacher status. It is interesting to note that nationally defined curriculum specifications for children's learning have been reduced and yet the reverse is true for teachers. The government-specified standards in science require that trainees for school teaching of ages 3-11 should "...identify how the different areas of science relate to each other (unifying principles and concepts), so that they can make conceptual links across the subject, present pupils with a coherent perspective of the subject matter taught, and ensure progression in pupil's learning" (DfEE, 1998, p. 77). This is a significant demand on student teachers. Clearly it is insufficient for them to simply possess knowledge of say, forces or energy. Instead they should develop an understanding of the *interaction* of these underlying principles. This is a conceptually challenging requirement.

Work embracing ideas on structures can be seen as having dual purposes in the assembling of knowledge and understanding. It may serve to combine knowledge and experience of the properties of materials with an understanding of forces acting on the materials.

At a classroom level, when children are engaged in design-and-make activities, such as modeling buildings in card or paper, they are using a sheet material that can be shaped so that it is able to offer resistance to certain forces. As a consequence, the card can maintain its shape for presentational and structural purposes. The act of putting a crease or bend in a piece of sheet material is significant and the rationale behind this action may be based on the notion that "bends make certain things stronger." In the light of ideas such as this, questioning and observation of actions of student teachers in design and technology workshops has provided some useful evidence. It has shown ways in which thinking and past experience have played a part in shaping responses and serves to indicate levels of conceptual grasp. In particular, some previously formed ideas that student teachers carry to new learning situations can exert significant influence.

Aspects of Misconceptions: A Literature Review

A considerable research arena has been built up around the issue of what, in literature stemming from science education, cognitive science, and developmental psychology, may be termed "misconceptions". These have been succinctly described as situations arising from the ways that "children and adults construct their own ideas about natural phenomena that are often different from scientists' ideas" (Suzuki, 1998, p. 130).

The term "misconception" is but one of many descriptors for this phenomenon. Other terms include "preconceptions" (Ausubel, 1968) and "children's ideas" (Driver, Guesne, & Tiberghien, 1985; Osborne & Freyberg, 1985). Generally these descriptors can be seen within the scope of a theory of knowledge and learning recognized by the genetic epistemologist as one of continuous construction since "in each act of understanding, some degree of invention is involved; in development, the passage from one stage to the next is always characterized by the formation of new structures which did not exist before, either in the external world or in the subject's mind" (Piaget, 1970, p. 77).

The philosophical underpinning of the theory of continuous construction, or constructivism, contrasts sharply with other perspectives. Among these can be identified the notion of empiricism, in which discoveries, although new to the subjects making them, are already perceived to have existed in reality and did not result in the construction of new realities. Another view is that of the nativist or a priorist. This asserts the predetermination of forms of knowledge inside the subject.

Misconceptions can be seen to arise as part of the process of continuous construction. They represent mental models, constructed by individuals who have used whatever evidence has been at hand, that are at odds with the views held by the majority of members of a community of knowledge.

A significant body of research has been conducted on the basis of investigating children's misconceptions. However it is reasonable to assume that misconceptions reside in adults, too, and that inappropriate ideas left unchallenged in children will persist into adulthood.

A perception within the constructivist view of education is that appropriate elicitation of ideas may expose misconceptions. Subsequent learning experiences may provide settings to challenge misconceived ideas and so promote conceptual shift towards that held by a majority of participants in a community of knowledge, such as scientists (Bentley & Watts, 1994; Ollerenshaw & Ritchie, 1993). It could be said, for example, that the more "scientific" an individual becomes may be due to the enhanced opportunities they have had to gain and analyze evidence and set this against the ideas they already hold. This cannot happen in isolation. Opportunities to discuss ideas and effectively form localized communities of knowledge through small-group discussions would appear to be part of a "sense-making" pathway to enhanced understanding (Shapiro, 1994, p. 182).

The notion of constructivism can be taken further into a broad philosophical arena with the assertion that, "Radical constructivism, thus, is radical because it breaks with convention and develops a theory of knowledge in which knowledge does not reflect an "objective" ontological reality, but exclusively an ordering and organization of a world constituted by our experience" (von Glasersfeld, 1987, p. 199). Such construction of the individual's subjective reality possesses not only elements assembled through personal actions, but also the influence of prevailing social and environmental conditions. A logical, and perhaps disturbing endpoint of this line of thought can be determined. If social and radical constructivism deny the existence of an objectivist, ontological reality, then this metaphysical and epistemological denial "effectively opposes the basis of knowledge for science and social studies education as well as the knowledge which helps to structure the organization of schooling itself" (Fleury, 1998, p. 160).

The notion of strength and how and where forces may act are central to student understanding of structures. Student teachers will carry their own ideas about these concepts and some of them will be misconceived. One of the principal misconceptions revolves around the notion of "reaction forces." Learners do not readily appear to recognize that forces act in pairs and that as a consequence of a force acting upon a structure, the structure will react in opposition to the applied force. This can be seen as a fundamental plank in terms of the pathway to understanding since "Only when more than one force is recognized can thinking about equilibrium start" (Simon, Black, Brown, & Blondel, p. 277).

Minstrell (1982) in his study of high school physics students demonstrated that only half of a classroom sample suggested that a table might "push back" on an overlying book. From the Minstrell evidence it seems that even young adults in the specialized learning environment of a physics class will cling to previous ideas. Within the development of student teacher's expanding body of knowledge it is possible, then, for a range of misconceptions to persist into and beyond their training environments and thus indeed into the classroom. Research evidence collected from children in the 7-11 age range for the SPACE research reports (Russell, McGuigan, & Hughes, 1998) similarly substantiates the widely held misconception relating to reaction forces.

On leaving training, to what extent will misconceptions significant to the future teaching environment be still embedded in the mind of the teacher?

Problem solving as the context for the Study

The role of problem-solving has early links with the evolution of "technology"—later resolved from information technology to become Design and Technology (Department of Education and Science/Welsh Office, 1990) in the English and Welsh curriculum. Various key texts have had a profound influence on shaping the minds of young designers, their teachers, and curriculum developers alike. Notable among these is Johnsey's (1986) model of problem-solving in school science with its fundamental contextual links between technology and science.

For the purposes of this study, a problem-solving setting was utilized. Problem-solving as a means of learning has a host of benefits including task ownership, cross-curricular activity, and communication enhancement (Watts, 1991). All of these performance traits contributed to the conduct of this study. A group-based social setting for problem-solving was employed which had numerous benefits in terms of role-finding and the sharing of ideas (Lave & Wenger, 1991; Rogoff, 1995). Furthermore, within these social settings, language flowed freely and informal tutor eavesdropping, as well as more direct questioning of groups, revealed much about the how the quality of thought, prior experience, and on-task conceptual re-shaping had impacted the problem-solving situation.

Study Participants

The subjects for this study were drawn from a teacher education background and were engaged in the first year of a Bachelor of Arts Qualified Teacher Status (BA QTS) degree course at an English university college. The BA QTS degree is a three- year program specific to the training of teachers who will teach in the 3-11 grade levels of education. The subjects were drawn from two student cohorts taking design and technology short courses. These 20 hour courses are taken by all students in the first year of the BA QTS and are part of a first year introduction that stresses curriculum breadth.

The subjects (n=40) were predominantly female (n = 37), reflecting the general recruitment pattern into the BA QTS. Just over half of the sample (n = 22) were between the ages of 18 and 21 years. Those over the age of 21 are classified as "mature" students in English student statistical data.

The nature of the problem framed for student teachers

The problem was focused on an apparently simple bridge-building task, using limited materials. The use of limited materials had a direct effect in terms of guiding participants towards a variety of structural solutions. The problem was based upon an idea from a seminal work produced by the Berkshire Local Education Authority featuring child-centered designing-and-making, problem-solving situations sketched out for direct use in classrooms.

The focal point activity offered to students in this study was actually an extension of one of the examples taken from this text. The problem, centered upon a popular children's folk tale entitled "The Three Billy Goats Gruff," is framed with these words:

> "The Troll was so angry at the three Billy Goats Gruff crossing the bridge and eating his green grass that he demolished the bridge. To stop the goats making a new bridge he removed all the wood from the river bank and has left some paper behind because he does not think the goats could make a paper bridge" (Berkshire Local Education Authority, 1986, p.37).

Conditions are then attached to this task for children. They are to model the bridge across a gap of 25 cm. They can use only 3 sheets of letter size paper (210 X 296 mm) and goats made of modeling clay of specified masses must be able to make the crossing.

For the purposes of this study the Billy Goat problem was utilized for work with student teachers. Changes in the structural specification were made in order to provide challenge at an adult level. Student teachers were thus required to work to an enhanced set of performance criteria attached to the following task: "Design and make a structure across a 40 cm gap so that it may be traversed by a (specified) simple vehicle. The structure must be capable of supporting a 50 g mass at its center, but not when the vehicle is crossing." Additional design criteria were specified to enhance the problem-solving setting such as: "The structure will enable you to give the simple vehicle one push on one side of the gap. It should then traverse the gap on its wheels so that it arrives on the other side still traveling on wheels" and " You may only use paper clips and A4 sheets of paper to build the structure."

Further conditions on construction techniques were specified such as "You may not use any other materials. You may not pierce the sides of the intervening gap to fix paper clips. You can cut the paper with scissors." Finally economic specifications were added such as "Paper clips cost £3 each. Paper costs £10 per sheet" and " The budget limit for the task is £100. You may experiment with unlimited supplies of paper and paper clips —the budget applies to the *finished* structure".

Further challenge to the problem-solving task was provided with an economic dimension. Although a budget had been set, clearly if bridges could be constructed which met the criteria and undercut the £100 limit then these could be seen as being economically advantageous. As an ongoing task, students who met the initial criteria refined their designs and considered other possibilities with lower cost implications.

Study Method

Students were encouraged to work in pairs. Observation and final-outcome product assessment provided the main basis for gathering the data. Informal eavesdropping on conversations and questioning was undertaken to provide supporting evidence to the main purpose of this study that concerned the production of artifacts. One of the key weaknesses in the method chosen was the moderating effect of students working in pairs: individual ideas inevitably were subject to negotiation, and there was a "cross-fertilization" effect of pairs of students seeing, reacting to, and incorporating the work of colleagues.

Data Collection

Data were collected as informal notes on conversations, systematic recording of student teacher definitions of the term "strong," and artifacts arising from the problem solving events themselves.

There were difficulties in terms of expressing the data concerning outcomes from the artifacts produced since they were not simply final designs, but a range of intermediate designs of which some were abandoned for totally new ideas and others progressively modified to become new forms of structure. For this reason, broad classes of designs are described in the following results, with appropriate notes on design transformations as they presented themselves.

Language data were collected through a survey. Subjects engaged in the bridge problem-solving activity were asked to record their definition of "strong." This process of data gathering was achieved on an individual basis with subjects recording their definitions on pieces of paper and not revealing these to colleagues.

Results and data analysis

Artifacts

Outcomes of the problem-solving activity considered from the perspective of artifacts can largely be categorized into three broad classifications. The first outcome was one in which a tubular structure had been devised through which the simple vehicle could travel. A variation on this theme was a pair or more of longitudinal tubes onto which paper decking was laid. Tube-based solutions were one of the most popular modes of problem-solving responses to the bridge scenario. Sometimes students made tubes with a triangular cross section rather than one that was circular.

The second outcome consisted of structures that had been assembled with multiple concertina-like (accordion-like) folds. There were two variations on this theme. With variant one, the concertina arrangement was disposed so that it was at right angles to the long axis of the bridge. These folds were often incorporated as a core to a "sandwich" with paper decking above and below. This first variant was inherently weak. Failure to achieve a solution with this first concertina variant led to a second concertina solution in which the folds were arranged longitudinally to the alignment of the bridge. Entry ramps provided vehicular access to the structure this being necessarily raised to accommodate the thickness of folds.

The third outcome, often arrived at by refinement and simplification of the other routes, was the simple folded U-shaped structure where vertical slab-like sides offered a means of simultaneously retaining the crossing vehicle and providing resistance to a variety of forces as the vehicle passed over. An entry ramp was not required. Of all the above constructions, the U-shaped variant was the simplest, strongest, and least often attempted. In design terms, it was instructive to watch the shift in thinking that directed students toward U-shaped solutions. The two other variants invariably had some form of decking laid upon concertina or tubular elements. This decking might be simply full-width pieces of paper (from which a crossing vehicle would tend to fall) or paper with edges folded upwards to retain the vehicle in the act of crossing the structure.

Some students experiment with this added vehicle-retaining deck piece. In some cases they discarded the underlying structure of concertina pieces or tubes and simply explored the U-shaped decking on its own as a replacement structural element. Refinement of the decking, such as providing taller sides and longer overlaps of sheets of paper, led to the discovery of a new structural element, the U-beam. The U-shaped solutions utilized the fewest resources and undercut the budget limit of £100 by a surprising degree. This low-cost approach to the problem offers an example of an "elegant solution" (Gustafson, Rowell, & Rose, 1999, p. 37) by virtue of simplicity and effectiveness.

Language

Analysis of data concerning student teacher definitions (n = 40) showed that of the key words used as qualifications to help define "strong," the word used most frequently was "weight" (n = 19). Far less popular were the terms "support" (n = 7) and "force" (n = 7). In some cases the terms "strong" as well as "support" were used together in definitions.

Trailing well behind these terms were key terms such as "durable," "power," and "energy" ($n < 3$). Considering that the problem called for the loading of 50 g masses onto the structures, it was no surprise that the subjects derived definitions based upon weight.

Discussion

Problem solving and design

The limits to the use of resources in this task delivered significant dividends in terms of developing student teacher designing and evaluation skills. Students were compelled to consider the ways in which the materials—paper clips and sheets of paper—could be rearranged to become "strong," that is, to resist deformation. Patterns of behavior in which rearrangements are considered, tested, and rejected are consistent with the "serial development of solutions" problem solving pattern identified by Welch (1999) and the complex interactions of technological activity in terms of interactive strands of building, modeling, idea-generation, and understanding (Welch, 1997).

Johnsey (1993) similarly recognizes this complexity of interactions in the designing and making process with his analysis of pupil behavior in primary settings. As an example of problem solving, the task has great merit for there is no "right" answer: if the bridges perform in accordance with the specification that was set, then the task is completed.

Student understanding of forces and the structural strength of materials

Student teachers questions about the construction techniques utilized in the problem-solving settings outlined in this study invariably focused on the term "strong" when describing and justifying arrangements of materials. As has been indicated earlier in this account, changing the shape of materials –perhaps by folding or bending—is seen as a way of making a "weak" material such as a sheet of paper into a "strong" one. There are a number of issues that arise here.

Issue one—what is meant by "strong"?

The first issue is that most students did not readily articulate a link between the terms "strong" and "force." From the survey evidence regarding definitions of "strong" it was clear that the influence of the context, especially the load-bearing setting of the problem presented, guided subjects towards weight-derived definitions. Strength was predominantly seen as a quality that enabled the potentially deforming influences of weight to be resisted, yet weight was not readily articulated as an expression of force.

Issue two—what is meant by "weak"?

The second issue concerns student notions of paper as a "weak" material. Students had a tendency to justify their structural arrangements in terms of giving strength to the "weak" paper by actions such as folding or bending. The presumption of weakness in paper is perhaps directly related to an inadequate linking of the concept of strength to ideas on force. If strength is related to force, and if force is simply expressed in terms of pushes and pulls, then a "strong" substance – or structurally devised arrangement of that substance - is one that can offer resistance to various forces. Moreover, the resistance to force can be recognized in the effects of pushes and pulls. Some "strong" substances, like the keystone of a stone arch, can offer very considerable resistance to pushing forces. Sheets of paper, however, offer little resistance to pushing forces applied at each end. Some "strong" substances can offer considerable resistance to pulling forces and sheets of paper can certainly do this. Of course, all these terms are relative. Sheets of paper offer considerably more resistance to pulling forces that they do pushing forces

Where were the misconceptions?

It would seem that the sample of students reviewed in this study carried elements of part-formed knowledge into their problem-solving setting. Informal discussions with these student teachers suggested that this part-formed knowledge had been carried over from previous experiences, often from when they were children. These experiences embraced situations such as working with paper (for example, to achieve strength by folding), and pre-existing ideas on the nature of bridges, based perhaps more on what they look like than what they do. From a design perspective, misconceived thinking may have been imported from ideas on form (the "look" of bridges) into presumptions regarding function. Nonetheless, these experiences became fused into the new learning situation to produce not only physical outcomes, such as the bridges themselves, but also a deeper experience which yielded structural solutions based on corrugations, pipes, and U-beams as means of resisting various forces. This was despite the fact that students did not seem to be sure which forces were operating and where or how they were acting.

In particular, students seemed to make an intuitive (and appropriate) response to a structural problem in the sense of providing as much as possible of the building material (for example folded paper) for forces to act upon. They devised ways of "spreading the load"—in other words, they applied stress reduction measures. This form of intuitive response can be likened to the notion of "understanding the situation" (Donaldson, 1978, p. 37) in which the learner makes sense of events as they perceive them, not necessarily being aware of, or understanding all the factors that may be present. The misconception that paper was not "strong" could be related perhaps to an incomplete understanding of the nature of force and its inter-relationships with materials, especially when these materials were shaped in various ways. It is worth noting, of course, that the notion of strength is contextually bound. It was possible for students to perceive pushing forces acting on the paper: it buckled. Less obvious, but central to the structural context of the bridge, was the effect of pulling forces that acted on the paper, yet offered no visible clues to this situation. The notion that forces could be acting as reaction pairs was largely absent. Students had incomplete ideas of the way that a structure, or indeed a material, may "push back" against a force in order to maintain established morphological integrity.

In a profile of the constructivist teacher operating in classrooms for children aged 3-11, it has been suggested that the teacher should have a prior awareness of the ideas that learners will bring to the learning situation and that they should "use pupils' ideas in the development of the lesson, as it happens" (Juca & Maskill, 1997, p. 13). In the light of this, the exposure of student teachers to their own misconceptions would seem most relevant. They need to appreciate that they may carry misconceptions in their own learning, as well as understand some of the most common misconceptions held by children. The study context outlined in this article is thus portrayed as an example of a way in which student thinking can be challenged and how classroom practices can be modeled in adult learning situations.

From a teaching perspective, the process of achieving effective conceptual shift is not straightforward. It has been suggested that this notion of conceptual change is complex and that "the altering or reorganization of existing schemata to account for new learning, appears to take place only under certain conditions. These conditions, as yet, are poorly understood when it does occur, conceptual change has been hypothesized to be the result of several interacting factors, epistemological, cognitive, and affective in nature" (Hynd, Alvermann, & Qian, 1997, p. 3).

Some specific strategies for enabling conceptual shift to occur have been assembled, particularly with reference to "anchoring examples" (Kruger, Palacio, & Summers, 1991, p. 125), that bridge understanding between intuitive beliefs and accepted scientific views. The broader nature of the learning landscape with respect to misconceptions in Design and Technology may prove to be a fertile setting for further investigation and development.

While trainee teachers working within the bridge-based project may have been immersed in an environment that involved scientific and technological ideas, they did not appear to formally acknowledge the linkages of their work to science. The relatively low incidence of the use of the term "force" in discussions is a key pointer in this respect. Instead, the term "strong" was employed and seemingly intuitive interpretations of the role of "strength" led to solutions, but little consideration given to what the term might actually mean.

This view of poor links to science is supported by a broadly similar study of construction with bridges, but undertaken with Year 9 pupils in Australia. Within this study it is noted that:

> Although some of the students interviewed from this classroom demonstrated surprisingly good understanding of some of the scientific principles associated with the bridge project, three of the five students did not think their scientific knowledge was useful during this project and one other student identified creativity as the only aspect of science that he used. One possible explanation for this lack of recognition of the science aspects of the technology project is that students saw science more as a content oriented subject rather than a skill or a process oriented subject (Venville, Wallace, Rennie, & Malone, 1999, p. 45).

If science is seen as “different,” then scientific ideas embedded in broader fields of experience may be seen to be different or irrelevant—or perhaps, may even fail to surface as ideas at all.

Conclusions

On the whole it would seem desirable that misconceptions are challenged and reconstructed in student teacher training sessions. The more active student teachers become in the construction of their own knowledge, the more able they may be to appreciate the breadth and significance of constructivist learning theory and how it may be applied to enhance the learning of the children they will teach. Additionally, the more that the knowledge of the student teacher is constructed along the lines of the scientific community, the less likely it is that these future teachers will foster the development of inappropriate conceptual frameworks in the minds of the children they will teach.

This article has exposed some of the issues in which science plays a part in informing technological outcomes. In light of this, perhaps closer ties between science and technology are desirable as part of a cross-curricular approach. Layton (1993) exemplified aspects of this relationship with his multi-layered images of science as a cathedral. For the technologist, this venerated building can house natural laws to which technological devices must comply; or it may act as a quarry in which to search out items that might be of use. At another level, Layton likens the cathedral to a company store, housing a body of accessible, organized products. From all of these settings, science may nourish technology and technology in turn may usefully provide the contexts within which scientific ideas may grow and develop.

In the past, notably through debate promoted by Black and Harrison (1985), there has been a tendency to identify differences between science and technology. This in turn has led towards the teaching of separate subjects at the expense of cross curricular work. This is especially true relative to how the national curriculum in England and Wales has been interpreted for the 3-11 age group.

However, it could be that a closer association between science and technology within the curriculum of England and Wales would pay considerable dividends. Johnsey (1999) has proposed an enhancement of such links, but it is largely in the hands of schools as to whether subject-driven content will be maintained at the expense of possible wider benefits across the curriculum. The recognition of the role of scientific and technological literacy (STL) as a medium for curriculum change is fundamental. Significant efforts to add STL to the global curriculum (Association for Science Education/ UNESCO, 1999) are underway, and the operationalization of this thrust is underpinned by a range of international agencies. STL is, however, a limited curriculum model coming from the science-with-technology stable. It is not a cross-curricular thoroughbred. Nonetheless, STL has the capability to add technological contexts from everyday life to science-based learning situations. From this starting point, learning in science may be seen to gain relevance and to have a part to play in developing problem-solving and decision-making among students. In terms of teaching and learning, then, STL may possess potential to provide added impetus to technology education.

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Learning Style and Laboratory Preference: A Study of Middle School Technology Education Teachers in Virginia

Philip A. Reed

Laboratory instruction has long been a cornerstone of technology education pedagogy. The French realized the potential for technical laboratory instruction within general education in 1865 (Bennett, 1926). By the 1880s, the United States also realized the benefits of the technical laboratory for general education (Anderson, 1926). Despite these early roots and the continued practice of utilizing laboratory instruction within technology education, there is little research to support this teaching method. McCrory (1987) noted that there were no studies on laboratories (excluding machine safety) or new technology education equipment during the period 1980-1986. Laboratory studies during the period 1987-1993 concentrated on curriculum and did not focus on new instructional methods and strategies (Zuga, 1994).

The adoption of modular technology education has only heightened the need for research on laboratory instructional methods. Since the middle of the 1980s, modular technology education has grown considerably. Brusic and LaPorte (2000) found that almost half of the technology education teachers they surveyed in Virginia taught in some type of modular lab. Despite such emerging research, opinions concerning the merit of modular technology education, especially commercially created packages, dominate the field of technology education. To address these opinions, this study investigated whether the preference for a conventional or modular laboratory is influenced by the learning style of the teacher.

Related Literature

Modular Laboratories

Modular technology education (MTE) labs have been widely implemented in secondary technology education programs during the last two decades. The Gestalt principle of summation, which states that the whole is more than the sum of its parts (Rothstein, 1990), along with the teaching machines of B. F. Skinner, appear to have influenced the creation of MTE. Other aspects of the "behavioral systems family" (Joyce, Weil, & Calhoun, 2000) appear to have influenced the development of MTE through such methods as programmed instruction, self-training, and learning from simulations.

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The “teaching machine” research of B. F. Skinner (1968) created a wealth of classroom investigation and curriculum development. This line of research soon became known as programmed instruction. Programmed instruction was characterized by small instructional steps, active student involvement, immediate confirmation or reinforcement, and self-pacing. T. Neville Postlethwait is credited for using programmed instruction to create “a small unit of subject matter which could be treated coherently as an individual topic and could be conveniently integrated into a study program” (Russell, 1974, p. 3). Postlethwait used audio and self-instructional carrels to create “micro-courses” that were centered on content objectives. Similar instructional methods were soon developed under titles such as “concept-o-pac,” “instruc-o-pac,” “unipak,” “learning activity package” (LAP) and “individualized learning package” (ILP) (Russell, 1974, p. 3).

In the early 1970's the term “module” emerged as a generic description for individualized learning packages (Bolvin, 1972). Russell's definition of a module could easily describe the packages currently being used by technology education:

> A module is an instructional package dealing with a single conceptual unit of subject matter. It is an attempt to individualize learning by enabling the student to master one unit of content before moving to another. The multi-media learning experiences are often presented in a self-instructional format (Russell, 1974, p. 3).

In technology education, Johnston (1986) used the work of Russell (1974) to compare the effectiveness of conventional and modular instruction in a high school manufacturing class. Four written modules were created and presented to one class while a second class was taught with conventional instruction. Johnston found that students who received conventional instruction achieved higher scores on a post-test than students who received modular instruction. Although Johnston's research appears to be the earliest work dealing with modular instruction in technology education, his findings are limited since the research only involved two classes at one high school.

When the American Industrial Arts Association (AIAA) changed its name to the International Technology Education Association (ITEA) at the 1985 San Diego conference, concerns over content and facilities resulted (Dean, 1997). After the conference, Max Lundquest and Mike Neden returned to Pittsburg, Kansas to create a middle school laboratory that would reflect their vision of the new technology education paradigm. According to Dean (1997), the current form of MTE was created at Pittsburg Middle School.

Many polemic papers have been written which discuss the advantages and disadvantages of MTE (e.g., Petrina, 1993; Gloeckner and Adamson, 1996; Pullias, 1997; Starkweather, 1997; Rogers, 1998a). Several studies support concerns involving student achievement in MTE. Rogers (1998b) studied seventh grade technology students in three Nebraska technology programs. The findings suggested that the achievement gain of students in a contemporary lab (up-to-date technology education lab with modern equipment) were significantly greater than students in a traditional lab (industrial arts shop) and those in a modular lab.

In another experimental study, Weymer (1999) used demographic variables, the Group Embedded Figures Test, and several other test scores to determine how 142 sixth-grade technology students performed in an engineering structures module. He determined that many of the field dependent students (scores $\leq$ 0.5 *SD* below the sample mean) and field intermediate students (scores between -0.5 *SD* and +0.5 *SD* of the sample mean) were lost in a modular lab. He felt that many of the students did not have the verbal skills necessary to follow the self-paced format of modular instruction. Weymer also concluded that a modular laboratory might not be appropriate for all types of learners.

Conventional Laboratories

William E. Warner wrote that society had changed after World War II from an industrial complex to an elaborate social environment that consisted of producers, consumers and managers of technology. This view is expressed in Warner's *A Curriculum to Reflect Technology* (1947). One of the notable suggestions by Warner was the use of a general area shop as opposed to the traditional unit shop. Warner's vision of the general area shop included tools and machines that could be used for a variety of materials and processes as opposed to the unit shops' focus on one material or process.

Delmar W. Olson's dissertation and subsequent publication, *Industrial Arts and Technology* (1963), expanded Warner's notion of using technology as the content base of industrial arts. *Industrial Arts and Technology* also contained many sample laboratory designs. When reviewing these designs, one can clearly see how Olson took the general area shop to a new level. Many of the designs are arranged in a modular format. It is important to note, however, that Olson did not intend these lab areas to be autonomous curriculum units. On the contrary, Olson envisioned flexibility in his labs with student's moving between stations and utilizing the tools and materials in an integrated manner. The influence of Olson's work upon industrial arts philosophy, curriculum, and laboratory development in the 1960's is apparent in such projects as The Maine Plan (Maine State Department of Education, 1965).

The American Council on Industrial Arts Teacher Education (ACIATE) has published several yearbooks that focus on technology education facilities. The eighth ACIATE yearbook published in 1959 detailed existing laboratories, equipment selection, architecture, and planning and evaluation procedures. This yearbook contained numerous photographs, reference lists and sample laboratory layouts (Nair, 1959). To reflect the unparalleled period of curriculum changes during the 1960's and as a reaction to the popularity of the eighth Yearbook, the ACIATE published a second yearbook on facilities in 1975.

The twenty-fourth ACIATE yearbook included many of the features of the eighth yearbook but also contained facility information for many of the curriculum projects created in the 1960's. Specifically, the 1975 yearbook presented facility information for the following curriculum projects: American Industry Project, Georgia Plan, Industrial Arts Curriculum Project, Maryland

Plan, Occupational Versatility, and the Orchestrated Systems Approach. In addition, information was provided on transportable industrial arts laboratories and the emerging field of visual communications (Moon, 1975).

To reflect the name change from Industrial Arts to Technology Education and the paradigm shift of curriculum based on industry to curriculum based on technology, the ACIATE (renamed the Council on Technology Teacher Education [CTTE] in 1986) created a series of six yearbooks related to content, facilities, and instruction. The first two yearbooks in the series, 1986 and 1988, established the conceptual foundations for technology education (Israel, 1994).

The 1990-1994 CTTE Yearbooks were each based on one of the content organizers outlined in the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder and Hales, 1981). The four CTTE yearbooks dealing with communication, transportation, manufacturing, and construction each contain a chapter on facilities. Although these chapters focus more on content than on physical characteristics, their differences from earlier facilities yearbooks can be seen in several ways. First, there was considerable emphasis on studying the impacts of technology. Second, laboratory areas for research and experimentation are suggested. Both of these concepts, however, are not new to technology education (see Olson, 1963; Maley, 1970; Earl, 1960).

In summary of this section, many of the conventional facility plans reviewed are strikingly similar, regardless of their age. Although the title *Industrial Arts* was changed to *Technology Education* in 1985 by the International Technology Education Association, industrial arts courses such as woodworking still dominated secondary instruction in 1991 (Dugger, French, Peckham, Starkweather, 1992). Even as late as 1995, secondary principals in North Carolina still believed woodworking and metalworking should be a part of technology education (Jewell, 1995). More recently, Sanders (2001) found that curriculum, philosophy, and course titles within secondary technology education in the United States are still in a state of flux.

Teaching Styles

Contemporary literature on teaching and learning styles supports the notion that teachers should understand their own teaching and learning styles in order to be more flexible (Claxton and Ralston, 1978; Dunn and Dunn, 1979; Cornett, 1983; Marshall, 1991). Historically there have been three dominant methods of analyzing teaching behavior. In the beginning of the nineteenth century, studies focused on student perceptions of their instructor. The second phase of teaching style research began in the 1930's and focused on observing teachers in an attempt to identify similar characteristics. The third method of analyzing teaching behavior began in the 1960's. These studies identified effective teaching behaviors and then created instruments to examine other teachers. The current research on teaching styles is heavily grounded in this third method (Silvernail, 1986).

Despite significant research by Bennett (1976), Flanders (1970), and others, teaching style research contains several inherent problems. First, the research is time-intensive. Second, validity and reliability are serious issues due to the qualitative methods used by many teaching style studies. Third, the theme that teachers should utilize a variety of teaching styles is echoed throughout the literature (Bennett, 1976; the National Association of Secondary School Principals, 1979; Guild and Garger, 1985; McCarthy, 1987; Mosston and Ashworth, 1990).

Learning Styles

Jung's (1923) *Psychological Types* is cited as the beginning of modern learning style theory (Lawrence, 1982; Guild and Garger, 1985). Jung established four learning styles that are defined by the way individuals perceive new information and how they judge new knowledge once in consciousness. Jung, however, never developed his theory of psychological type for practical use through instruments or models. The use of model formulation in learning style theory is attributed to organizational psychologist David A. Kolb (McCarthy, 1987).

McCarthy (1979, 1987) reviewed the work of twelve learning style researchers from various disciplines and found that almost all of the theories defined two ways of perceiving information and two ways of processing information. Next, McCarthy synthesized the strands from each theory and placed them into Kolb's (1984) model. McCarthy was thereby able to develop composites of four different types of learners to create the 4MAT System of learning and instruction. Finally, work from Carl Jung, David Kolb, Kurt Lewin, Isabel Myers, Joseph Bogen, and Bernice McCarthy were used to create the Learning Type Measure (LTM) instrument which could be used with the 4MAT System of learning and instruction. Part A of the LTM is used to assess the four learning styles identified by the 4MAT System: Analytic, Common Sense, Dynamic, and Imaginative. Part B of the LTM identifies how individuals process new learning. *Watchers* tend to engage in subjective introspection before acting on information or experience. People who prefer *Doing* act first and then reflect on their actions.

Many instruments designed to measure learning style have encountered criticism from the broader psychological community for their lack of validity and reliability (Sadler-Smith, 1997; Stahl, 1999). The 4MAT System model and LTM, however, were selected to describe the learning styles of technology education teachers in Virginia because of their established validity and reliability (McCarthy, 1987; Excel, 1998).

Purpose

This study was designed to describe the learning styles of modular and conventional laboratory teachers in the Commonwealth of Virginia. Based on support in the literature that suggests a relationship between teaching and learning styles, it was hypothesized that teacher preference for one type of laboratory over another (conventional or modular) may be an issue of learning style. This study was also designed to highlight the need for technology educators to understand their learning style and how it influences their teaching style. A third purpose was to determine whether technology teachers have different learning styles from secondary teachers in general.

Procedures

A random sample (n = 195) was drawn from the entire population (as identified by the Virginia Department of Education in 1998) of public middle school technology education teachers (N = 392). Randomly selected teachers were mailed a cover letter, demographic questionnaire, postage-paid return envelope, the Learning Type Measure (LTM) instrument (Excel, 1998), and one dollar for taking the time to complete and return the materials. The demographic questionnaire included questions on gender, the type of laboratory in which the majority of technology instruction took place (conventional or modular), the respondent's preferred laboratory (conventional or modular) for implementing Virginia's middle school curriculum, and the amount of respondent's teaching experience. The LTM is a paper and pencil instrument that is well grounded within learning style research. Based on the work of Carl Jung, David A. Kolb, Kurt Lewin, Isabel Myers, Joseph Bogen, and Bernice McCarthy, the LTM is a reflection of:

1. Situational adaptations of Jung's constructs of feeling, thinking, sensing, intuition, extroversion, and introversion,
2. Behaviors modeled after Kolb's constructs of concrete experiential, reflective, abstract, and active learners,
3. Representations of hemispherity drawn from Bogen, and
4. McCarthy's field work (Excel, 1998, p. 3).

Data collected were compared using contingency tables and Pearson's Chi-square analysis. The learning styles of modular laboratory teachers were compared to the learning styles of conventional laboratory teachers. The respondents' learning styles were also compared to the findings of 2,367 other secondary administrators and teachers who participated in 4MAT workshops between 1986-1987 (McCarthy, 1987).

Findings

Eighty-three (42.5%) of the teachers surveyed returned their instruments. Of these, sixty-five were usable for an overall response of 33.3%. Sixty-percent of respondents (n = 39) teach the majority of their classes in a modular lab while only forty-percent (n = 26) teach in a conventional laboratory. Conventional laboratory teachers had slightly more teaching experience (mean = 18.4) than modular laboratory teachers (mean = 16.7). Respondents were asked if the laboratory in which they currently taught technology education was their preferred laboratory for implementing Virginia's middle school curriculum. Table 1 illustrates the crosstabulation of laboratory environment and laboratory preference. Although this finding was not statistically significant, it does demonstrate that conventional laboratory teachers are not as satisfied with their current environment as modular laboratory teachers.

Eleven non-respondents (10%) were randomly drawn and contacted by telephone. The data were collected on gender, laboratory environment, laboratory preference, and teaching experience. Learning style could not be assessed over the telephone because of the length of the LTM. Analysis of variance found no significant difference between the selected non-respondents and respondents among the selected variables.

Table 1
Comparison of Respondents Preferred Laboratory to Current Laboratory

Current Laboratory Environment	Preferred Laboratory: Modular *n*	Modular %	Conventional *n*	Conventional %
Modular	33	84.6	6	15.4
Conventional	8	30.8	18	69.2

Due to low frequency counts in some of the learning style cells, several learning style categories were combined to maintain the validity of the Chi-square and contingency table analysis. It was felt that the pooling of categories would not have an adverse effect since the data were collected for descriptive purposes only. Since a large number of respondents were Common Sense learners, this category did not need to be pooled. The three remaining learning styles, Imaginative, Analytic, and Dynamic, were all pooled due to cell size. Table 2 illustrates the inverse relationship between the respondents of this study and McCarthy's (1987) national study of secondary teachers and administrators (n = 2,367). This relationship must be viewed cautiously however, since the number of administrators in McCarthy's (1987) sample could not be determined.

With regard to the first hypothesis, the learning styles of conventional laboratory and modular laboratory respondents did not differ significantly from the learning style proportions of all respondents, χ^2 (3, n = 65) = .301, p < 960. Table 3 illustrates that the observed frequencies of the laboratory environments and learning styles did not differ from expected values more than would be predicted by chance, Pearson χ^2 (1, n = 65) = .301, p < 583.

Table 2
Comparison of Learning Style Between Respondents and National Sample

Learning Style	Middle School Technology Teachers in Virginia	Rank	National Study of Secondary Teachers and Administrators (McCarthy, 1987)	Rank
Imaginative (Type I)	13.9%	2	23.0%	3
Analytic (Type II)	4.6%	4	31.1%	1
Common Sense (Type III)	69.2%	1	17.4%	4
Dynamic (Type IV)	12.3%	3	28.5%	2

To further investigate the first hypothesis, respondents' learning styles were cross-tabulated with their laboratory preference (Table 4). Chi-square analysis revealed that the frequencies for laboratory preference and learning style did not differ significantly from expected values, Pearson χ^2 (1, n = 65) = .046, p < 830.

Table 3
Distribution of Learning Style by Laboratory Environment

	Learning Styles			
	1,2,4[a]		3[b]	
Laboratory Environment	*n*	%	*n*	%
Modular	13	33.3	26	66.7
Conventional	7	26.9	19	73.1

[a] Imaginative, Analytic, and Dynamic Learning Styles
[b] Common Sense Learning Style

Crosstabulation of the learning styles of middle school technology teachers in Virginia by the national findings of McCarthy (1987) showed a significant difference, χ^2 (1, n = 65) = 126.5, p < 001. Table 5 illustrates that the observed frequencies of the technology teachers and the learning styles from the national sample do differ from expected values more than would be expected by chance, Pearson χ^2 (1, n = 65) = 5.885, p < 015.

Table 4
Distribution of Learning Style by Laboratory Preference

	Learning Styles			
Laboratory	1,2,4[a]		3[b]	
Preference	*n*	%	*n*	%
Modular	13	31.7	28	68.3
Conventional	7	29.2	17	70.8

[a] Imaginative, Analytic, and Dynamic Learning Styles
[b] Common Sense Learning Style

Table 5
Comparison of Learning Styles of Respondents to National Sample

Learning Styles	National Learning Styles Study[c]			
of Technology	1,2,4[a]		3[b]	
Teachers in VA	*n*	%	*n*	%
1,2,4[a]	20	100.0	0	0.0
3[b]	34	75.6	11	24.4

[a] Imaginative, Analytic, and Dynamic Learning Styles
[b] Common Sense Learning Style
[c] McCarthy (1987)

Part A of the LTM is used to assess the four learning styles identified by McCarthy (1987). A second section of the LTM measures how individuals process new learning. When new information is obtained, individuals have a predisposition to handle it one of two ways. *Watchers* prefer to engage in subjective introspection before acting on information or experience. People who prefer *Doing* act first and then reflect on their actions. Of the sixty-five respondents only two (3%) were balanced between *watching* and *doing*. Fifty-one percent of respondents (n = 33) preferred to *Watch* and make sense of new learning before acting. The remaining 46% (n = 30) of respondents *Do* when they process new information.

Discussion

The self-perceived learning styles of respondents to this study were significantly different when compared to McCarthy's (1987) findings for secondary teachers and administrators. This demonstrates the uniqueness of the technology teachers in this sample and supports past research concerning technology teachers. Namely, in a national study of ITEA members, Wicklein and Rojewski (1995) used the Keirsey-Bates Temperament Sorter to assess the temperament types of technology teachers. When compared to the general population, technology teachers demonstrated a higher preference for a Sensing-Judgement (SJ) temperament. Individuals with an SJ temperament tend to gather information directly through the five senses and prefer to live in a structured, orderly, and planned fashion.

Of the four learning styles defined by the Learning Type Measure instrument (Imaginative, Analytic, Common Sense, and Dynamic), over sixty-nine percent of the technology teachers in this sample were identified as Common Sense learners. Therefore, these teachers…

- are interested in productivity and competence.
- try to give students the skills they will need to be economically independent in life.
- believe curricula should be geared to this kind of focus.
- see knowledge as enabling students to be capable of making their own way.
- encourage practical applications.
- like technical things and hands-on activities.
- are exacting and seek quality and productivity.
- believe the best way is determined pragmatically.
- use measured rewards.
- tend to be inflexible and self-contained and lack team-work skills (Excel, 1998).

This finding suggests homogeneity among these middle school technology education teachers and supports research reported by Heikkinen, Pettigrew, and Zakrajsek (1985) concerning industrial arts/technology education. They showed that college education majors of different subject matter fields exhibited distinct learning styles. Students majoring in industrial arts demonstrated high preferences for working with things, direct experience, and detail.

An overwhelming majority (84.6%) of modular laboratory teachers in this study indicated that their current laboratory environment was their preferred method for implementing Virginia's middle school technology education curriculum. In a similar finding, Brusic and LaPorte (2000) reported that their sample of modular laboratory teachers thought modular labs allowed them to implement most (60% or more) of the Virginia curriculum, but not nearly all (80% or more) of it. There is clear support among modular laboratory teachers in Virginia that modular laboratories can be used to implement a majority of Virginia's middle school technology education curriculum.

The learning styles of respondents in conventional laboratories were not significantly different from the learning styles of respondents in modular laboratories. Though it seems logical that learning style might explain laboratory preference, this notion was not supported by this study. Perhaps the LTM was not sensitive enough to assess the learning style differences of this sample. Since both conventional and modular laboratory teachers were overwhelmingly Common Sense learners, there might be a range within this particular learning style that was not detected.

Rogers (1998a) suggested that many teacher education programs are not preparing technology teachers for the type of laboratory environment they will typically encounter upon graduation. Hopefully, teacher educators will assess the learning styles of pre-service teachers and help them understand the relationship between learning style and instructional variety. By understanding the concept of instructional variety, pre-service teachers will be prepared for a wide range of teaching environments.

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Book Review

Are We Thinking About Technology?

Pitt, J. C. (2000). *Thinking About Technology: Foundations of the Philosophy of Technology***.** Seven Bridges Press, New York. $22.75 (paperback), 138 pp. (ISBN 1-889119-12-1).

Reviewed by Robert C. Wicklein, Claude D. Hames, and Kenneth Rufo

As the title, *Thinking about Technology,* implies, Joseph Pitt encourages his reader to think about technology, albeit in nontraditional ways. He suggests rethinking and redefining several key concepts: the definition of technology, the epistemological basis for evaluating technology and science, and the relationships between technology and science. Pitt argues persuasively for debunking the myth of technology as the handmaiden of science and insists instead that we understand scientific change in the context of its technological infrastructure.

All experienced educators are aware of both the prevalence and the effects of flawed reasoning and flawed epistemology in the thinking of our students. Despite our best efforts to explain a concept fully, each student interprets and reinterprets and remembers (or does not) every fact and nexus of facts in a peculiarly personal way. Additionally, students form their personal knowledge within the context of social constructs. When the epistemology behind these social constructs is flawed we are left with, at best, benign misunderstanding, and at worst, catastrophic consequences. Examples include a flat earth, disease caused by “bad air” or too much blood, a geocentric universe, a space shuttle program with an unacceptably low chance of surviving liftoff, and, Pitt would argue, the belief in a technology with a life of its own, that can manipulate us against our will or even our awareness. Particularly interesting are Pitt’s responses to social critics’ claims that “technology is taking over our lives.”

In the preface, Pitt outlines his straightforward plan of presentation (p. xii - xiii). He develops a framework for examining issues about specific technologies. He compares concepts developed by philosophers of science with counterpart concepts relating to technology and shows that we might want to rethink how closely we link science with technology. Pitt then attacks assumptions about technology is not an autonomous “thing” that can take over our lives. He concludes the book with a discussion of how technological change differs froscientific change.

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Pitt begins his search for definition with a simple example most will remember from middle school, the distinction between “pure” and “applied” research. This distinction, he argues, leaves the impression that applied is somehow inferior to the pure, and by implication, that technology (applied) is somehow inferior to science (pure). Pitt then proceeds to examine the claims of how we know facts of science and shows that often we produce workable (and even excellent) technology using a scientific theory we later learn to be false (e.g., Galileo’s telescope worked for reasons he did not understand). Pitt reasons that the relationships between science and technology are much more complicated than the simple pure/applied distinctions would allow. In short, he sees technology and science as mutually symbiotic, with science being a (rather specialized) subset of technology instead of technology being “the handmaiden of science.”

Pitt’s definition of technology, “*Humanity at Work*,” is arguably more broad than those definitions which focus on tools or artifacts. He draws a distinction between tools *per se* and the use of those tools. Technology is the *use* of tools, Pitt insists, *not* the tools themselves. This definition at the least promises to clarify the problem of a common confusion known only too well to Technology Education professionals, “Oh, you’re the ones who teach computers?”

If we accept Pitt’s definition of science, that is, science in the modern sense (complete with hypotheses, controls, etc.), then, as he notes, technology is epistemologically prior to science (p. 24). Indeed, humans engineered, manufactured, and produced goods and structures for millennia before we developed and canonized the cardinal points of what a modern scientific experiment might look like. Pitt compares and contrasts the concepts of scientific knowledge vs. technological (engineering) knowledge, scientific explanation vs. technological explanation (with a particularly instructive example from the initial failure of the Hubble space telescope).

Pitt shows, with examples from Heidegger’s philosophical musings and Langdon Winner’s social criticism (from Winner’s book, *The Whale and the Reactor*), how ideology informs our epistemology of technology. If we approach technology with value-laden, polemical assumptions (in the case of Winner’s concerns), or with tautological jargon (Heidegger) “…we bypass the *epistemological* questions associated with inquiries into technology.” (p. 83). We imbue technology with a mysticism that resists empirical investigation and invites acceptance or rejection on the basis of ideological bias. Pitt claims that cognitive values are often overlooked when technology is seen only in ideological terms. He argues instead for an investigation of the tools and techniques (technology) based on the actions of the humans who use them. He even suggests that one of the reasons for the mysticism is to allow humans to escape the responsibility of their actions.

Arguably, one of Pitt’s most cogent contributions in this book may well be his efforts to refute the concept of autonomous technology and its alleged negative influence on individuals and society. In Chapter 6, he debates Jacques Ellul’s claim that technology *is* autonomous with respect to economics and politics. Ellul, and other writers, present technology as an autonomous thing, controlling and manipulating us apart from our own will and even our awareness. Technology, for these writers, is a thing to be feared, or at least to be watched with a critical eye. Pitt discusses what he calls trivial autonomy, for example, the claim that an invention can outgrow the intent and control of its inventor and that the inventor could not have foreseen the consequences of an invention. Once the invention is in the public domain, Pitt argues, the technology doesn't become autonomous. It is being used, converted, improved, etc. by other *humans*. It is not, therefore, autonomous. To quote Pitt, "…the long and the short of it is that those who fear reified technology really fear men. It is not the machine that is frightening, but what some will do with the machine…" (p. 99). In Chapter 7, Pitt expands this reasoning to argue that technology does not exercise autonomy over democracy or society. The difficulties that arise from Pitt's extremely strict understanding of autonomy ("freedom from influence in development and use") would relegate no thing and no one from any independent action or thought. Life is nothing if not influence and being influenced. Politics, religion, and language – these forces permeate who we are just as they permeate objects we create. Pitt's understanding of autonomy is, in our opinion, bankrupt of any utility and as a consequence incorrect on the impact that technology is having on society.

A few examples from everyday American society should suffice to prove that technology is autonomous. The nuclear weapon, that mainstay of American power projection, certainly creates its own order. The presence of a nuclear weapon continues to exert influence, to create structure, long after its creators brought it into being. The creators don't instill fear, their creation does. The automobile creates its own system of disorder as well, spewing out airborne toxins and changing the nature of social organization. The designers of the automobile did not create the roads and sprawl; these things are caused by the nature of the car itself. These kinds of technologies can rightly be called autonomous.

Have humans lost control of their creations? Perhaps we have embarked upon the road forecast by the Terminator movies. Perhaps not. Nevertheless, our creations are already coming back to destroy us, albeit with less dramatic means. The weapons of choice include accidents like Chernobyl and environmental disasters like global warming. Pitt believes we can just gather our collective will together to stop these technologies from harming us. Pitt is wrong. Many technologies have such large lag-times between their use and their effect that they may be stopped or changed too late to avoid the eventual negative consequences. Other technologies, like the Three Gorges Dam or oil exploration in the Artic Wildlife Preserve, are irreversible. That is by definition, autonomous.

Pitt concludes with an engaging discussion of the interrelationships (with emphasis on the plural) between science and the technological infrastructure within which science and technology are mutually nurtured. For the student of technology, science, or philosophy, this chapter alone is worth the cost of the book. In today's often fragmented educational setting, where information is presented and learned in seemingly unrelated chunks, Joseph Pitt offers a refreshing and compelling case for synthesis and symbiosis in *Thinking About Technology*. Get the book, read it slowly with much thought and you will understand how the concepts and issues are applicable and needed to the study of technology in our schools and universities. Think about technology!

Miscellany

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