Journal of Technology Education

Volume 10 Number 2 Spring, 1999

ISSN 1045-1064

From the Editor

From Inkwells to an Electronic Learning Community

When I was taught handwriting in elementary school, the fountain pen was the prescribed writing instrument. All of the desks in the classroom had inkwells in the upper right-hand corners (favoring right-handers, of course). The ball point pen had just been introduced, making the whole writing process easier, cleaner, and certainly less prone to accidents. Nonetheless, we were forbidden to use the ballpoint pen in those early years. The teacher felt that it represented a passing fad and that if we learned to write with a fountain pen, it would equip us with skills for a lifetime. Though it is interesting that the fountain pen is now returning to the marketplace as the writing instrument for “sophisticated” and “discerning” people, the ballpoint has been the mainstay method for manually putting ink on paper for nearly 50 years. Once I was allowed to use the ball point for my school work, I was elated with how easy it was to use. I must admit, though, that I missed the requisite pauses afforded by refilling my fountain pen and attending to the other maintenance chores it required during the arduous writing tasks that I had to complete.

A similar situation occurred when calculators were introduced. Professors insisted that we learn how to operate a slide rule, since the calculators of the time were unwieldy desktop units and were too expensive for the average person to ever purchase. Knowing how to operate a slide rule was essential since they were not only low in cost, but they were portable as well. Mastering a slide rule would most certainly have life-long usefulness.

In the early 80s, microcomputers were just making their entre’ into our lives. Investing in a computer system for our family seemed to be a rational and judicious decision, especially for the homework that our three children had ahead of them. I wondered, though, if my wife and I had made a purchasing mistake, for in these early years of the computer several of the teachers that taught our children forbade the use of a computer for doing homework assignments. I remember vividly how perplexed and distraught I was when I found that our son was doing his writing assignments with the word processing software that came with our computer, printing his work, and then transcribing it in hand writing to meet the teacher’s requirements. Even though already mastered, doing more handwriting would most certainly elevate a person to a higher level of fulfillment over the course of a lifetime.

The current status of the World Wide Web is leading to situations that are analogous to these earlier examples. When my students first turned in writing assignments with sources cited that were exclusively from the Web, it alarmed me. My thoughts led me to feel that I needed to place some control on the extent to which I would allow my students to use the Web as a reference for their writings. When I honestly analyzed my feelings, though, I realized that I was a bit jealous about how little time it took them to do background research for a paper they were writing compared to what I had to endure. I wanted them to use the library, just as I had been required to do. I guess it was sort of like the reasoning that football games are in a stadium, religious services are in a place of worship, and book research is done in a library. Even though I prided myself in embracing new technology and applying it, I had not really conceptualized the library beyond the bricks and mortar. I had thought of the Web and the physical library as useful, but somewhat dichotomous entities.

Just as the transition away from fountain pens, slide rules, and handwriting caused a change in behavior on our part, so does the use of the Web as a scholarly resource. In the conventional library there is a tradition of control from several different fronts over the quality and nature of the volumes available. Publishers make decisions on the books they produce so that they maintain their market and carry on the reputation of the company in terms of accuracy and quality. Libraries purchase materials that are consistent with the interests and needs of the communities they serve and reflect those communities' mores. Popular magazines generally apply editorial standards to what they publish to maintain credibility among their readership and nurture subscriptions. Scholarly journals, such as the JTE, maintain quality and focus through the refereeing process.

Alternatively, the Web is a totally uncontrolled storehouse of information. There are no restrictions to what is available. Though pornography on the Web is a popularly known problem, especially in educational circles, it goes far beyond that single issue. On the other hand, the Web is an awesomely wonderful resource. It is imperative that we not restrict students' use of Web references in an artificial or superficial manner. Rather, we must teach students to become wise and informed consumers of the information that is available to them in this era of decontrol. We must help them develop the new sense of responsibility that comes with the widespread availability of information. Though we have a long way to go before most of the information in the world is available electronically, it seems quite plausible that the day will arrive relatively soon.

One way to assess the validity of information and extend our knowledge is through discourse with one another as members of a learning community. The pervasiveness of the Web and email has enabled us to shrink the world even further and to make it more personal at the same time. Beginning with this issue, each author has the option of including an email address in the byline of the article. Though this is not a new practice among scholarly journals, it is agreeably not yet widespread. It assuredly offers to us a unique way of nurturing the members of our learning community. And most certainly, the skills that we teach to our students in using the Web and email will last them a lifetime…..

JEL

Articles

KEY FACTORS INFLUENCING PUPIL MOTIVATION IN DESIGN AND TECHNOLOGY

E. Stephanie Atkinson

Introduction

This article seeks to examine the relationship that exists between pupil motivation and the following internal and external factors: pupil performance in design and technology (D&T) project work, pupil skills associated with D&T project work, pupil personal goal orientation, pupil cognitive style, pupil creativity, teaching strategy, and teacher motivation. The data under discussion were collected as part of a four-year research project. The article examines the research investigated during the final year of the study when a sample of 50, 15 and 16-year-old pupils was selected from eight schools in the northeast region of England.

Data were collected throughout a GCSE[1] Design and Technology (D&T) course work project. A cognitive style test and a questionnaire ascertaining each pupil's perception of their ability and enjoyment in D&T project work were given to the sample at the beginning of the academic year. A case study approach based on observation and informal interviews was then used to monitor the pupils throughout the designing and making of their projects. Upon completion of the project, a summative questionnaire, a goal orientation index, and a creativity test were completed by each pupil. Data about the school's internal moderated mark for each pupil's D&T project were also collected.

In discussing the findings, the relationship between the internal factors and a pupil's ability to perform and be motivated will be discussed. Conclusions will be drawn concerning the influence that external factors, such as assessment and teaching and learning strategies, have upon the attitude and ability of pupils,

---

E. Stephanie Atkinson (stephanie.atkinson@sunderland.ac.uk) is a Technology Coordinator at the University of Sunderland, Tyne and Wear, England.

---

[1]GCSE - The General Certificate of Secondary Education examinations are taken by pupils in England and Wales at the end of compulsory education at the age of 16. There are four separate Examination Boards. Each Board designs their own examinations within a given framework. Under normal circumstances pupils take two years to complete a GCSE examination syllabus. In D&T the examination is in two parts. A 40% examination element and a 60% coursework element. The course work is in the form of an extended design and make task completed during the final year of the course.

while the importance of teacher motivation in sustaining, enhancing or decreasing pupil motivation will also be targeted.

Background to the study

In schools in the United Kingdom (UK), D&T involves a complex integration of processes, concepts, knowledge, and skills (DES, 1992). As the subject area has developed, so has the use of the design process as a method of delivering and examining subject content (e.g. Design Council, 1980; DES, 1987; Kimbell, Stables, Wheeler, Wosniak & Kelly, 1991). These processes have developed out of the linear design models used in the early 1960's (e.g. Kimbell *et al*, 1991). As teachers have become more experienced in working with them and as the subtlety of the process has become more apparent, the models have correspondingly become more complex. By the end of the 1980's many models of the process had been developed (Layton, 1991). It was acknowledged that some models became so complex that they were confusing to those who used them (Kimbell et al, 1991). In 1987 the Department for Education and Science suggested that what was needed was a loose framework to guide designing rather than a well-defined process model which they saw as a straitjacket. This approach was supported by Lawson (1990) who stressed that designing required flexible procedures.

Educationalists would have us believe that the assessment used to judge pupils' work should not dictate the curriculum content. Examination syllabuses should be designed to develop capability and test competence (SEC, 1986; NEAB, 1993). However, the importance of public examination results to pupils and teachers alike dictate that the nature of assessment and its criteria influence what is learned and how it is taught (Scott, 1990; Gipps, 1990). Additionally, the recent need for accountability in the UK has meant that assessment has become overly objective (Wiliam, 1992). As far as GCSE examination syllabuses for Design and Technology have been concerned, this has lead to the use of a prescriptive design process with a very specific list of criteria to be met. Layton (1991) aptly suggested that if teachers were not careful, the process could impose "a procrustean regime" (Layton, 1991, p 5) on the way pupils designed. Pupils have become outcome driven, with the process becoming a series of products. To obtain good examination grades pupils have had to provide evidence that each stage of the specified process has been addressed, irrespective of whether it was appropriate to the design of their particular product or not.

In the UK throughout the 1970's and 1980's it was generally believed that designing and making in the form of project work was an exciting and motivating activity during which the necessary skills, knowledge, and concepts could be taught (Design Council, 1980, Kimbell, 1982; HMI, 1983; Down, 1986). However, during the early 1990's growing evidence suggested that some aspects of that process were forming stumbling blocks for certain pupils (Kimbell et al, 1991; Chidgey, 1994; McCormick, Hennessy & Murphy, 1993). Atkinson (1993, 1994, 1995, 1997) provided evidence that these problems involved a significantly large number of pupils, even though many of them were able to complete their work and therefore appeared to be successful. Other writers (e.g. DES, 1992; Grieve, 1993; Hendley & Jephcote, 1992) and many teachers placed the blame for the problems on the introduction and implementation of the National Curriculum.

In addition to the approach taken to designing, research has indicated that a complex pattern of factors affect a pupil's performance, learning, and motivation (Kimbell et al, 1991; Naughton, 1986; DES, 1989; NCC, 1993). There are those attributes that a pupil brings with them: their gender, general ability, creative ability, cognitive style, personal goals, knowledge base, and curriculum experience. There are also the attributes of the task itself: its contextual location, its structure, and its likely demands upon the pupil. In the context of D&T, the complex relationship among all these factors and such external forces as culture, context, and parental and teacher expectations cannot be underestimated. Nor can the effect of attitude upon motivation be ignored. Attitudes towards success and failure have a significant bearing upon motivation for both teacher and learner. To identify which attitude has caused motivation or demotivation and then to determine whether attribution could be considered to have been internal or external, stable or fluctuating, and whether it could have been controlled or was uncontrollable is a difficult task (Weiner, 1992).

The theory concerning self-efficacy and personal causation would suggest that individual's have the ability to influence events in their life (Rotter, 1966). In an educational context it has been shown that academically successful pupils are inclined to have an internal locus of control (Atman, 1993). These pupils tend to believe that they are responsible for their own success, while pupils who fail to achieve academic success have an external locus of control and tend to blame their poor results on external factors such as their teacher. McClelland (1961) indicated that those who were academically successful displayed a need for achievement. In addition, he explained that they were able to set goals, determine how to reach them, use data for decision making, delay the reward, and assume personal responsibility for their own behavior. Atman's research during the 1980's led to the development of an instrument that could determine the level of an individual's goal achievement proficiency (Atman, 1993). Her index was designed to provide an individual score for each of the interwoven stages of reflecting, planning, and acting which she, and others, explained were important behavioral characteristics needed in order to accomplish goals. She believed that an understanding of goal orientation was important for design and technology educators as inherent in the design process were two assumptions: (1) that pupils must be able to identify and solve problems and (2) be able to set and accomplish goals.

The terms learning style and cognitive style have been widely used by educational theorists for the past sixty years. Terminology has varied from writer to writer (Curry, 1983, Riding & Cheema, 1991), although most (e.g. Tennent, 1988; Biggs & Moore, 1993; Riding & Pearson, 1994) have agreed that it is a distinct and consistent way of encoding, storing and performing, and one that is mainly independent of intelligence. Riding and Cheema (1991) grouped cognitive style into a Wholist-Analytic Cognitive Style Family, and a Verbalizer-Imager Cognitive Style Family. The Wholist-Analytic style has been defined as the tendency for individuals to process information in wholes or in parts; the Verbalizer-Imager style has been defined as the tendency for individuals to represent information during thinking verbally or in images. The appropriateness to this study of this categorization of cognitive style can be more easily appreciated when the activity of designing is examined further. The perception and evaluation of information, be it in wholes or in parts, in images or in words, form an integral and important part of the design process used in D&T project work. With regard to the connection between the Wholist-Analytic cognitive style dimension and designing, design methodologists have suggested that for designing to be successful, the process should be an holistic experience (e.g. Kimbell et al, 1991; McCormick et al, 1993; Atkinson, 1997; 1998; NEAB, 1993). Over concern with individual discrete elements "…has frequently emasculated it [the process] by ripping it apart in quite unnatural and unnecessary ways." (APU, 1994, p. 61). Interpretation of this belief in the context of cognitive style would suggest that those at the wholist rather than analytic end of the Wholist-Analytic dimension should make the best designers.

The relationship between designing and the Verbalizer-Imager cognitive style dimension can be understood when one considers the fact that imagining has been shown to be central to the generation and development of ideas (e.g. Kimbell et al, 1991; Garner, 1989; Chidgey, 1994, Liddament, 1993; Barlex, 1994). Glegg (1986) suggested that "…the subconscious has no vocabulary" (p. 87). He explained that when generating ideas in a design situation it was "... important to realize that our subconscious minds will hand up their suggestions in the form of symbols or pictures" (Glegg, 1986 p. 87). In this instance one would expect that those whose cognitive style was situated at the imaging rather than verbalizing end of the Verbalizer-Imager dimension should make the best designers. When a combination of both cognitive style dimensions was considered one would therefore anticipate that Wholist-Imagers should have a potential advantage over pupils in other cognitive style groupings in the context of D&T project work.

During the study it became apparent that delivery programs devised by each school had the potential to be problematic in terms of pupil motivation during their examination project work. The intention of each program was to enable pupils to cover all aspects of the examination syllabus. Each school followed examination guidelines and allowed the same number of teaching hours for the project work. However, in certain schools the examination theory work and the project work were run concurrently while in others one element of the syllabus was dealt with at a time. These two models provided pupils with very different overall time scales for their project work. In some schools the project work was finished in a short period of time while in others it stretched over a full academic year. It was also noted that the actual amount of time used to complete the work did vary greatly from pupil to pupil. The differences were accounted for by the amount of "extra" time each pupil was willing to spend on their project both at home and in school.

Observation of the approaches to designing adopted by the pupils raised a number of motivational issues. Quite naturally, pupil approaches were influenced by the Examination Board's documentation and the teaching strategies adopted by individual teachers. Observation indicated that teachers tended to utilize one of two strategies to enable their pupils to meet deadlines and address the specified assessment criteria. In one of the strategies the teacher tended to act as a collaborator, while in the other a more 'interventionist' mode of teaching was adopted.

In schools where teachers utilized an "interventionist" approach, pupils tended to move very quickly from designing to the manufacturing stage. Very few pupils produced carefully detailed drawings. Development of the chosen idea was carried out as manufacturing took place. Pupils lost ownership of their project, as decisions were made in a piecemeal, "interventionist" manner by the teacher. Ill-defined, but often in the context of the pupil's existing technological or constructional understanding, adventurous ideas meant that pupils were working in areas beyond their technological capability. This led to many disillusioned pupils and poorly-made, unfinished outcomes.

In schools where teachers exhibited what has been defined as the "collaborative" model, time was given to individual pupil-teacher discussions. Designing and making were a "collaborative" effort in which pupils were able to retain ownership of their project throughout the process. However, for some pupils there were disadvantages associated with this model. The problems tended to center around boredom. Pupils saw the design process stretching interminably ahead of them. The manufacturing stage to which they looked forward seemed an impossible target to reach. This caused a noticeable slowing down of work rates that only exacerbated the situation. For these pupils, deadlines came and went.

Against this complex background the relationship that existed between pupil motivation and certain identified internal and external factors was examined.

Method

Population and Sample

The initial sample of schools used in the study was a non-probability, purposive sample of 150 schools in seven Local Education Authorities (Atkinson, 1993). These schools were used by technology students on an Initial Teacher Training program at a University in the northeast area of England. From this sample 50 schools were selected using data from the Education Authorities Directory and Annual (1992) in order to provide a balance of size, type, and location of school. A questionnaire seeking pertinent background information was sent to each Head teacher and Head of D&T. Forty-five of the 50 schools returned the questionnaire. Analysis of the data enabled a final sample of eight schools to be selected. This selection was carried out in two stages. In the first instance, in order to avoid sampling bias, only schools that offered all three D&T GCSE examinations[2] were considered. The second stage used a four cell matrix based on the location of the school (inner city or large town/suburbia or

[2]Design and Realisation; Design and Communication; Technology.

small town) and the size of 10th grade (Over 125/Under 125). The size of each school's population was not used as a sampling mechanism since the range of ages was variable from school to school. Some schools were 11-16, some were 11-18 while others were 13-18. This meant that schools of the same size did not necessarily have parity between the size of their 10th grade cohort.

The sample of pupils reported in this study initially involved 112, 15 to 16-year-old pupils (85 boys and 27 girls) and their D&T teachers in the eight targeted schools. The research was carried out during the first year in which it was compulsory for all 15 and 16-year-old pupils to study D&T as part of the National Curriculum. This made it possible for the eight teachers to select a single mixed-ability class from their school and for that chosen class to be representative of the 15 and 16-year-old cohort within that particular school. After an initial data collection period, 50 pupils (36 boys and 14 girls) were selected from the targeted sample using a matrix of eight pupil types. This was based upon data concerning a pupil's cognitive style, their ability to design, and their perceived enjoyment of designing and making. These pupils were then observed on a regular basis for the duration of the D&T examination project work with the intention of identifying some of the causes of pupil demotivation[3] that were becoming a concern to teachers and educationalists in the UK.

Instrumentation

The following data gathering instruments were used in the study.

Research instruments that provided quantitative data:

- Appropriately tried and tested questionnaires – administered before and after the D&T project work.
- GCSE examination marks for the D&T project work. The distribution of marks for the sample were checked against the normal distribution curve achieved by the total examinees for the GCSE D&T examination and were found to be similar.
- A computer presented, self administered Cognitive Style Analysis (CSA) designed by Riding (1991). This assessed two fundamental ways of thinking and working (cognitive style dimensions): wholist-analytic and verbal-imagery. The validity of the instrument was supported by " ... the finding of significant relationships between style and a range of school learning performance (e.g. Riding & Caine, 1993; Riding & Douglas, 1993; Riding & Mathias, 1991; Riding & Sadler-Smith, 1992;)" (Riding, Burton, Rees & Sharratt, 1995, p. 115).
- A goal orientation test that set out to assess important behavioral characteristics associated with accomplishing personal goals. This was based on an index designed by Atman (1986). To provide construct validity Atman had undertaken "...correlation studies with several well-

[3]The definition for demotivation is taken from the New Shorter Oxford English Dictionary where it is defined as - to make less strongly moticated (Brown, 1993) and the Collins Today English Dictionary where it is defined as - to loose ones determination to do something (Sinclair, 1995).

known instruments (e.g. Jackson Personality Inventory, the Bass Orientation Index, Nideffer's Test of Attentional and Interpersonal Style, the Myers-Briggs Type Indicator)" (Atman, 1993, p. 4).

- A creativity test in two parts. The first section was used only to stimulate the pupil's creativity and was not scored. It was taken from De Carlo's (1983) *Psychological Games.* The second section was based on the then unpublished doctoral work of Oxlee (1996). This test was particularly appropriate to testing creativity in the context of design activity, although the present author recognized that proof of its validity was minimal since it had been developed by Oxlee so recently.

72 Categorization of pupils as motivated or unmotivated. This was established as an on-going process throughout the observation period. Pupil motivation was determined using a rating scale. A researcher response to each criterion listed below, was located on a coding frame of fixed alternatives at the end of the observation period and a score for motivation was then calculated. This score was checked against the teacher's perception of each pupil's level of motivation and triangulated against data elicited from the pupil questionnaire concerning their perceived level of motivation. Judgments on levels of motivation were made using the following criteria:
  - observed enthusiasm for their project;
  - observed pupil interaction with their teacher;
  - observed pupil interaction with their peers;
  - attendance;
  - time keeping;
  - ability of pupil to stay "on task" during lessons;
  - teacher comments on pupil's levels of motivation;
  - pupil comments on their own level of motivation;
  - on-going scrutiny of design and practical outcomes.

- Categorization of teachers as motivated or unmotivated. This was established as an on-going process throughout the observation period. As in the case of determining pupil motivation, a rating scale was used. A response to each criterion listed below was located by the researcher on a coding frame of fixed alternatives at the end of the observation period. Additionally, a score for motivation was then calculated. Judgments on levels of motivation were made using the following criteria:
  - teacher interaction with the whole class;
  - teacher interaction with individual pupils;
  - time keeping;
  - teaching style;
  - observed enthusiasm for the subject based on interaction with pupils;
  - observed enthusiasm for the subject based on interaction with researcher;
  - observed enthusiasm for project work based on interaction with pupils;
  - observed enthusiasm for the project work based on interaction with researcher.

Research Instruments that provided qualitative as well as quantitative data:

- Observation of project work. Observation sheets, designed by the researcher, were completed on pupil project progress and skill levels on a regular basis for the duration of the examination project work;
- Semi-structured and informal interviews. These were carried out with both pupils and teachers whenever appropriate throughout the observation period.

For the purpose of comparability between data the scores achieved by each pupil for the different tests were converted proportionally to a four-point scale, with four being the highest and one being the lowest.

Procedures

Instrumentation was developed as reported and the sample was drawn as described. The data were collected between June 1995 and May 1996. Coding and analysis of the data were carried out as each set of data was collected. The statistical analyses included percentage distribution, rank order, one sample *chi*-square test of variance, unpaired comparison of averages using *t*–tests, *chi*-square test for independence, and Fisher's Exact Test for 2x2 tables. Descriptive analysis included mean scores and line charts.

Results

The relationship between pupil motivation and pupil performance

Chi-square analysis of the data collected during the observation period indicated that a disappointingly high proportion of the total sample were unmotivated by the activity in which they were involved. The level of significance was found to be <.0001. The raw data concerning the number of pupils in each motivational category is reported in Table 1.

Table 1
Number of pupils and the mean score for performance, creativity, drawing skills, writing skills, design skills, manufacturing skills achieved by each motivational group

Pupil Motivation Group	Mean Scores (Maximum Score 4)						
	n	Performance	Creativity	Drawing	Writing	Design	Manufacture
Motivated	10	3.20	2.50	2.80	3.30	2.60	3.10
Motivated towards result but unenthusiastic about activity	11	3.00	2.29	2.14	2.71	2.00	2.57
Unmotivated	29*	1.76	2.28	1.55	2.27	1.30	1.58

*p<.0001

Analysis of pupil performance and levels of motivation indicated that the relationship between performance and motivation was positive. Pupils who were motivated achieved a high mean score in their examination project work while those who were unmotivated achieved a low mean score. These results are reported in Table 1.

The relationship between pupil skills, motivation and performance

Data collected throughout the examination project work indicated that there was a positive correlation between a pupil's drawing, writing, design, and manufacturing skills, and their levels of motivation. Those pupils who were motivated achieved high mean scores for their drawing, writing and designing while those who were unmotivated achieved low mean scores. Results are reported in Table 1.

The data as shown in Table 2 indicated that those pupils who were motivated and possessed above average design skills achieved the highest mean score in their project work, while those who were unmotivated and had below average writing skills achieved the lowest mean score.

Table 2 also indicated that a significant number of pupils who were unmotivated had below average design skills. In the case of manufacturing skills it was found that a significant number of unmotivated pupils had below average skill levels while a significant number of motivated pupils had above average skill levels.

The relationship between personal goal orientation, motivation, and performance

In order to analyze the relationship between a pupil's personal goal orientation, motivation, and performance, the individual scores for reflecting, planning, and acting were calculated for each pupil. The results indicated that a pupil's ability to "act" tended to remain constant whether they achieved high or low marks. These results are reported in Table 3. However, with regard to "planning" and "reflecting" there were significant differences between those who performed well and those who did not, as indicated in Table 3.

Table 3

The mean scores (max. 4) achieved by pupils for their GCSE project work when grouped by personal goal characteristics

	Average Mean Scores for Total Sample *n*=50	Mean Scores for Those Who Achieved Low Marks *n*=16	Mean Scores for Those Who Achieved High Marks *n*=16
Acting	2.49	2.44	2.44
Planning	2.44	0.98*	3.00
Reflecting	2.47	0.97**	3.13

*t=5.550, df 30, p-value <0.0001
**t=5.028, df 30, p-value <0.0001

Table 2

The mean project work score achieved by each motivational group when split by drawing, writing, design and manufacturing skill level (n in parentheses)

Pupil	Above Average Skill Level				Below Average Skill Level			
Motivation	Drawing	Writing	Design	Manufacture	Drawing	Writing	Design	Manufacture
Motivated	3.50(6)	3.43(7)	3.67(7)	3.25(8)*	3.00(4)	2.67(3)	3.00(3)	3.00(2)
Motivated towards result but unenthusiastic about activity	3.00(3)	4.00(3)	3.61(3)	3.00(4)	3.00(4)	2.25(4)	2.50(4)	3.00(3)
Unmotivated	2.00(5)	2.42(12)	1.87(3)	3.00(3)	1.71(28)	1.38(21)	1.87(30)*	1.63(30)*

*p<.0001

It was found that when the relationship between goal orientation and motivation was investigated it could be seen that there were similarities between the data collected and the data concerning the relationship between goal orientation and performance as portrayed in Figure 1.

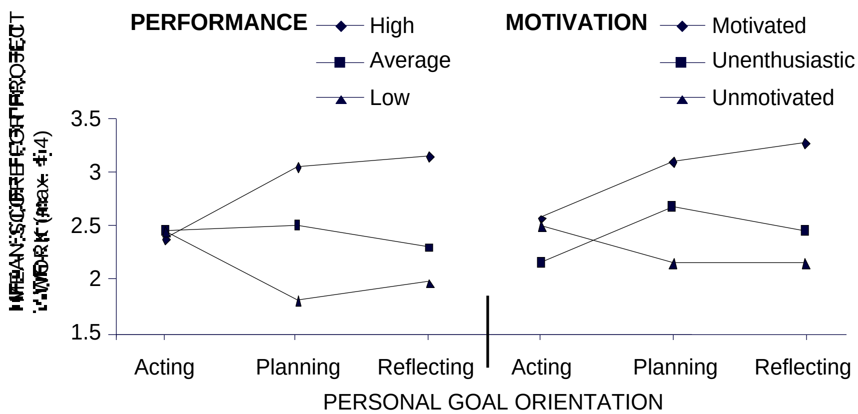

Figure 1. A comparison between the data for motivation and the data for performance split by the three behavioral characteristics: Acting, Planning and Reflecting.

The relationship between cognitive style, motivation and performance

The data collected during this research project indicated that those pupils who were Imagers and Wholists were the ones who achieved the poorest results during their project work, while the data collected also indicated that those who were analytic, whether they were Imagers or Verbalizers, tended to achieve high marks. This is portrayed in Table 4.

When the targeted sample of 50 pupils was scrutinized, 18 pupils were found to be Analytic-Verbalizers; 13 were Analytic-Imagers; 10 were Wholist-Imagers; and nine were Wholist-Verbalizers.

In the case of the Analytic-Imagers, Wholist-Imagers and Wholist-Verbalizers, a significant number of them were unmotivated in comparison to those who were motivated. Analytic-Verbalizers were more evenly spread between the motivated and unmotivated categories. See Table 5 for Chi-square test results.

Table 4

The average percentage mark achieved by the original sample of 112 pupils (minus eight pupils who were withdrawn from the examination) grouped by the selection of sample factors

Cognitive Style	Enjoyed designing and can		Enjoyed designing but can't		Preferred making and can design		Preferred making and can't design	
	Analytic	Wholist	Analytic	Wholist	Analytic	Wholist	Analytic	Wholist
Verbalizers	75	67	40	22	64	45	43	39
Imagers	88	48	62	20	66	36	32	28

Table 5

A Chi-square test on levels of motivation for each cognitive style group

Cognitive Style	Motivated	Unenthusiastic about the activity	Unmotivated	Variance	df	Chi-square	*p*-value
Analytic-Imagers	2	2	9	24.5	1	24.5	<.0001
Wholist-Verbalizers	0	3	6	18.0	1	18.0	<.0001
Wholist-Imagers	2	0	8	18.0	1	18.0	<.0001
Analytic-Verbalizers	6	2	10	8.0	1	8.0	.0094

The relationship between creativity, motivation and performance

Analysis of the data collected in this research study indicated a positive relationship between creativity and performance as portrayed in Table 6. This is in contrast to the data in Table 1 where it was shown that there was not a significant difference in the level of creativity between those pupils who were motivated and those who were unmotivated.

Table 6
The relationship between a pupil's creativity level and performance (max. score 4)

Level of Creativity	Poor Level	Average Level	Good Level
Performance Mean Score	1.41	2.05	2.82

The relationship between teaching strategy, motivation and performance

Table 7 illustrates the relationship that exists between teaching strategy, motivation, and performance. Pupils attained higher levels of achievement in schools adopting an "interventionist" approach. However, 72% of the pupils in those schools were found to be unmotivated in comparison to only 55% of pupils in schools adopting a "collaborative" teaching strategy.

Table 7
The mean score achieved by the sample grouped by teaching strategy and pupil motivational level

	"Interventionist" model		"Collaborative" model	
Motivational Level	*n*	mean score	*n*	mean score
Motivated	5	3.75	5	2.80
Motivated towards result but unenthusiastic about activity	4	3.60	3	2.00
Unmotivated	23	2.04	10	110
Total	32	2.50	18	1.72

It was considered that project work completion may be an indicator of levels of motivation. In the case of schools adopting an "interventionist" model there was less motivation and also a considerable number of pupils with incomplete projects when the project deadline was reached. These data are portrayed in Table 8.

The relationship between pupil motivation and teacher motivation

In order to examine the relationship between pupil motivation and teacher motivation data were collected throughout the observation period using the list of criteria indicated in the methods section. The number of pupils in each motivational category is displayed in Table 1. As far as the teachers were concerned, analysis of the collected data indicated that in only three of the eight schools could the teacher be said to be inclined towards high levels of motivation. In each of the other five cases the teachers were found to fall predominantly at the unmotivated end of the motivational spectrum.

When the data concerning teacher motivation and pupil motivation were compared, it was found that a significant number of the sample of pupils being taught by unmotivated teachers were unmotivated themselves as indicated in Table 9.

Table 8
The percentage completion rates of pupils (n=50) in schools adopting either "interventionist" or "collaborative" teaching strategies. The Fisher's Exact Test for 2x2 tables was also carried out on the data

Completion Rate	"Interventionist" Model *n*=32	"Collaborative" Model *n*=18
Complete	34% (11)	61% (11)
Unfinished	66% (21)	39% (7)

Fisher's Exact *p*-value=.0827

Table 9
The mean score (max. 4) achieved for the examination project work grouped by teacher motivation and pupil motivation

Pupil Motivation	Motivated Teacher	Unmotivated Teacher
Motivated	3.40 (5)	3.00 (5)
Motivated towards result but unenthusiastic about activity	3.57 (7)	2.50 (4)
Unmotivated	1.86 (7)	1.41 (22)*
Total number of pupils	19	31

*p=<.0001

Discussion

The relationship between pupil motivation and pupil performance

The data collected during this research project supports the well-documented belief that there is an association between motivation and performance (e.g. Weiner, 1992; Bandura & Dweck, 1985; Dweck & Leggett, 1988; Elliot & Dweck, 1988). Performance has been shown to affect motivation and motivation has been shown to affect performance. In the case of this study with its emphasis on GCSE examination work this belief was found to be particularly pertinent and well founded.

There is a theory that behavior is controlled by the pleasure-pain principle in which people maximize the pleasure linked to success and minimize the pain generated by failure (Weiner, 1992). It was expected that this theory would apply to this study and that many of the pupils would be motivated by their desire to achieve good results in their examinations and also by their wish to make an artifact of which they and their parents could be proud. However, by the end of the study it was disappointing to find that only 42% of pupils were found to be in this category and only five percent of this sub-sample was enthusiastic about the process in which they had been involved. The following discussion concerning the identified factors provides an insight into possible reasons for these findings.

The relationship between pupil skills, motivation and performance

In all schools in the sample, the lack of skills and understanding regarding processes and materials were found to present a major problem for many of the pupils during both the design and the manufacturing stage of their project work. Analysis of the evidence during the observation period suggested that pupils' ideas, when carried through to the manufacturing stage, caused many of them to work beyond their technological and craft capability. Teachers had indicated that they were all aware of this problem. They were disappointed by the quality of the artifacts produced by the majority of their pupils. In an attempt to support all pupils throughout their project work, teachers were seen to develop a strategy in which they designed solutions to pupils' problems in their heads, as the need arose. The necessity for many pupils to have an understanding of the direction in which they should head was given a low priority. However well intentioned this course of action may have been, the evidence would suggest that it had a demotivating effect upon many of the pupils. They became very frustrated by their inability to proceed without continuous reference to their teacher. The common belief that ownership develops a sense of responsibility, pride, and the motivation to succeed would support the use of strategies that would enable pupils to retain ownership of their idea throughout the project rather than the loss of ownership witnessed among many pupils during this research project.

The relationship between personal goal orientation, motivation, and performance

The analysis of goal orientation data indicated that there was little difference between those pupils who were motivated and those who were unmotivated with regard to their belief in their ability to act. Although it should be pointed out that unmotivated pupils could be said to have an inflated image of this ability if their poor completion rate in the project work was taken as an indication of an inability to "make it happen."

An essential element of each aspect of the design process, and one which is highly prized in the GCSE examination marking criteria, is an ability to reflect upon and evaluate personal thoughts and actions. The very high score achieved by motivated pupils in this aspect of goal orientation along with the high score they achieved for "planning" were seen as providing one of the possible reasons why these pupils achieved high project work marks. Those pupils who were categorized as unenthusiastic about the activity also scored relatively highly in their ability to plan. This gave some support to their above average mean project work mark. However, their belief that they were generally not as good at "reflecting" and that they were particularly poor at getting on with a task provided a possible explanation for their lack of enthusiasm for an activity which demanded good reflective skills and an ability to complete each stage of the process by a given time.

The relationship between cognitive style, motivation and performance

Due to the nature of the design activity central to this study, the expectation had been that Wholist-Imagers would achieve high marks for their project work. However, this was not the case, Wholist-Imagers achieved the poorest results. Analysis enabled the researcher to identify and quantify the reasons for this unexpected feature of the data. Factors concerning the design processes adopted provided an explanation for this sub-sample achieving a low mean score.

It is well accepted that for designing to be successful it should be a holistic experience. However, in order to ensure that pupils met each of the assessment criteria, teachers were seen to split the process into easily managed units of work. Observation showed that these were tackled often in isolation before the next aspect of the process was discussed. The holistic nature of the process was therefore fragmented, thus playing into the hands of those who were analytic.

Analysis of the process indicated that since drawing is such an important aspect of designing, one might have expected Verbalizers who preferred processing information verbally to achieve significantly lower marks for their projects than those pupils who preferred working with images. This was not, however, found to be the case. Not all Imagers were able to draw. Nor could the majority of Imagers rely upon their writing skills, as these skills were generally found to be unsatisfactory.

For those Imagers who avoided writing, their on-going evaluation was mainly to be found hidden in subtle forms within their drawn images. Access to a pupil's immediate thoughts at the time of the conception of ideas was impractical. Moreover, it was not easy to credit these thoughts objectively at a later date during the assessment process. In comparison, those who were Verbalizers communicated their thoughts in a form that was more easily interpreted by teachers during assessment, thereby gaining them praise from their teachers and valuable marks for their examination.

The relationship between creativity, motivation and performance

Evidence from the study supported the researcher's hypothesis that there was a connection between a pupil's level of creativity and the strategies they would adopt while engaged in project work. Much has been written concerning the high levels of motivation and performance witnessed amongst those who are creative (e.g Amabile, 1985; McAlpine, 1988; Osche, 1990). With regard to performance, the evidence collected during this study supported these findings. However, with regard to the relationship between creativity and motivation the evidence did not provide a clear-cut case. There was a similarity between the mean creativity scores for each motivational category. Once again, analysis of the process used by the pupils to complete their examination project work provided an explanation for the lack of a positive relationship between creativity and motivation.

The data collected enabled the researcher to categorize those who were creative and those who were not creative into two sub-groups. The inherently creative could be divided further into those who were able to design within the constraints of the GCSE examination process model and those who were inhibited and unmotivated by such a structured approach. The latter group encompassed the majority of pupils and within it there were those who were neither creative nor receptive towards working with the design process models offered to them. This group was seen to become increasingly unmotivated as the project work progressed. The other sub-group was willing to accept the design methodology taught, although they too were not naturally creative. At the start of the project these pupils were motivated because they wished to produce satisfactory outcomes of which they could be proud. However, as time progressed they too became increasingly dissatisfied with the process they had been asked to adopt. This group maintained motivation by concentrating upon achieving a good examination result rather than enjoying the activity.

The relationship between teaching strategy, motivation, and performance

As explained earlier, the research had identified two basic strategies that were adopted by teachers in the schools, a “collaborative” approach and an “interventionist” approach. Schools adopting “interventionist” approaches tended to use delivery programs that were completed in a short period of time. In these schools, deadlines tended to be well before the deadline set by examination boards. This provided pupils with extra time in which to complete work that was unfinished.

In schools adopting the “collaborative” model, deadlines tended to coincide with examination board deadlines. The consequence of this was that pupils did not have extra time to finish incomplete work. This had a detrimental effect upon final performance scores for these pupils. Pupils achieved lower scores in each motivational category in these schools. However, it was interesting to note that as far as motivation was concerned there was a higher percentage of motivated pupils in schools adopting a “collaborative” approach.

An analysis of the teaching strategies suggested reasons for these differences. In schools where teachers exhibited what has been defined as the “collaborative” model, time was given to individual pupil-teacher discussions. Detailing of ideas was a “collaborative” effort between pupil and teacher, with pupils retaining ownership of their idea. Many of those who succeeded in reaching the manufacturing stage of their project were able to complete their work in time for assessment. For those pupils who did not, the problems associated with this model came about through boredom. From a fairly early stage these pupils saw the design process stretching interminably ahead of them. The manufacturing stage to which they looked forward seemed an impossible target to reach. This caused a noticeable slowing down of work rates that only exacerbated the situation.

Evidence would suggest that the speed of the process used by schools adopting an “interventionist” approach failed to provide pupils with enough time for the maturation of thoughts and ideas at each stage of the process. Although pupils in schools where “collaborative” strategies were used technically had the same number of hours for their projects, the evidence would suggest that the spread of this time over months rather than weeks allowed pupils access to this important maturation time. “Collaborative” approaches also gave teachers time to familiarize themselves with pupils’ projects. This enabled them to prevent some of their pupils from making unwise design decisions, whereas many teachers using “interventionist” strategies were found to be frustrated by their inability to prevent design disasters from occurring.

As far as the design folders prepared by the students to document the design process were concerned, very few were completed without considerable pressure being applied by the teachers. Motivated pupils in all schools were persuaded to re-work or “pretty-up” existing work and fill gaps in their design process. The limited time spent on the folder work in the “interventionist” model meant that the folders, of even those who believed that they could design presented little evidence of using designers’ thought processes at the various stages of the project. In an attempt to present the required evidence for assessment, pupils were encouraged to complete written sections describing their decision-making procedures. This was often carried out retrospectively on the pupils’ own time when they were pulling their design folder together.

The design work of those working in schools where a “collaborative” approach had been adopted displayed two different levels of success relative to their design folders. Those who enjoyed the act of designing produced visually excellent folders that contained creative thinking. At the same time, they showed a considerable amount of re-worked and over-worked sheets. Those who did not enjoy designing produced numerous sheets of work attempting to satisfy the examination criteria but showing little evidence of a designer’s thought processes.

With regard to pupils developing a sound understanding of the process of designing, analysis of the two strategies adopted by the schools indicated that neither the “collaborative” or the “interventionist” model were successful. Feedback from pupils after they had finished their examination projects supported the researcher’s findings. Pupils’ reactions indicated that although some of them were able to obtain satisfaction from achieving success in the examination, many of the pupils in schools adopting either approach were unmotivated and skeptical about the validity of the process they had been asked to adopt.

The relationship between pupil motivation and teacher motivation

Throughout the observation period a growing picture emerged that indicated the importance of teacher motivation when considering the causes of reduced pupil motivation in D&T. The reasons for reduced teacher motivation were found to be as complex and numerous as the reasons for the loss of motivation among pupils. However in the context of D&T these summarily included the developing ill-defined philosophy of D&T, the introduction of the National Curriculum, accountability, financial constraints, and the speed of the changes in direction imposed by each revision of the National Curriculum.

In the schools where the D&T teachers were enthusiastic, there was an air of optimism surrounding the classroom/workshops. This was despite the fact that they, like the unmotivated teachers, believed that external pressures affected the work they were carrying out with their pupils. The “optimistic” teachers seemed to treat these pressures as a challenge rather than as an excuse for poor results. In each case it was also noticeable that the teacher was part of an enthusiastic team of D&T staff lead by a motivated Head of Department. In the five schools where teachers lacked enthusiasm for their work it was found that in three instances the noted despondency prevailed across the whole D&T department, including the Head of Department.

As stated earlier, only ten out of the 50 pupils were found to be motivated by the end of their project work. The data collected did indicate some support for the researcher’s hypothesis that fewer pupils would be found to be unmotivated in schools where enthusiastic, motivated teachers were teaching the D&T lessons. However, it was disappointing to find that there was not a statistically significant difference between the two groups of teachers. Twenty-six percent of the sample taught by motivated teachers were enthusiastic about their project work in comparison to 16% of the pupils taught by despondent teachers.

Conclusion

Analysis of the research findings indicated that only twenty percent of the pupils studying at 10th grade were motivated by their D&T examination project work. Using the collected data it was found that a significantly larger number of pupils, just under sixty percent, were categorized as unmotivated. A further twenty-two percent of pupils had not enjoyed the activity, although their wish to perform well in their GCSE examinations had been a contributing factor in keeping them motivated in their D&T project work.

The evidence of the research concerning reasons for the differing levels of pupil motivation painted a complex picture of interactions between internal and external factors. A positive relationship was established between a pupil’s ability to perform and their level of motivation. Such factors as a pupil’s ways of thinking and working, personal goal orientation, and skills appropriate to D&T were found to show a positive relationship with both performance and motivation. On the other hand, although a pupil’s level of creativity was found to relate positively to performance, no similar relationship was found between creativity and motivation. An equal number of pupils at both extremes of the creativity spectrum were found to be unmotivated. Analysis suggested that the prescriptive nature of the examination design process models adopted, as well as the effect of GCSE D&T assessment criteria upon ways of working, were frustrating for many pupils, particularly those who were creative. It was also evident that external factors such as delivery programs, as well as teaching strategies adopted by teachers to meet examination deadlines and requirements, influenced both pupil performance and pupil motivation.

The researcher would suggest that lessons to be learned from the findings include, firstly, the need for Examination Boards to develop holistic assessment procedures that will encourage the use of more appropriate, flexible, design process models. Secondly, the study supported the generally held belief that most teachers need to feel in control of classroom activities. To achieve this "control" in the context of D&T many teachers were seen to remove ownership of ideas from pupils at an early stage of the process. The common belief that ownership develops a sense of responsibility, pride, and the motivation to succeed has tended to be overlooked. In order to remedy this teachers need to develop strategies that will enable them to guide pupils through the process in a partnership where ownership is a joint affair. To achieve this teachers need to develop a far deeper understanding of the activity involved in designing than the present evidence would suggest is the case.

References

APU. (1994). Assessment of design and technology. In F. Banks (Ed.), *Teaching Technology,* London: Routledge, 161-172.

Amabile, T. M. (1985). Motivation and creativity: effects of motivational orientation on creative writers. *Journal of Personality and Social Psychology, 48*, 393-399.

Atkinson, E. S. (1993). Identification of some causes of demotivation amongst pupils in Year 10 and 11 studying technology with special reference to design and technology. In J. S. Smith (Ed.), *IDATER93,* Loughborough: Design and Technology, Loughborough University, 17-25.

Atkinson, E. S. (1994). Key factors which affect pupils performance in technology project work. In J. S. Smith (Ed.), *IDATER 94,* Loughborough: Design and Technology, Loughborough University, 30-37.

Atkinson, E. S. (1995). Approaches to designing at key stage 4. In J. S. Smith (Ed.), *IDATER 95*, Loughborough: Design and Technology, Loughborough University, 36-47.

Atkinson, E. S. (1997). *Identification of some causes of demotivation amongst Key Stage 4 pupils studying design and technology*. Ph. D. thesis, Newcastle-upon-Tyne: Newcastle University.

Atkinson, E. S. (1998) Cognitive Style in the Context of Design and Technology Project Work. *Educational Psychology, 18:2,* 183-194

Atman, K. S. (1986). *Goal orientation index.* Pittsburgh: Curriculum Innovators and Implementors.

Atman, K. S. (1993) Curriculum implications of goal accomplishment style for design technology education. In: J. S. Smith (Ed.), *IDATER 92: Keynote lectures*, pp. 1-10. Loughborough: Design and Technology, Loughborough University.

Bandura, M., & Dweck, C. S. (1985). The relationship of conceptions of intelligence and achievement goals to achievement-related cognition, affect and behaviour. In C. S. Dweck, & E. L. Leggett, (1988). A social-cognitive approach to motivation and personality, *Psychological Review, 95*(2), 256-273.

Barlex, D. (1994). Modelling in science and design and technology. In F. Banks (Ed.), *Teaching Technology,* London and New York: Routledge, 74-81.

Biggs, J. B., & Moore, P. J. (1993). *The process of learning*, 3rd ed., Australia: Prentice Hall.

Brown, L. (Ed.). (1993). *New Shorter Oxford English Dictionary,* Oxford: Clarendon.

Chidgey, J. (1994). A Critique of the design process. In F. Banks (Ed.), *Teaching Technology*, London: Routledge, 89-93.

Curry, L. (1983). An organisation of learning styles theory and constructs. *ERIC Document* 235 185.

De Carlo, N. A. (1983). *Psychological games*, London: Guild Publishing.

Department for Education and the Welsh Office (DES). (1987). *Craft, Design and Technology from 5 to 16: Curriculum Matters 9*, London: HMSO.

Department for Education and the Welsh Office (DES). (1989). *Design and Technology for Ages 5 to 16: Proposals*, London: HMSO.

Department for Education and the Welsh Office (DES). (1992). *Technology for ages 5 to 16 (1992)*, London: HMSO.

Design Council. (1980). *Design education at secondary level,* (Design Council Report) London: The Design Council.

Down, B. K. (1986). Problem solving, CDT and child-centredness. In A. Cross, & B. McCormick (Eds.), *Technology in Schools,* Milton Keynes: Open University Press, 228-239.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality *Psychological Review, 95*(2), 256-273.

Education Authorities Directory and Annual. (1992). London: The School Government Publishing Company Ltd.

Elliot, E. S., & Dweck, C. S. (1988). Gaols: an approach to motivation and achievement, *Journal of Personality and Social Psychology, 54*, 5-12.

Gipps, C. (1990). *Assessment: A teacher's guide to the issues.* London: Hodder & Stoughton.

Garner, S. W. (1989). Drawing and designing: exploration and manipulation through two-dimensional modelling. In J. S. Smith (Ed.), *DATER 89*, Loughborough: Design and Technology, Loughborough University, 43-50.

Glegg, G. L. (1986). The design of the designer. In R. Roy, & D. Wield, (1986). *Product Design and Technological Innovation.* Milton Keynes: Open University, 86-91.

Grieve, E. (1993). Pupils' and Teachers' experiences of project work in Technology at Key Stage 4, (unpublished paper) presented at *IDATER 93,* Loughborough: Design and Technology, Loughborough University.

Hendley, D., & Jephcote, M. (1992). A critical analysis of the operational aims and objectives for technology for 14 to 16 year olds in England and Wales. In J. S. Smith (Ed.), *IDATER 92*, Loughborough: Design and Technology, Loughborough University, 4-8.

Her Majesty Inspectorate of Schools: Craft Design and Technology Committee, (1983). *CDT: a curriculum statement for the 11-16+ age group,* London: HMI.

Kimbell, R. A. (1982). *Design education - foundation years,* London: Routledge, Keegan Paul.

Kimbell, R. A. (1994). Tasks in technology, *International Journal of Technology and Design Education*, *1*, 1-15.
Kimbell, R., Stables, K., Wheeler, T., Wosniak, A., & Kelly, V. (1991). *The assessment of performance in design and technology - The Final Report of the APU Design and Technology Project 1985-91,* London: School Examinations & Assessment Council/Evaluation & Monitoring Unit.
Lawson, B. (1990). *How designers think: the design process de-mystified (2nd Edition),* London: Butterworth Architecture.
Layton, D. (1991). *Aspects of national curriculum design and technology*, York: National Curriculum Council.
Liddament, T. (1993). Using models in design and technology education: some conceptual and pedagogic issues. In J. S. Smith (Ed.), *IDATER 93,* Loughborough: Design and Technology, Loughborough University, 92-96.
McAlpine, D. (1988). *Creativity: Thinking processes and teaching implications,* Paper presented at 4th Annual National Association for Curriculum Enrichment & Extension (NACE) Conference, Northampton: Nene College.
McClelland, D. (1961). *The Achieving Society,* Toronto: Collier Macmillan Canada, Ltd.
McCormick, B., Hennessey, S., & Murphy, P. (1993). A pilot study of children's problem solving processes. In J. S. Smith (Ed.), *IDATER 93,* Loughborough: Design and Technology, Loughborough University, 8-12.
National Curriculum Council. (1993). *Technology Programmes of Study and Attainment Targets: Recommendations of the National Curriculum Council,* York: NCC.
National Curriculum: Design and Technology Working Group. (1988). *National Curriculum, Design and Technology Working Group, Interim Report.*
Naughton, J. (1986). What is 'technology' anyway? In A.Cross & B. McCormick (Eds.), *Technology in Schools,* Milton Keynes: Open University Press, 2-10.
Northern Examinations and Assessment Board (NEAB). (1993). *General Certificate of Secondary Education: Design and Technology Syllabus for 1995,* Newcastle: NEAB.
Osche, R. (1990). *Before the gates of excellence: the determinants of creative genius,* Cambridge: Cambridge University Press.
Oxlee, J. (1996). *Analysis of creativity in the practise and teaching of the visual arts with reference to the current work of art students at GCSE level and above,* Ph. D. Thesis Newcastle-upon-Tyne: Newcastle University.
Riding, R. J. (1991). *Cognitive styles analysis,* Birmingham: Learning and Training Technology, Assessment Research Unit, Birmingham University.
Riding, R. J., Burton, Rees & Sharrott. (1995). Cognitive style and personality in 12-year-old children. *British Journal of Educational Psychology, 65,* 113-124.
Riding, R. J., & Cheema, I. (1991). Cognitive styles: an overview and integration. *Educational Psychology, 11*(3&4), 193-215.
Riding, R. J., & Pearson, F. (1994). The relationship between cognitive style and intelligence, *Educational Psychology, 14*(4), 413-425.

Rotter, J. (1966). General expectancies for internal versus external control of reinforcement. *Psychological Monographs, 80,* (Whole No. 609).

Secondary Examination Council, (1986). Kimbell, R. (Ed.), *G.C.S.E, C.D.T: A guide for teachers*, Milton Keynes: Open University Press.

Scott, G. (1990). *Course work and course work assessment in G.C.S.E.,* Cedar Report 6, Warwick: University of Warwick.

Sinclair, J. (Ed.). (1995). *Collins Today English Dictionary*, London: Harper Collins

Tennent, M. (1988). *Psychology and Adult Learning*, New York: Wiley.

Weiner, B. (1992). *Human motivation, metaphors, theories, and research,* London: Sage.

Wiliam, D. (1992). Some technical issues in assessment: a user's guide. *British Journal of Curriculum & Assessment, 2*(3), 11-20.

Cross-Gender Interaction in Technology Education: A Survey

W. J. Haynie, III

Though the traditional "industrial arts" programs of the 1950s which involved woodworking, metalworking, and other "shop" areas were heavily male dominated (Cummings, 1998; Hill, 1998; and Zuga, 1998), modern technology education could be more appealing to females. At one time there were very few female students and almost no female teachers in industrial arts courses, but as the discipline began to evolve towards a study of technology during the 1960s and 1970s a trickle of females joined the profession (Zuga, 1998). ITEA records show more females joining the profession since the name change to Technology Education than in the previous decade and an upward trend since then. Part of this increase is due to the attraction of predominately female elementary teachers to membership in the Technology Education for Children Council (TECC), but there are also more females in all segments of the profession than in the past (ITEA, 1998). In the 1950s, the boys who enrolled in industrial arts shop courses, and the men who taught those courses, viewed them as a "man's world" and there was little effort to foster participation by females.

At the same time that more females have been entering technology education, changes have been occurring in what is considered acceptable behavior in general society (Foster, 1996; Stevens, 1996; and Wolters & Fridgen, 1996). In the 1950s there were recognized lines of speech that most people generally agreed were not to be crossed. This especially was true in regard to sexually oriented comments, jokes, gestures, and speech—it was understood that such things were not talked about freely in "mixed company." The liberal movement of the 1960s began some change in those cultural mores and today much of what would have seemed absolutely taboo in the 1950s is presented on television during the "family hours." The terms "conservative" and "liberal" will be used rather loosely in this article, and they were on the instrument as well. Their inferred meanings may be understood by contrasting the television shows "Leave It To Beaver," "Donna Reed," and "Ed Sullivan" (all representing "conservative" views and values) versus "The Simpsons," "Roseanne," and "Late Night With David Letterman" (deemed "liberal").

William J. Haynie (haynie@poe.coe.ncsu.edu) is an Associate Professor in the Department of Mathematics, Science and Technology Education, North Carolina State University, Raleigh, NC.

Though this method of defining terms is not scientifically precise, readers should find it helpful in interpreting findings and implications.

How can males and females interact most comfortably within technology education? Though some research has been done concerning fairness of opportunity, attractiveness of topics/approaches, and ways to encourage more females to enter the profession (ITEA, 1994; Liedtke, 1995; Markert, 1996; Silverman & Pritchard, 1996; Trautman, Hayden, & Smink, 1995; and Volk & Holsey, 1997), there is still a need to determine how men and women feel about the cultural atmosphere within our profession, our classrooms and laboratories, and how teachers and students interact. This study is intended to be a beginning in the effort to assess how professionals in technology education feel about certain issues concerning cross-gender interaction in technology education and whether the perceptions of men and women differ on those issues. Since some of the topics are sensitive in nature, perhaps even taboo for some people, this work and its findings must be viewed as establishing a starting place rather than purporting definitive conclusions. Likewise, the cultural mores of our society and within our discipline are not stagnate, therefore continuing work will be needed to track the evolving cultural climate within our discipline. Do the factors studied here negatively impact the comfort level of females and add their weight to others responsible for low levels of participation by females in technology education at all levels?

Methodology

A survey of technology education professionals was conducted at the 1997 Technology Student Association (TSA) national conference in Washington, DC, June 23-27, 1997. Volunteer participants were sought at the "Advisors' Update" meetings. All of the advisors were practicing technology education teachers. Respondents were asked to complete the form while at the conference. Questionnaires were distributed to volunteers at the door and a brief announcement describing the study was made during the meeting. Of the 150 questionnaires distributed, 113 were returned. However, 18 of those were incomplete, so the final sample consisted of 95 (39 females and 56 males) for a response of 63.3%. Only one advisor from each school formally registers for the conference, but many schools have two or more advisors. Of the 238 officially registered advisors, only 31 were female (13%). So, it is clear that females were the minority, but a much higher percentage of females than males chose to be in the study. Perhaps the males were less concerned about these issues and females perceived them as more important.

The researcher developed the questionnaire. It included a brief demographics section that identified factors used in the analysis of issues considered in the survey. Most of the survey consisted of 52 items intended to determine respondents' perceptions on issues or situations. Rather than using traditional Likert-type scales for these items, each statement was followed by a continuum line on which respondents were instructed to mark with an "X" to indicate their perception between the two end points or poles of the continuum line. This is a variation of a technique used by Thurstone nearly 70 years ago and altered by others following him (Mueller, 1986). Each continuum was marked "0" on the left end, "100" on the right end, and had the center marked with "50." These three points on each continuum also had verbal descriptors related to the item. The left end of each continuum represented conservative (1950s) values or perceptions and the right end represented very liberal "anything goes" view-points (or extreme feminist perspectives for some items). For this study "conservative" connotes values evidenced in the "Leave It To Beaver" era on television in the USA and "liberal" connotes those prevalent in USA media today. This was noted in the general instructions at the beginning of the questionnaire.

Participants' responses were scored by actually measuring the position of the "X" they marked on each continuum using a 100-increment rule and entering the measured point (any whole number from 0 to 100) into the computer. Thus, all marks below 50 would represent some degree of conservatism, but a mark at the 13 point on the continuum would be considerably more conservative than a mark at the 37 point.

Since participants' response marks could vary between 0 and 100, the data were treated as continuous and were averaged and analyzed via comparison of means with SAS statistical software. Omnibus tests used the GLM variation of ANOVA and comparison of means used the LSD option for *t* testing. The .05 level of significance was used for all tests.

A series of open response items at the end of the questionnaire also provided opportunities for respondents to comment more freely. The instrument was rather lengthy and the four graduate students (2 male and 2 female) who field-tested it required an average of just over 17 minutes for completion. Because of the time required, there were many who did not complete the open response items or who only commented on one or two of them (these responses are noted where deemed important). The graduate students who helped to field test the instrument agreed that it was long, but they felt that the difficult nature of the problem and its importance warranted the length. These four professionals had public school teaching experience in technology education ranging from 2 to 13 years. Only minor editorial revisions were made after the initial field test.

Findings

Demographic information is displayed in Table 1. Some of these factors were used in later analyses to see if they influenced respondents' perceptions of the issues. One item used a continuum to ask how participants felt about the changing social climate: "The social trends of our times have led to more apparent general acceptance of crude and sexually oriented language in many settings. In my view this change is:" "0=disgraceful," "50=OK," "100=open & healthy." The overall mean of 23.4 indicates a conservative viewpoint and there was no difference between the views of males and females. However, teachers with more than ten years of experience were more conservative in their perception than their less experienced colleagues [$F(1,90) = 4.87$, $p = .0298$].

Table 1
Demographic information

	Groupings Used in Data Analysis	
Gender	Male, 56 (59%)	Female, 39 (41%)
Age	40 years or less, 46 (48%)	41 or older, 49 (59%)
Experience	10 years or less, 51 (54%)	11 or more, 44 (46%)

n=95

One item asked whether men and women are treated fairly in technology education. The overall mean of 44.4 indicates relative fairness with slight advantage to men. The means and ranges were: Women 41.7, 0-70, and men 46.2, 16-100 (no significant difference).

A series of six continuums were used to assess participants' perceptions of "sexually oriented comments, jokes, gestures or speech" (see Table 2). Each continuum was marked: "0=absolutely forbidden," "50=OK if tasteful," and "100=anything goes." Half of these items specified situations in which only "your own gender" is present and the other half included "the opposite sex." There were three situations: 1) students present; 2) on duty, but no students present; and 3) off duty (lounge or eating out at a conference). There were no significant differences between the means of men and women on any of these

Table 2
Perceptions on Sexually-Oriented Jokes and Speech

	Mean Responses				
	Males		Females		Overall
Situations	M	(SD) (Range)	M	(SD) (Range)	M (SD) (Range)
Mixed Company:					
Students Present	11.7	(14.2) (0-49)	12.7	(18.1) (0-50)	12.1
On Duty, No Students	24.3	(18.7) (0-50)	27.0	(20.9) (0-51)	25.4
Off Duty	31.1	(21.4) (0-75)	34.4	(18.3) (2-65)	32.5
Same Sex Only:					
Students Present	17.8	(15.7) (0-50)	16.9	(20.6) (0-59)	17.4
On Duty, No Students	28.5	(17.8) (0-78)	28.9	(22.2) (0-58)	28.7
Off Duty	35.1	(20.7) (0-87)	34.8	(20.7) (0-65)	35.0

Key:
0=Absolutely forbidden, 50=OK if tasteful, 100=Anything goes

continuums and all of them were below 36, indicating some degree of prohibition. There was, however, a definite pattern in the means. Means were a few points higher (less prohibition) when only one gender was present and they also were higher for the "off duty" settings. When students were present, the means were much lower, indicating that a higher standard of decency is expected when working with students. Of all of the analyses performed with various demographic sub groupings, the only one which was significant was that women who had one or more brothers were less tolerant of such comments and jokes in mixed company than were women who had no brothers [$F(1,37)=7.01$, $p=.0119$].

Another item stated: "I enjoy telling and hearing sexually oriented jokes in general." The continuum was marked: "0=never," "50=in limited settings," "100=very much." The overall mean was 29.7 and there was a significant difference between the views of men and women on this item, [$F(1,88)=4.87$, $p=.0300$]. Though both groups' means were considerably below the midpoint of 50, men (34.4, range 0-90) reported that they enjoy these sorts of jokes more than women (23.1, range 0-77). The less experienced teachers were also more tolerant of these jokes than teachers with over ten years of experience, $F(1,88)=6.36$, $p=.0135$.

A series of four items asked about gender specific but non-salacious jokes (see Table 3). As before, half of these items involved situations in which only one's own gender was present and the others included mixed company. Two of the items asked about jokes which were "gender specific but not derogatory (or only mildly so), with plays on 'male machismo' or 'female sensitivity'." There were no significant differences between the genders on these two items, but there was a trend that showed more liberal views when only one gender was present. Teachers with more than ten years of experience were more tolerant of these mild jokes than their junior colleagues. The remaining two items in this series concerned jokes which were "gender specific and intentionally derogatory, but not salacious (male immaturity/impatience, impulsiveness, PMS, driving, 'dumb blonde,' etc.)." These means were lower than those for the less offensive jokes above. There was no significant difference, though the trend showed slightly greater enjoyment of these jokes by males when with other males.

One item read: "In most regards, I feel that professionals in technology education correctly recognize the expected language and behavior patterns in cross-gender relationships, and they act/speak accordingly." The continuum was marked: "0=No! Too crude;" "50=Yes, OK;" and "100=No! Too stilted." Perceptions of men and women did not differ. The overall mean was 45.2, just slightly lower (cruder) than the "OK" point on the continuum. Another series of items concerned appropriate ways to greet colleagues and students and when it is acceptable to touch other people (Table 4). The continuums for all of these items were marked: "0=No! Forbidden;" "50=OK;" and "100=Yes, encouraged." Participants agreed that it is appropriate to greet both same sex and opposite sex professionals and students with a handshake. Greeting with an embrace, however, was not encouraged in general and there was no significant

Table 3

Perceptions on Gender Specific, Non Salacious Jokes

	Mean Responses								
	Males		Females		Less Experience		More Experience		Overall
Situations	M	(SD) (Range)	M	(SD) (Range)	M	(SD) (Range)	M	(SD) (Range)	M
Mixed Company:									
Mild, Non Derogatory	36.7	(19.1) (0-62)	29.8	(23.1) (0-77)	28.8	(22.6)* (0-77)	39.5	(17.5) (0-62)	33.86
Intentionally Derogatory	33.1	(17.5) (0-52)	27.6	(22.8) (0-78)	29.0	(21.8) (0-78)	32.9	(17.5) (0-52)	30.81
Same Sex Only:									
Mild, Non Derogatory	40.0	(20.9) (0-93)	31.8	(19.9) (0-63)	30.3	(19.7)* (0-63)	43.8	(19.8) (0-93)	36.69
Intentionally Derogatory	37.2	(21.9) (0-87)	28.5	(20.9) (0-79)	30.3	(19.8) (0-79)	37.3	(23.7) (0-87)	33.57

Key: 0=Absolutely forbidden, 50=OK if tasteful, 100=Anything goes

*$p<.05$

difference between genders in this regard. The overall mean was 39.9 which is below the 50=OK point on the continuum. On the other hand, when asked about greeting same sex professionals with an embrace, men and women differed significantly [F(1,92)= 9.06, p=.0034]. Men rarely thought it was appropriate to greet each other with an embrace and women felt it was very near the "OK" point on the continuum. Both men and women agreed that it is not appropriate to greet same sex or opposite sex students with an embrace.

Four items (Table 4) asked about the appropriateness of touching of colleagues or students "on the shoulder." In all of these items, men had significantly higher means than women, showing that they encouraged touching more, and in each case the men's mean was slightly above the "50=OK" point on the continuum while the women's mean was below.

The subgroup of teachers with more than ten years of experience had significantly higher means (showing greater levels of acceptance) than their less experienced peers on three of these items (as noted in Table 4). The last series of items using continuums for responses involved, "What would you do if…" statements which asked respondents how they would handle potentially embarrassing or otherwise uncomfortable situations. Each continuum was marked: "0=No! Chastise;" "50=OK, Ignore it;" and "100=Yes, Encourage." None of these situations was marked 50=OK or higher by either men or women, but there were some significant differences in how harshly men and women would react to some situations (see Table 5). The viewpoints of teachers who had opposite gender siblings differed significantly from their colleagues in four of these items (as indicated by notes "a" and "b" in Table 5). It appears that women who had brothers expected a higher standard of modesty from men than women without brothers—they were more likely to chastise men who said something they did not like or who took an uninvited "second look" at them. An earlier item had found that they did not condone salacious jokes in mixed company. In these cases, the women with brothers appeared to have somewhat a "they know better" attitude while the women without any brothers seemed to exhibit more of a "men will be men" attitude of resignation.

In another item it was found that men who had sisters were more likely to chastise students for making comments about another student's body/sex appeal than were men with no sisters. Perhaps growing up in a home with sisters allows men to sense how personally hurtful such comments can be, especially to girls in their teenage years. There were only four items in which significant differences such as these were found, but there were numerous items in which the non significant trends showed people of both genders who had opposite sex siblings to be more sensitive to the issues and more conservative in their viewpoints.

The final section of the questionnaire consisted of the open response items. The first of these was, "If a colleague asks you out, and you do not wish to go, how many times may they try again before you feel they have crossed the line to be harassing you?" The overall mean response on this item was 2.12 and there was no significant difference between the means of men and women. The ranges of responses were: Men=0-7, Women=1-5.

Table 5

Perceptions on Appropriate Reactions to Uncomfortable Interactions

	Mean Responses				
	Males	Females	Less Experience	More Experience	Overall
	M (SD) (Range)	M (SD) (Range)	M (SD) (Range)	M (SD) (Range)	M
A colleague touched you and you did not like it[a]	27.8 (29.9) (0-50)	21.5 (18.6) (0-50)	26.9 (16.9) (0-50)	23.3 (22.4) (0-50)	25.26
A student touched another student who seemed not to mind the action	39.2 (18.4)* (0-63)	29.9 (19.3) (0-50)	31.5 (19.6) (0-57)	39.8 (17.9) (0-63)	35.42
A student touched another student who recoiled	13.6 (14.7)* (0-50)	7.7 (12.3) (0-35)	11.4 (12.7) (0-36)	10.9 (15.5) (0-50)	11.22
A student complained about being touched	17.0 (29.5) (0-100)	19.8 (33.9) (0-100)	27.1 (34.9)* (0-100)	7.7 (22.6) (0-100)	18.16
A colleague said something sexual you did not like[b]	17.9 (16.9) (0-50)	20.1 (17.3) (0-50)	20.1 (16.3) (0-50)	17.3 (17.8) (0-50)	18.82
A student said something sexual you did not like	9.4 (11.1) (0-41)	6.5 (9.6) (0-34)	9.5 (11.2) (0-41)	6.8 (9.5) (0-31)	8.21
A student said something that offended other students	7.0 (9.1) (0-26)	3.8 (6.4) (0-18)	7.7 (8.8)* (0-23)	3.5 (7.0) (0-26)	5.70
A student used derogatory slang about homosexuals	15.67 (17.5)* (0-52)	5.2 (9.4) (0-31)	10.6 (12.1) (0-40)	12.2 (18.8) (0-52)	11.34
A student called another student a “fag”	12.9 (15.5)* (0-50)	4.8 (8.9) (0-28)	9.6 (12.1) (0-40)	9.5 (15.6) (0-50)	9.55

A student comments on another student's body/sex appeal[b]	15.1 (15.4) (0-50)	10.5 (13.2) (0-35)	12.4 (13.4) (0-43)	14.1 (15.9) (0-50)	13.18
A colleague used a crude, but not sexually oriented word	28.4 (18.3)* (0-57)	19.7 (19.0) (0-50)	23.5 (19.1) (0-50)	26.3 (18.9) (0-57)	24.78
A student used a crude, but not sexually oriented word	15.5 (16.6) (0-50)	9.9 (13.7) (0-50)	12.6 (15.0) (0-50)	13.9 (16.5) (0-50)	13.21
You noticed a professional of the opposite sex taking an obvious, but uninvited, "second look" at you[a]	39.0 (22.0) (0-87)	34.0 (21.4) (0-52)	32.8 (22.6)* (0-84)	41.8 (19.9) (0-87)	36.87
A male student uninvitedly "takes over" difficult task from a female student who was struggling to do it	29.1 (24.2) (0-100)	23.2 (24.4) (0-77)	25.5 (23.9) (0-77)	27.9 (25.1) (0-100)	26.56
A male colleague uninvitedly "takes over" a difficult task from you when you are struggling to do it (males omit)	NA	25.0 (25.7) (50-100)	28.3 (28.1) (50-100)	16.5 (16.3) (50-100)	25.00

Key: 0=No! Chastize; 50=OK, Ignore; 100=Yes, Encourage
[a]=Females with brothers were significantly more likely to confront
[b]=Males with sisters were significantly more likely to confront
*$p<.05$

Three items asked how respondents would signal that they disapproved of actions or speech of others. Facial expressions, frowns, backing away, and looking away were all mentioned frequently. Only a few respondents said they would confront the offending party openly, and they would do this only if the situation became a severe problem. Most respondents agreed that most people would recognize these "signals" of disapproval, and that they generally respond accordingly.

One item asked: "If a colleague desired to tell a crude or sexually oriented joke in mixed company and asked permission (hinting at its content), would you feel uncomfortable about answering truthfully?" To this question, 21 respondents answered yes and 40 answered no. This was followed with: "In most cases, would you allow them to tell it?" Responses were yes=37, and no=24. So, despite the fact that the mean (in an earlier item) for appreciation of such jokes was below 30 on a scale of 100, and the fact that another previous consensus mean of 23.4 showed that respondents believe our society is becoming too crude, over 60% of the respondents would allow someone to tell salacious jokes in mixed company if they were asked for permission. Many people evidently tolerate behavior that they do not appreciate.

Three items concerned respondents' general comfort level within technology education. "Do you generally feel comfortable among opposite sex colleagues in technology education?" (yes=59, and no=4). "Do you feel that colleagues of your own gender generally speak and act in appropriate ways around people of the opposite sex?" (yes=61, and no=5). The final item in this series asked if respondents felt that "inappropriate or excessive use of profanity, gestures, and/or sexually suggestive language and jokes by males is a major factor in explaining why more women do not enter the technology education profession?" Only one of the 59 participants who responded to this item answered yes.

Of the 21 responses to the final free response item and solicited comments item, 10 were entirely positive and commended our profession on its positive cross-gender interactions. Four respondents mentioned problems they had experienced with dating within the profession. The following quotations were selected noteworthy:

- "We should all monitor the reactions of others and adjust."
- "All people should be treated with respect."
- "Getting girls into TE earlier will increase female #'s and any problems will disappear."
- "The type of personality of women encountered in a male dominated area usually provides for an easier mix of attitudes and does not allow for slurs to be seen in every action."

This last comment was from a conservative veteran female teacher. She indicated here that a certain "type" of woman would feel more at home in technology education than others would. Thus, her comment could appear to be a positive one in that it expressed a reasonable comfort level, but it also has a very negative connotation in that it could exclude a large segment of females from our profession. It was the only comment that even hinted at this perception among all of the free response items—hopefully it is both a minority and a false impression. If only certain "types" of women are attracted to technology education, then we still have a good bit of work to do to make our profession attractive to all "types" of men and women.

Considerations

The author hesitates to attempt to draw firm conclusions from this research for two reasons. First, it was a very broad attempt to open a new area of inquiry within our profession and, like most early efforts, it likely has some flaws that would limit its interpretation. Among these are the fact that only a small percentage of technology teachers attend national TSA Conferences; participants in the study were all volunteers; due to conference location, the eastern portion of the country was likely over represented; and requesting participants to complete the questionnaire while at the conference may have been burdensome. Thus, the findings may only represent the views of those who felt strongly about the issues. It is clear that a higher percentage of the females at the conference participated in the study than did males. Nonetheless, should not these voices be heard if our male dominated profession is to attract and retain more females? Is it possible that the disproportionate response of females is itself an important finding that indicates a lack of sensitivity among males about these issues?

The other reason for hesitation in interpretation is the unusual nature of the instrument itself. Collecting the data via continuums may have been novel to most participants and may have resulted in a lower reliability than more well known Likert scales. However, this technique did allow participants to mark each response exactly where they thought it should be on a continuum instead of "force fitting" their perceptions into categories devised by the researcher. So, having conceded that drawing firm conclusions may be fraught with potential hazard, or even error, the following "considerations" are offered.

Most of the technology education professionals who were respondents to this study appear to be slightly conservative in their views and in their acceptance of salacious behavior. There was consistent agreement that this sort of discourse is not acceptable around students. Moreover, there was evidence to support the general notion that salacious behavior is not acceptable in any of the professional settings presented. Despite the influence on our society of examples of crude behavior in popular television shows, our profession appears to be conservative in regard to sexually suggestive behavior. Whether or not technology education professionals differ in this regard relative to teachers of other subjects, or other professionals in general, is not known and warrants further inquiry. Perhaps this or similar research should be conducted again in ten years to track changes.

In general, professionals of both genders indicated that they would confront (to some degree) persons who offended them or their students. Men are, evidently, more tolerant in some settings and less likely to chastise offenders than women. It was noteworthy that men were significantly more tolerant than women of derogatory statements about homosexuals and students calling each other a "fag." Since prejudice of any sort cannot be allowed in public schools, male teachers are encouraged to chastise anti homosexual speech, slurs, and actions with the same fervor as other abusive behaviors, regardless of their own personal views on homosexuality. Pre-service teachers should be made aware of this problem.

It appears that there is a reasonably healthy relationship between the genders within our profession. It seems that many technology education professionals feel that most colleagues recognize and uphold a level of good taste in their speech, and that a facial expression or simple rebuff is all that is generally required to indicate when one is offended by something someone else has said or done. Several statements were made that indicated that women wanted to be perceived for their abilities rather than their gender. This may be the most important outcome of this study.

Perhaps the closest thing to true "conclusions" that can be drawn from this initial work is that: (1) all technology education professionals should regard the school environment as a setting that requires a more conservative demeanor than society at large, (2) they should realize that their colleagues are likely to be slightly more conservative than the values implied by contemporary society, (3) they should be sensitive to constantly monitor the appropriateness of their own actions and adjust them according to the reactions of others, (4) and they should treat all persons with respect and fairness—judging them on their performance and ignoring all other potentially divisive factors.

Though our field is still predominantly male, there does appear to be some level of common understanding among males and females concerning the appropriate cultural mores for our profession at the present time and the majority of professionals evidently do conduct themselves accordingly. In addition to simple replications or variations with other groups of technology education professionals, three areas of inquiry should be probed as a continuation of the work herein. First, the finding that women who had brothers were less tolerant of coarse male behavior needs to be studied further. One might expect those women who had brothers to be more accustomed to and tolerant of traditional male behavior than women who did not grow up in homes with male siblings, but this was not the case in this study. Second, comparisons need to be made between the views of technology education professionals and those of professionals from other disciplines within education. Lastly, comparisons also need to be made with professionals in other technical (traditionally male dominated) fields outside of education. Perhaps the social climate is changing more or less in some of these other settings than it is in technology education. These potential changes could be approaching our profession.

References

Cummings, J. (1998). Foreword. In B. L. Rider (Ed.), *Diversity in technology education* (pp. iii-v). New York: Glencoe.

Foster, W. T. (1996). Technology, the arts, and social constructivism: R2D2 meets Degas. In R. L. Custer & A. E. Wiens (eds.), *Technology and the quality of life* (pp. 239-272). New York: Glencoe.

Hill, C. E. (1998). Women as technology educators. In B. L. Rider (Ed.), *Diversity in technology education* (pp. 57-75). New York: Glencoe.

International Technology Education Association. (1994). ITEA strategic plan: Advancing technological literacy. Reston, VA: ITEA.

International Technology Education Association. (1998). Personal interview and FAX memo from ITEA staff concerning membership trends, April 14, 1998.

Liedtke, J. (1995). Changing the organizational culture of technology education to attract minorities and women. *The Technology Teacher*, *54*(6), 9-14.

Markert, L. R. (1996). Gender related to success in science and technology. *The Journal of Technology Studies*, *22*(2), 21-29.

Mueller, D. J. (1986). Measuring social attitudes. New York: Teachers College Press.

Silverman, S., & Pritchard, A. M. (1996). Building their future: Girls and technology education in Connecticut. *Journal of Technology Education*, *7*(2), 41-54.

Stephens, G. (1996). Technology, crime & civil liberties. In R. L. Custer & A. E. Wiens (eds.), *Technology and the quality of life* (pp. 345-380). New York: Glencoe.

Trautman, D. K., Hayden, T. E., & Smink, J. M. (1995). Women surviving in technology education: What does it take? *The Technology Teacher*, *54*(5), 39-42.

Volk, K., & Holsey, L. (1997). TAP: A gender equity program in high technology. *The Technology Teacher*, *56*(4), 10-13.

Wolters, F. K., & Fridgen, J. D. (1996). The impact of technology on leisure. In R. L. Custer & A. E. Wiens (eds.), *Technology and the quality of life* (pp. 459-500). New York: Glencoe.

Zuga, K. F. (1998). A historical view of women's roles in technology education. In B. L. Rider (Ed.), *Diversity in technology education* (pp. 13-35). New York: Glencoe.

Research in Technology Education— Some Areas of Need

Theodore Lewis

Research is an important way in which the field of technology education can become further established. At least in the United States, this is not a field that has attracted sustained sponsored research funding over the decades. There has been no equivalent of the federally supported National Center for Research in Vocational Education (NCRVE), an agency that in the past two decades has given substantial character, both in terms of volume and direction, to inquiry in vocational education. For example, the current emphasis on integration of academic and vocational education, a major tenet of the new American vocationalism, draws heavily on NCRVE-generated research. Mainly because of the lack of sustained funding sponsorship, research in technology education has been sparse, outside of the theses of students, and unable to assume a coherent programmatic character. This is not to say that mere sponsorship is the curative the field needs. Sponsorship has its perils, not the least being the politicization of research agendas. But absence of funding reduces the scope and scale of the research efforts of the field.

In her review of research in technology education over the period 1987-1993, Zuga (1994) identified an imbalance of treatment. The studies were skewed in favor of curricular concerns. Among shortcomings were that few studies focussed upon the inherent value of the field. Topic areas that had received little attention included problem solving, cognition, instructional methods and strategies, and technological literacy.

Foster (1992) examined the research topics and methods of graduate students in the general field of industrial education, inclusive of technology education. The results were somewhat different from Zuga's in that program evaluation, and not curriculum, was the most frequent topic area. Foster commented that there was a predominance of surveys, and that about one quarter of the work consisted of status studies. He called for "clear direction from the leaders and veterans in the field" (p.71). Foster (1996) subsequently set forth a research agenda based upon the preferences of selected leaders and researchers. It was consistent with some of the recommendations of Zuga, both viewing technological literacy, and effectiveness of instructional techniques as research priorities.

Theodore Lewis (lewis007@maroon.tc.umn.edu) is professor in Industrial Education, College of Education and Human Development, University of Minnesota, St. Paul, MN.

In his meta-study of work published in the JTE since its inception, Petrina (1998) suggested that in general, authors have pursued an orthodox line, with very little published in the realm of critical theory. He found that few studies had situated technology education against a backdrop of the politics of education. Reviewing frameworks proposed for the field, Petrina found that none had acknowledged the politics of research. He proposed a comprehensive research framework, guided by a set of "cultural framing questions," paraphrased here as follows:

- How do we come to practice and understand technology?
- Toward what ends and means is the subject practiced?
- What should be the nature of technological knowledge?
- How should the content of the subject be organized?
- How is the subject today influenced by its history?
- How is technology practiced across cultures?
- Who participates in the subject and why or why not?

Petrina strongly suggests that the dearth of studies in the critical paradigm is evidence that the field is conservatively inclined. This makes the research of the journal "political." By way of remedy, he calls for activism on the part of editors and reviewers that could lead to the "shaping" of manuscripts accepted and published in the *JTE*. But this entreaty itself has an unwitting political ring to it, seeming to invest in these editors and reviewers a kind of regulatory power that would take them beyond their expected neutrality, toward artificial contrivance of the discourse of the field. While one can agree that there is need for encouragement and accommodation of a variety of research traditions within technology education, choice of paradigms should probably remain subject to the personal preferences of researchers.

The purpose of this article is to identify and discuss some promising lines along which the research of the field can proceed. The path to be taken here has to some degree been traversed previously, by Foster (1992, 1996), Petrina (1998), Wicklein (1993), and Zuga (1994). Shared with these prior works is the premise that the research of the field needs to proceed on several fronts, and that it should encompass a range of research paradigms. Also shared is the need to provide a means by which researchers can narrow their quest for interesting problems and questions. And indeed, some recurring topics from these prior works are discussed here. But this article also extends beyond the works cited above, in ways that include (a) a willingness to look at research in other subject matter areas of the school curriculum for inspiration for inquiry in technology education, and (b) the willingness to go beyond mere prescription of what ought to be studied, by dwelling and reflecting upon examples of the kind of inquiry being envisaged.

Research agendas are political instruments. They reflect the beliefs and values of those who propose them. But irrespective of political or ideological stance, we must come to terms with the basic question "what are the important questions of the field, and how do we arrive at them?" And the response to that should lead us first to the primary site where the subject is enacted, namely, schools. Thus, the most important questions of the field probably have to do with challenges encountered by students as they try to learn the concepts and processes of the subject, and by teachers as they try to impart this content. If we can agree that schools constitute the primary site of inquiry in technology education, then the ethos of classrooms and laboratories where the subject is taught must be a prime area of research need. And the administrative and policy milieu (comprised of state departments of education, school districts and school boards, principals, and teachers of other subjects) from which the subject must emerge to take its final shape as curriculum would be a target of inquiry.

These initial thoughts provide insight into the value orientation that this author brings to the work. The final outcome here is not intended to be a blueprint from which researchers of the field can proceed. Such a blueprint, to the extent that it is needed, has been adequately set forth by Petrina (1998). Instead, I dwell upon a few selected areas of inquiry that are compelling, because: (a) they relate fundamentally to the basic claims of the field, (b) they remind us that technology education ultimately is about learning and teaching and the primary actors in that enterprise must be brought into sharper focus, and (c) they share and conform to conceptual frameworks (such as situated cognition and constructivism) that unite technology education with other school subjects.

In the remainder of the paper, eight types of questions that can be the basis of inquiry are identified and discussed. These questions pertain to (a) technological literacy, (b) conceptions and misconceptions of technological phenomena, (c) perceptions of technology, (d) technology and creativity, (e) gender in technology classrooms, (f) curriculum change, (g) integration of technology and other school subjects, and (h) the work of technology teachers. Beyond these questions, a brief discussion of the need for adherence to new paradigms for research in technology education is presented, then final reflections are offered.

Areas of Research Potential

Questions pertaining to technological literacy

Though technological literacy is the primary claim of adherents of technology education, the field remains some distance still from being able to operationalize it routinely, thence to standardize it for assessment purposes. The dearth of research here was a common theme in Foster (1992), Petrina (1998), and Zuga, (1994). The clear need is for a multi-dimensioned, sustained program of work. This has been a strong area of conceptualization (e.g. Croft, 1990; Hayden, 1989; Lewis & Gagel, 1992; Pucel, 1995). In *Technology for All Americans*, the International Technology Education Association (1996) asserted that it is vital that the subject be included in the curriculum and made available to all. All high school graduates ought to be technologically literate, meaning that they can “understand the nature of technology, appropriately use technological devices and processes, and participate in society’s decisions on technological issues” (p.1). To ensure the inculcation of technological literacy, a need was indentified for educational programs “where learners become engaged in critical thinking as they design and develop products, systems, and environments to solve practical problems” (p.1).

One interesting line of research here can revolve around the quest for meaning. What do we mean by the term “technological literacy”? An example of work in this realm can be seen in Gagel (1995, 1997). Gagel employed phenomenological strategy, primarily hermeneutics (textual analysis), to explore meanings that are ascribed to the notion of technological literacy, and ways in which such meanings diverge depending on the particular disciplinary traditions to which advocates subscribe. Whether there is shared meaning in the field regarding what constitutes technological literacy is debatable. Since advocates of the subject tend to be polarized into process and content camps, it is conceivable that on this count alone there will be divergence of view as to what it means to be technologically literate. There is also the question of the role of performance in technological literacy. Should a technologically literate person be able to display some degree of practical competence? Can technological literacy be measured by paper and pencil examination only?

Another promising line of research here is the manifestation of technological literacy in adult life. Welty (1992) conducted a study of this type, in which adult behaviors, attitudes and knowledge about technological issues were probed. Did these adult subjects engage in political action regarding technological issues? Did they write letters to legislators, sign petitions, or vote on referenda? Such studies could be quite interesting, especially where the importance of taking technology education courses can be shown to influence such manifestations of adult literate behavior.

Whatever we say technological literacy might be, there is a need to avoid the development of an omnibus instrument to measure it. Instead, the concept would have to reflect variation in grade or developmental level. Measuring the technological literacy of a child in the second grade has to be different from measuring that of a child in the ninth grade. Adults would require a different form of the instrument than children.

How to deal with the content of technological literacy instruments is complicated, but the need for instrumentation is clear. Several versions of instruments are conceivable, some assuming a process approach to the subject, and others taking a content approach. In the former, technological literacy might focus on items that test critical thinking or problem solving. In the latter, specific content knowledge would have to be tested, reflecting the main areas of the field, namely, manufacturing, construction, manufacturing, energy and power, and transportation.

Inquiry on technological literacy must allow for consideration of both functional knowledge and school knowledge. Functional knowledge is knowledge and understanding that students derive from everyday life, outside of classrooms (see Tamir, 1991, for an example from science). To make claims about the subject with respect to student achievement, functional aspects of technological literacy would have to be controlled. What do students know about technology, independent of the taught curriculum?

Questions pertaining to conceptions or misconceptions held by students

A fruitful area of inquiry relates to functional knowledge, more particularly to the conceptions that students hold regarding aspects of the subject matter of technology or of technological phenomena. Do the conceptions held by students conform to normative expectations? For example, what conceptions do students have about what happens in an electric circuit when a switch is turned on? Or, do students have conceptions regarding how standard metal bars and rods get their shapes? Do students understand what occurs during the cooling of a casting? Do they understand why an airplane can fly, or what makes elevators go up and down? If asked to represent selected technological phenomena in the form of sketches, what would such representations reveal?

Understanding the conceptions (and misconceptions) that students have about aspects of the subject matter of technology is an important prerequisite for better teaching, and for improved learning. Parallels of this kind of research can be found in science. For example, Trumper (1996) studied conceptions of energy held by Israeli children. Children in the study held anthropocentric views about energy; that is, they associated energy with human beings. Energy was held to be a concrete rather than abstract idea. Fetherstonhaugh (1994) studied the breadth of ideas students held about energy (e.g., can it be stored, is it human-made or natural?). The authors asserted that it is necessary to devise theory that takes into account students' personal constructions of meaning.

Cosgrove (1995) got students to use analogies to help bridge the difference between their own conceptions of electricity, and a standard scientific notion of it. E. L. Lewis (1996) studied conceptual change in eighth grade students regarding elementary thermodynamics. The question of interest was how do students reorganize and reformulate knowledge. Parallels of these types of studies are possible in technology education. Such work would be new, and would open up exciting frontiers for the field.

Questions relating to perceptions about technology

How students view particular aspects of technology content leads to an inductive approach to inquiry. But equally critical is a deductive approach where the larger question regarding how students perceive technology as a whole can be explored. What do students hold the nature of technology to be, and what is the range of their perceptions? Do they view technology as being good or evil? Is technology perceived as something out of control and something we must fear? Is technology viewed to be synonymous with computers? Would everyday implements such as a knife and fork be considered examples of technology? In one recent study, Yasin (1998) examined the perceptions of technology held by high school students in Malaysia. The students were more apt to view modern tools and processes as quintessentially technology than they would traditional tools and processes. They were however concerned that traditional technologies should be preserved as part of cultural heritage. Studies of this type are needed, if we are to gauge whether conceptual change takes place after students pursue technological studies in school. Work in this realm is greatly aided by the development of approaches for such study by Rennie & Jarvis (1995) (see also Jarvis and Rennie, 1996).

Of interest would be the logic that students adopt in discerning what is and what is not an instance of technology. The role of developmental stages in determining the nature of the perceptions of students regarding technology remains an area of promise.

Questions pertaining to technology and creativity

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. Technology as a context for creativity is an important area of research. Much of the theorizing and research here has focused upon problem solving. The standard problem solving model called "the technological method" was proposed by Savage & Sterry (1990), in a work that had the imprimatur of ITEA. A facsimile of this model was subsequently proposed by Pucel (1992). The approach calls for identifying a need, developing a solution strategy, producing a solution, modifying that solution, and implementing it. An important advance here is the model set forth by Custer (1995). Custer classified types of problem solving activities in terms of complexity and goal clarity. He shows that all problem solving activities are not of equal creative merit. Troubleshooting is not of the same order of creativity as inventing. Custer's model could be an important research tool in helping researchers classify problem-solving activities they see in practice. While some problems may lend themselves to algorithms, others may respond only to heuristics. A second work of importance here is that of Hill (1997), who designed an instrument that could gauge the mental processes that students employed as they solved technological problems.

Writing in the context of art education, Johnson (1995) suggested that "the elements and principles of art are not written in stone at all, but in something perhaps more like finger jello: loose, pliable, and hard to pick up" (p. 58). This kind of thinking is needed with respect to creativity and technology. Also needed are constructivist notions which hold that students may bring uniqueness to how they approach problems. For example, Wu, Custer & Dyrenfyrth (1996) explored whether personal style might be a variable in solving problems. McCormick, Murphy & Hennessy (1994) found that students do not solve problems following the traditional steps of design (see also Hennessy & McCormick, 1994). There is thus the need for research that tries to find out just how students actually solve technological problems in classrooms. An important illustrative work here is that conducted by Glass (1992), in which the "think-aloud approach" was used to gain deep insight into children's creative thought while they solved problems.

It can be argued that the most creative aspect of problem solving is problem finding (or problem posing). And research that can probe the depths of the imagination of children as they propose problems that require technology as solution would add much to our understanding of creativity and technology. Lewis, Petrina & Hill (1998) argue for greater attention to problem posing in the teaching of the subject, and propose constructivism and situated cognition as conceptual frames that can be utilized as backdrops for such studies.

Within science education are examples of how constructivism and situated cognition approaches are used in the examination of problem posing as children do science. For example, Roth (1995) videotaped children as they worked on solutions to engineering structures problems, subsequently analyzing the dialogue employed by them as they worked cooperatively to solve the problems. It was found that students exhibited flexibility in framing and re-framing the problems. The process was not linear. In a like vein Appleton (1995) studied how students explored the problem space in solving discrepant event problems in science. The social context of the classroom, and encouragement to the students by the teacher to find their own solutions, were key factors in learning.

From the realm of mathematics, Cobb, Yackel & Wood (1989) raised the prospect that affect may be a factor in how children solve problems. This is interesting, suggesting that teachers have a role to play in influencing affective behavior. Teachers who provide encouragement and support may get better results or response from children than those who do not. Interesting questions here include: How do students solve technological problems? What kinds of problems requiring technology as solution would children pose if given the opportunity? What tends to inhibit or enhance problem solving and creativity? What can we learn from the talk of children as they solve technological problems? What do we know about those children who are successful in producing creative products? Is affect a determinant of creativity in the technology classroom? What actions on the part of teachers are more likely to promote creative behavior?

Questions pertaining to gender

Technology is a gendered subject, associated essentially with males. This is a major stigma for the subject, and thus a natural and high priority area of research. What prevents girls from being attracted to the subject? Zuga (1996) examined historical reasons for gender bias in the field, pointing out that important memory has been erased here in the form of the silent voices of female pioneers. There is need for historical research aimed at telling the story of women in the field more fully. O'Riley (1996) called for research in technology education from the point of view of women. This gender focus bears inquiry. How do girls feel about the subject? Do they see it as the domain of boys? What concerns or reservations do they have regarding their taking of technology classes? How do technology teachers treat girls in technology classrooms? Are girls treated differently than boys? Do girls approach the subject differently than boys? Do girls and boys show the same preferences for activities or projects? What perceptions do boys and girls have about each other within the realm of technology education classes? What social patterns emerge in coed technology classes?

There is much we can learn here from inquiry in science education where girls have comparable problems with respect to participation. A key issue is the empowerment of girls so that they see themselves as being capable of pursuing technology as elective courses, or pursuing technology-related careers (see Haggerty, 1995 for perspectives from science). Also from science, Harding & Parker (1995) point to the need for gender inclusive practice.

A good example of needed research relating to gender and technology education is the work of Silverman & Pritchard (1996) who studied gender differences in pursuing technology education elective courses. Though girls appeared to enjoy required technology education courses, they were less likely to continue taking such courses as electives. McCarthy & Moss (1994) also found that girls and boys liked the subject equally. These researchers found that the shift away from the emphasis on craft made the subject more palatable to girls. Thus, does the modular approach to the subject make it more accessible and appealing to girls?

Questions pertaining to curriculum change

Though curriculum has been the prime area of inquiry in technology education in the United States, little is known about the pragmatics of the curriculum change process. What the change from industrial arts to technology education entails in actual schools or school districts has been studied very little. There is rich literature in the field on curriculum. Within this literature the difficulties inherent in the change process have been examined, pathways available for curriculum designers explored, and commentaries made on curricular trends (e.g. Hansen, 1995; Herschbach, 1989; Johnson, 1989; Kuskie, 1991; Lewis, 1994; Petrina, 1994; Raizen, 1997; Shield, 1996; Zuga, 1993). But there is need for an empirical counterpart to this literature, the greatest of which might be for case studies that focus upon actual instances of attempts at curriculum change, where school districts, schools, or particular teachers could be the unit of analysis.

A good example of the type of studies needed is that reported by Treagust & Rennie (1993). This was an evaluation of how six schools in Western Australia implemented the new curriculum area of technology education. Questionnaires, school visits, and document analysis were aspects of the methodology. The focus included obstacles to implementation, and factors that contributed to successful outcomes.

There is need for studies that probe into why some teachers might be more prone to change than others. Are there contextual factors? Personal factors? Is it a matter of availability of resources? Is it a matter of leadership in school buildings? One impediment to examining change from industrial arts to technology education might be that we try to hold schools to a curricular ideal, from which they must work *backwards* to their practice. This requires whole-scale change. But perhaps another way to approach this question is incrementally; that is, the researcher works *forward* from practice towards the ideal. Every increment of change along the way counts. Thus, there is need for subtle methods to measure change. Small changes might be more typical in practice, and it would be a mistake for the field to overlook them. For example, instead of changing the entire curriculum, a school might decide to introduce one or two new courses that reflect technology. Or courses may retain their traditional names, but within them there is new content. Such an approach to curriculum change would require on-site data collecting. The researcher would not be able to discern such change without a close-up examination of programs, inclusive of conversations with the teachers in question.

In looking at change then, there are macro and micro possibilities. Macro possibilities include examination of the context of change, where principals, school-board members, parents, and teachers of other subjects, are potential key informants. Micro possibilities include examination of curriculum documents such as curriculum rationales, textbooks, course outlines, and tests; observations of laboratory equipment; observations of classes in session; and conversations with technology teachers and students.

What does curriculum change entail, in practical terms? What are the optimum conditions under which change best takes place? These are kinds of inquiry that can be pursued.

Questions pertaining to curriculum integration

If schooling is to have desired meaning for children, then the various elements of the curriculum must cohere. Lessons learned in one subject must be amplified in others. To take its place squarely in school curricula, technology education must establish itself not just in its own right, but crucially in relation to other subjects. Thus, the relationship of technology to other subjects in the curriculum is a fruitful area of inquiry. The field has to understand integration better. Within the research literature of the field can be found theoretical examination of integration (e.g. Dugger, 1994; Foster, 1995; LaPorte and Sanders, 1993). Further, there has been published empirical work, especially with regard to combinations of technology, mathematics, or science (e.g. Childress, 1996; Dugger & Meter, 1994; Scarborough & White, 1994). Dugger & Meter (1994) as well as Scarborough & White (1994) explored whether integration led to improved achievement in physics. Childress explored the influence of integration on technological problem solving ability.

One framework that can be of worth here is that of situated cognition, which calls for social learning and learning in authentic contexts (e.g. Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). Further, useful models for integrating curriculum and for framing related research questions are provided by Fogarty (1991). In the process of studying technology and learning technological concepts, other aspects of the curriculum can become more accessible for students. While science and mathematics have been more typical allies, it is conceivable that such alliances can extend across the curriculum, first with more natural allies, such as art, agriculture and home economics, then with others such English, music, and social studies. Needed are good case studies or evaluative studies that focus upon attempts at integration. Much can be learned from such studies that can be of benefit in improving the chances of integration projects achieving their goals.

The kinds of questions that can be pursued within the realm of curricular integration include: (a) does integration with technology help improve student learning of technological concepts and processes? Does such integration improve learning of collaborating subject areas? What models of integration bear the most promise? What strategies are more likely than others to lead to the success of curriculum integration projects?

One key area of opportunity for integration is the relationship between technology education and vocational education. Many aspects of these two fields coincide, including the situated nature of instruction (laboratory focus), and learning by doing. There are also historical alliances here, and natural possibilities for crossing curricular borders (see a discussion in T. Lewis, 1996). Further, the nature of work is changing, and one important dimension of such change is the new emphasis on knowledge work (e.g. Frenkel, Korczynski, Donoghue & Shire, 1995). Pointing to such workplace change, Layton (1993) asserted that vocational education was becoming more generalized, and general education was becoming more vocationalized. Technology education, he pointed out, would be an important context for the general curriculum—a way to connect it with the human-made world.

It is pointless to conceive of technology education purely as liberal education, when the true strength of the subject may lie in its real-world connections. Context helps students give meaning to school knowledge, and work is an important context for technology in the real world. Technologists are workers.

Technology education scholars have been exploring relationships with tech-prep (e.g. Betts, Welsh, & Ryerson, 1992; Roberts & Clark, 1994). This kind of inquiry should be promoted. By tradition, technology in the upper grades tends to be focused upon careers. But in the very earliest grades too, technology can be the vehicle for helping children understand the nature of work, and catching their first glimpses of careers. This natural affinity of technology education and vocational education gives the former a head start on school-to-work initiatives in schools. It needs to be remembered that it is connection with vocational education that gave to the field the halcyon period of the 1960s. Projects such as IACP, American Industry, and the Maryland Plan, were all rationalized in terms of the career possibilities of technology education. These funding possibilities have returned with the school-to-work movement and tech-prep. The natural career implications of studying technology education ought to be exploited. It is possible, and justifiable, to teach about careers as one teaches technology, at any grade level.

Useful frameworks for inquiry that explore integration of academic and vocational education are provided by Grubb, Davis, Lum, Plihal, Morgaine (1991); and Beck, Copa, & Pease (1991). Interesting questions in this realm of inquiry include: Does integration with vocational education improve student understanding of technology? Does such integration engender both vocational and technological literacy? Does integration of technology education and vocational education enhance student learning of the skills employers want? One approach to inquiry of this order would be to study cases of technology and vocational integration. Exemplary programs of technology education and vocational education integration can be studied as cases.

Questions that focus upon teachers

One further line of needed inquiry relates to the teachers of the profession. This research can be conceived from many angles, the following being but three areas of fruitful possibility: (a) the work and professional lives of teachers, (b) the experiences of beginning teachers, and (c) exemplary teachers.

Just what teachers of technology do in their classrooms—the practical and professional knowledge they draw upon, and the contextual factors that impact upon how they perform, needs to be examined. The voices of these teachers need to be heard. How do they feel about the level of support they get from their school boards, principals, and fellow teachers? What thoughts do they hold about their profession? How do they feel about the curriculum they must teach? What pedagogical thoughts and judgements do they harbor? How do they feel about the students who take their courses? What impediments do they identify as hindrances to their work?

Little & Threatt (1994) provide an excellent example of inquiry into the work of teachers, in their interpretive study of the travails of selected high-school vocational teachers in one state. Conceptual frameworks for such work are set forth in Little & McLaughlin (1993). Clandinin & Connelly (1996) provide an excellent model of inquiry into the professional knowledge of teachers, and the contexts that help shape such knowledge.

The experiences of beginning teachers in technology education represent a special case of the work of teachers. Understanding what it's like to be a beginning technology education teacher can be an important precursor of teacher education reform. This is an area where we know little. One line of such inquiry could focus on the effects of mentoring on the beginning teacher's performance (see Wildman, Magliaro, Niles & Niles, 1992). Another can examine the efficacy of structured beginning experiences (such as internships) (e.g. Johnson, Ratsoy, Holdaway, & Freisen, 1993). The kinds of help sought by beginning teachers could be examined (e.g., Tellez, 1992; or Veenman, 1984).

A counterpart to studying the circumstances of beginning teachers—novices—is to study expert or exemplary teachers. What are the behaviors exhibited by expert technology teachers? What do such teachers do that make them stand out? What do they believe about the curriculum, pedagogy, or children? What do students say about such teachers and about the classes they have taken from them? The need here would be especially for qualitative type studies that are classroom based and that extend over meaningful periods of time. The individual teacher could be the unit of analysis.

A Word on Methodology

The proposals I have set forth above are amenable to a range of research approaches and traditions. There are times when the researcher can conduct inquiry from a remote campus location, but to get primary evidence, first-hand, on-site observations are essential. The key to how the field views research priorities in the future will depend on the willingness of researchers to range beyond the traditional positivistic paradigm toward phenomenological and critical modes. In particular, teachers would have to be encouraged to be researchers in their own right, or collaborators in research.

Arguing the case for the acceptance of new paradigms for research in art education, Eisner (1993) pointed out that those in the arts would find qualitative approaches to be better suited to their core values than was possible with positivistic approaches. He argued, "…I can think of no more important research agenda for art education than the fine grained study, description, interpretation, and evaluation of what actually goes on in art classrooms" (p. 54). He went on to point out that there is "room in the educational research community for many mansions…Different methods make different forms of understanding possible." (p. 54). This is wise counsel. Applied, it means that we in technology education must employ the paradigm that can best answer the questions we wish to have answered. If we stick to tried and true paradigms, the consequence is that certain key kinds of questions will not be asked or answered.

Hoepfl (1997) has taken the important step of providing the field with a primer on how qualitative studies might be approached. Likewise, Petrina (1998) and Zuga (1994) have sought to push the field in this direction. It is a direction that would open up unlimited possibilities for inquiry.

Conclusion

The thoughts that have been set forth here are meant to contribute to a dialogue in the field regarding frontiers that need to be expanded next. Research is fundamentally a creative enterprise, with the most creative aspect arguably being the ability to find challenging and interesting problems. Any framework that purports to encompass all of the questions will militate against itself by stifling creativity. We have to talk about research needs in a way that engenders ever more possibilities. Rather than boxing in the researchers, we must see ways to push the limits and explore new and different frontiers. Researchers in the field are encouraged to use what has been presented herein as food for thought or starting points for new lines of inquiry. But the challenge is to find their own questions, well beyond those imagined and described here. Many areas of our field were left untouched by the research questions I have set forth for attention. For example, little attention was given to teacher education or elementary school technology. But I believe that a focus on the classroom, on students and teachers, and on the subject matter itself, such as what has been proposed, can lead to relevant and fruitful inquiry.

References

Appleton, K. (1995). Problem solving in science lessons: How students explore the problem space. *Research in Science Education*, *25*(4), 383-393.

Beck, R. H., Copa, G. H., Pease, V. H. (1991). Vocational and academic teachers work together. *Educational Leadership*, *49*(2), 29-31.

Betts, R., Welsh, H., & Ryerson, T. (1992). Tech Prep? Technology Education Relationship. *The Technology Teacher*, *51*(5), 5-6.

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32-42.

Childress, V. W. (1996). Does integrating technology, science, and mathematics improve technological problem solving? A Quasi-experiment. *Journal of Technology Education*, *8*(1), 16-26.

Clandinin, D. J., & Connelly, F. M. (1996). Teachers' professional knowledge landscapes: Teacher stories—stories of teachers—school stories—stories of schools. *Educational Researcher*, *25*(3), 24-30.

Cosgrove, M. (1995). A study of science-in-the-making as students generate an analogy for electricity. *International Journal of Science Education*, *17*(3), 295-310.

Cobb, P., Yackel, E., & Wood, T. (1989). Young children's emotional acts while engaged in mathematical problem solving. In D. B. McLead & V. M. Adams (Eds). *Affect and mathematical problem solving* (pp.117-148). London: Springer-Verlag.

Croft, V. E. (1990). Technological literacy: Characteristics of a high school graduate. Paper presented at the Annual Conference of the International Technology Education Association, Indianapolis, IN.

Custer, R. L. (1995). Examining the determinants of technology. *International Journal of Technology and Design Education*, *5*, 219-244.

Dugger, J. C., & Meier, R. L. (1994). A comparison of second-year Principles of Technology and high school physics student achievement using a Principles of Technology Achievement test. *Journal of Technology Education*, *5*(2), 5-14.

Dugger, W. E. (1994). The relationship between technology, science, engineering, and mathematics. *The Technology Teacher*, *53*(7), 5-23.

Eisner, E. W. (1993). The emergence of new paradigms for educational research. *Art Education, 46*(6), 51-55.

Fetherstonhaugh, T. (1994). Using the repertory grid to probe students' ideas about energy, *Research in Science and Technological Education*, *12*(2), 117-127.

Fogarty, R. (1991). Ten ways to integrate curriculum. *Educational Leadership, 49*(2), 61-65.

Foster, W. T. (1992). Topics and methods of recent graduate student research in industrial education and related fields. *Journal of Industrial Teacher Education*, *30*(1), 59-72.

Foster, W. T. (1995). Integrating educational disciplines. *The Technology Teacher*, *54*(8), 45.

Foster, W. T. (1996). A research agenda for technology education. *The Technology Teacher*, *56*(1), 31-33.

Frenkel, F., Korczynski, M., Donoghue, L., & Shire, K. (1995). Re-constituting work: Trends toward knowledge work and info-normative control. *Work, Employment & Society*, *9*(4), 773-796.

Gagel, C. (1995). Technological literacy: A critical exposition and interpretation for the study of technology in the general curriculum. Doctoral Dissertation, University of Minnesota, 1995). *Dissertation Abstracts International*, *56*, 2208A. (University Microfilms No. 9534116).

Gagel, C. W. (1997). Literacy and technology: Reflections and insights for technological literacy. *Journal of Industrial Teacher Education. 34*(3), 6-34.

Glass, A. R. (1992). The effects of thinking aloud pair problem solving on technology education students' thinking processes, procedures, and solutions. (Doctoral dissertation, University of Minnesota, 1992). *Dissertation Abstracts International*, *53*, 05A, p. 1382.

Grubb, W. N., Davis, G., Lum, J., Plihal, J., & Morgaine, C. (1991). *The cunning hand, the cultured mind: Models for integrating vocational and* *academic education*, Berkeley, CA: University of California, National Center for Research in Vocational Education.

Haggerty, S. M. (1995). Gender and teacher development: Issues of power and culture, *International Journal of Science Education*, *17*(1), 1-15.

Hansen, R. E. (1995). Five principles for guiding curriculum development practice: The case of technological teacher education. *Journal of Industrial Teacher Education*, *32*(2), 30-50.

Harding, J., & Parker, L. H. (1995). Agents for change: Policy and practice towards a more gender-inclusive science education. *International Journal of Science Education*. *17*(4), 537-553.

Hayden, M. A. (1989). What is technological literacy? *Bulletin of Science, Technology, and Society*, *9*, 228-233.

Hennessy, S., & McCormick, R. (1994). The general problem solving process in technology education: Myth or reality? In F. Banks, (ed). *Teaching technology,* (pp. 94-107). New York: Routledge.

Herschbach, D. R. (1989). Conceptualizing curriculum change. *The Journal of Epsilon Pi Tau*, *15*(1), 19-28.

Hill, R. B. (1997). The design of an instrument to assess problem solving activities in technology education, *Journal of Technology Education*, *9*(1), 31-46.

Hoepfl, M. C. (1997). Choosing qualitative research: A primer for technology education researchers, *Journal of Technology Education*, *9*(1), 47-63.

International Technology Education Asociation (1996). *Technology for All Americans*. Reston, VA: Author.

Jarvis, T., & Rennie, L. J.(1996). Understanding technology: the development of a concept. *International Journal of Science Education*, *18*(8), 977-992.

Johnson, M. (1995). The elements and principles of design: Written in finger jello? *Art Education*, *48*(1), 57-61.

Johnson, N. A., Ratsoy, E. W., Holdaway, E. A., & Friesen, D. (1993). The induction of teachers: A major internship program. *Journal of Teacher Education*, *44*(4), 296-304.

Johnson, S. D. (1989). Making the transition to technology education: Lessons from the past. *The Technology Teacher*, *48*(5), 9-12.

Kuskie, L. (1991). Making the transition from industrial arts to technology education. *The Technology Teacher*, *51*(1), 32-35.

LaPorte, J., & Sanders, M. (1993). Integrating technology, science, and mathematics in the middle school. *The Technology Teacher, 52*(6), 17-21.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Layton, D. (1993). *Technology's challenge to science education*, Buckingham, Open University Press.

Lewis, E. L. (1996). Conceptual change among middle school students studying elementary thermodynamics. *Journal of Science Education and Technology*, *5*(1), 3-31.

Lewis, T. (1994). Limits on change to the technology education curriculum. *Journal of Industrial Teacher Education*. *31*(2), 8-27.

Lewis, T. (1996). Accommodating border crossings. *Journal of Industrial Teacher Education*, *33*(2), 7-28.
Lewis, T., & Gagel, C. (1992). Technological literacy: A critical analysis. *Journal of Curriculum Studies*, *24*(2), 117-138.
Lewis, T., Petrina, S., & Hill, A.M. (1998). Problem posing—Adding a creative increment to technological problem solving. *Journal of Industrial Teacher Education*, *36*(1), 5-35.
Little, J. W., & McLaughlin, M. W. (Eds.) (1993). *Teachers' work: Individuals, colleagues, and contexts*. New York: Teachers College, Columbia University.
Little, J. W., & Threatt, S. M. (1994). Work on the margins: Compromises of purpose and content in secondary schools. *Curriculum Inquiry*, *24*(3), 269-292.
McCarthy, A. C., & Moss, G. D. (1994). A comparison of male and female pupil perceptions of technology in the curriculum. *Research in Science and Technological Education*, *12*(1), 5-13.
McCormick, R., Murphy, P., & Hennessy, S. (1994). Problem solving processes in technology education: A pilot study. *International Journal of Technology and Design*, *4*(1), 5-34.
O'Riley, P. (1996). A different story-telling of technology education curriculum re-visions: A storytelling of difference. *Journal of Technology Education*, *7*(2), 28-40.
Petrina, S. (1994). Curriculum organization in technology education: A critique of six techniques. *Journal of Industrial Teacher Education*, *31*(2), 44-69.
Petrina, S. (1998). The politics of research in technology education: A critical content and discourse analysis of the Journal of Technology Education, Volumes 1-8. *Journal of Technology Education*, *10*(1), 27-57.
Pucel, D. J. (1992). Technology education: A critical literacy requirement for all students. Paper presented at the 79th Mississippi Valley Industrial Education Conference, Chicago, Il.
Pucel, D. J. (1995). Developing technological literacy: A goal for technology education. *The Technology Teacher*, *55*(3), 35-43.
Raizen, S. A. (1997). Making way for technology education. *Journal of Science Education and Technology*, *6*(1), 59-70.
Rennie, L. J., & Jarvis, T. (1995). Three approaches to measuring children's perceptions of technology. *International Journal of Science Education*, *17*(6), 755-774.
Roberts, P., & Clark, D. (1994). Integrating technology education and Tech Prep. *The Technology Teacher*, *53*(6), 43-44.
Roth, W. M. (1995). From "Wiggly structures" to "Unshaky Towers": problem framing, solution finding, and negotiation of courses of actions during a civil engineering unit for elementary students. *Research in Science Education*, *25*(4), 365-381.
Savage, E., & Sterry, L. (1990). A conceptual framework for technology education. *The Technology Teacher*, *50*(1), 6-11.

Scarborough, J. D., & White, C. (1994). PHYS-MA-TECH: An integrated partnership. *Journal of Technology Education*, *5*(2), 31-39.

Shield, G. (1996). Formative influences on technology education: The search for an effective compromise in curriculum innovation. *Journal of Technology Education*, *8*(1), 50-60.

Silverman, S., & Pritchard, A. M. (1996). Building their future: Girls and technology education in Connecticut. *Journal of Technology Education*, *7*(2), 41-54.

Tamir, P. (1991). Factors associated with the acquisition of functional knowledge and understanding of science. *Research in science and Technological education*, *9*(1), 17-37.

Tellez, K. (1992). Mentors by choice, not design: Help-seeking by beginning teachers. *Journal of Teacher Education*, *43*(3), 214-221.

Treagust, D. T., & Rennie, L. J. (1993). Implementing technology in the school curriculum: A case study involving six secondary schools. *Journal of Technology Education*, *5*(1), 38-53.

Trumper, R. (1996). A survey of Israeli Physics students' conceptions of energy in pre-service training for high school teachers. *Research in Science and Technological Education*, *14*(2), 179-192.

Veenman, S. (1984). Perceived problems of beginning teachers. *Review of Educational Research*, *54*(2), 143-178.

Welty, K. (1992). Technological literacy and political participation in McLean County, Illinois. *Journal of Industrial Teacher Education*, *29*(4), 7-22.

Wicklein, R. C. (1993). Identifying critical issues and problems in technology education using a modified-delphi technique. *Journal of Technology Education*, *5*(1), 54-71.

Wildman, T. M., Magliaro, S. G., Niles, R. A., & Niles, J. A. (1992). Teacher mentoring: An analysis of roles, activities, and conditions. *Journal of Teacher Education*, *43*(3), 205-213.

Wu, T-F., Custer, R. L., & Dyrenfurth, M. J. (1996). Technological and personal problem solving styles: Is there a difference? *Journal of technology education*, *7*(2) 55-71.

Yasin, R. M. (1998). *A study of Malaysian students' Perception of Technology*. Unpublished doctoral dissertation, University of Minnesota, Twin Cities.

Zuga, K. F. (1993). A role for alternative curriculum theories in technology education, *Journal of Industrial Teacher Education*, *30*(4), 49-67.

Zuga, K. (1994). *Implementing technology education: A review and synthesis of the literature*. Columbus, Ohio: ERIC Clearinghouse on Adult, Career, and Vocational Education.

Zuga, K. F. (1996). Reclaiming the voices of female and elementary school educators in technology education. *Journal of Industrial Teacher Education*, *33*(3), 23-43.

Addressing Women's Ways of Knowing to Improve the Technology Education Environment for All Students

Karen F. Zuga

I often help my female friends to negotiate parts of the technical world. For one it may be going on a car buying expedition, for another it may be a computer installation, and for yet another it may be the replacement of rotten boards on a front porch. They know that I enjoy such expeditions and, I hope, that they actually believe that I can be helpful.

One recent Labor Day weekend I was engaged in helping a friend to replace the worn and damaged boards on her front porch. We worked the day away, pulling boards, removing rotten wood, and replacing it with solid wood. As we worked, I thought about how she probably had not been given much instruction in how to use tools and to construct with wood. Nonetheless, she was trying to do a simple household repair in order to save herself money. Her skills and tool selections were clear evidence of a lack of technical knowledge and her plans for the repair process, while adequate, needed some improvement. Probably, I thought, like my own school experiences, she did not have the opportunity to study "industrial arts" when she was going to school. Yet, I was concerned because young women today, given the opportunity to do so, are still not taking technology education courses in great numbers. Women and girls often perceive the subject of technology education as a male domain, especially after they have had a course in technology education (Hendley, Stables, Parkinson, & Tanner, 1996; Bame, Dugger, & deVries, 1993; Bame & Dugger, 1990).

Yet, women are technologists. Women are and have always been significant contributors to the making of the environment of which we are a part. Every woman has been a technological being, using and often inventing tools, materials, and processes in order to adapt and modify her world. Their contributions have been either focused on the traditional homemaking roles of females, or they have been diminished in the records of industrial and economic spheres (Wajcman, 1991). In addition to diminishing the role of women in technology and engineering, many technical occupations, including science, have a low representation of women. Are there differences between women and men which might influence their choice of study and which need to be addressed? Can technology educators begin to address the lack of participation

---

Karen F. Zuga (zuga.1@osu.edu) is an Associate Professor in Math, Science and Technology Education, School of Teaching & Learning, The Ohio State University, Columbus, OH.

of women and girls in technology education without understanding the potential for differences between men and women with regard to technology and to education? I want to explore these questions by discussing feminist theories of science and technology and of women's ways of knowing in order to bring cultural feminists' concerns to the attention of technology educators.

Feminist Theories

There is a rainbow of feminist theories which suit the ideological bent of women who espouse them. In an overview of feminism, Donovan (1994) described feminists as liberal; cultural; related to other theories such as Freudianism, Marxism, existentialism, etc.; radical; promoting a new feminist moral vision; and ecofeminists. Essentially, *liberal_feminists* have called attention to the inequality in society and have proposed remedies to that inequality. *Cultural feminists* have created a rationale for the differences in male and female cultures. *Feminists influenced by other philosophies* such as existentialism and postmodernism have interacted with those philosophies by both applying them to feminist ideas and principles and influencing the root philosophy with feminist ideas and principles. *Radical feminists* blame patriarchy as the cause of all societal problems and seek to supplant it with women's modes of thinking and acting. *Ecofeminists* incorporate several of the previously mentioned views into a theory of feminist values for the good of the environment. *Feminists of the new moral vision* integrate cultural feminism sans radical feminism in order to address inequity to create, for women and men, not just inclusion in a male dominated society, but a means of promoting the value of women's ways of thinking and acting. It is this category of feminist thought which underpins the discussion here.

Science, Technology, and Gender

Clearly, the dominant culture in Western society is the male culture, not by size but by influence. Evidence of this exists in the roles which women take on in relation to men, the valuing of traditional female roles in economic theory which historically has not factored in the contributions of women in the home (Fee, 1986; Rose, 1986; Donovan, 1994), the traditional use of language to prefer male pronouns to indicate all humans (Minnich, 1990), and the inability of politicians and citizens to successfully support an equal rights for women amendment to the Constitution. These and many other indications of the subjugation of the female in a hierarchy of value are explicitly evident in Greek philosophy, the bedrock of Western thought (Donovan, 1994; Minnich, 1990; Harding, 1986; Fox Keller, 1985). Essentially, women are relegated to second class status or invisibility in Western culture.

There are some who doubt the power of language and "ancient" philosophy, but Greek philosophical concepts persist in our culture through our use of language. About using the generic term "Man," Minnich (1990) provides a powerful illustration by using the rules of syllogistic logic that have been handed down from Greek philosophers.

> Consider the famous syllogism: ‘Man is mortal. Socrates is a man. Therefore, Socrates is mortal.’ Try it with a woman: ‘Man is mortal. Alice is__________’ what? A man? No one says that, not even philosophers. ‘Man,’ the supposedly generic term, does not allow us to say, ‘Alice is a woman.’ Then what are we to deduce? ‘Therefore, Alice is_____ ____’ what? …Reason flounders; the center holds, with Man in it, but it is an exclusive, not universal or neutral, center. Alice disappears through the looking glass. (Minnich, 1990, p. 39)

The use of language is powerful in shaping our thoughts (Wright, 1992), but Greek philosophy has shaped more than our thoughts through the use of language. It has shaped our actions.

Modern science is based in the rationalism and logical positivism inherited from our heritage of Greek philosophy (Longino, 1990; Arrington, 1989; Harding, 1986; Fox Keller, 1985; Bernstein, 1978). The rationale and argument which reinforced the duality of logic as science and emotion as nature and assigned gender characteristics to these concepts is found in Greek philosophy, especially the philosophy of Plato. According to a host of philosophers, both male and female, modern science is founded upon Plato’s philosophy (Longino, 1990; Arrington, 1989; Harding, 1986; Bernstein, 1978), Fox Keller (1985) summarized this thinking.

> Modern science can thus be said to be following Plato’s script, but without heeding his cautionary advice. In this script it appears inevitable that intercourse with physical nature evokes the domination and aggression appropriate to women and slaves. (p. 31)

Western science and technology have evolved based upon the concept of predicting and controlling nature, and nature has been assigned the female gender by Western philosophers.

Adding to the philosophy which has enabled the growth of Western science and technology was Bacon who furthered the arguments for power and domination of nature. Bacon helped to further separate the world into a duality, the mind as knower (masculine) and nature (feminine) as the knowable, a division into man as knower and subject and woman as knowable and object, placing man the subject and knower in control of women the object and knowable.

> Through science and art (that is, technology, or mechanical art), man can find the power to transform not so much the world as his relation to the world. The goal of science was, for Bacon, ‘the restitution and reinvesting of man to the sovereignty and power …which he had in his first state of creation’ [Robertson, 1905, p. 188]. (Fox Keller, 1985, p. 35)

In Western philosophy, through the language and metaphor, as well as through the history of practice, science and technology have become intertwined and linked to masculinity. Linked to science through the concept of applied science, technology assumes the masculine connotations given to science as an activity of power and conquest over nature. As an activity in itself, technology is an attempt to control nature, becoming another example of where gender assignment is made to the subject as control. Reinforcement of gender characteristics is carried out in duality of technology and nature and the metaphor of technology as masculine dominating nature as feminine.

> Masculine here connotes, as it so often does, autonomy, separation, and distance. It connotes radical rejection of any commingling of subject and object, which are, it now appears, quite consistently identified as male and female. (Fox Keller, 1985, p. 79)

While Bacon provided stepping stones of ideas for the growth of Western philosophy of science, Descartes has been given the credit for reifying the masculinization of Western scientific and technological thought (Bordo, 1987; Harding, 1986). Philosophers tend to agree that Descartes provided the arguments and rationale for attributing masculinity to rational and logical thought in science and technology.

> The notion that the project of modern science crystallizes 'masculinist' modes of thinking has been a prominent theme in some recent writing: '[What] we encounter in Cartesian rationalism,' says Karl Stern, 'is the pure masculinization of thought.' The scientific model of knowing, says Sandra Harding, represents a 'super-masculinization of rational knowledge.' 'The specific consciousness we call scientific, Western and modern,' claims James Hillman, 'is the long sharpened tool of the masculine mind that has discarded parts of its own substance, calling it 'Eve,' 'female' and 'inferior.'' (Bordo, 1987, p. 249)

Descartes provided for the separation of subject and object in philosophy and in science and technology, separating thought and logic from nature. Separation and individuation are strong themes in Descartes work with separation and detachment as essential characteristics for the scientific and technological mind (Bordo, 1987; Fox Keller, 1985). According to Descartes, achieving this separation depends upon a "rebirth," one which sheds the mystical and illogical images of nature so predominant during the Middle Ages. This change to autonomous logic is needed in order to reconstruct knowledge, especially scientific and technological knowledge, and the mysticism of nature is cast as feminine in order to separate logical thought from nature.

> Situating this masculine birth—or more precisely, *re*-birth—within the context of the cultural separation anxieties described earlier, it appears not only as an intellectual orientation but as a mode of denial as well, a reaction formation to the loss of 'being-one-with-the-world' brought about by the disintegration of the organic, centered cosmos of the Middle Ages and Renaissance. The Cartesian reconstruction of the world is a defiant gesture of independence from the female cosmos—a gesture that is at the same time compensation for a profound loss. (Bordo, 1987, p. 259)

Philosophers of all schools have given credit to Bacon and Descartes for creating the ideological framework for the growth of Western science. Much of the way in which science and technology are conducted today is a result of these fundamental ideas which shaped the procedures of science. Yet, as with any human endeavor, the influence of Bacon and Descartes has not been permanent, as the conduct of science continues to evolve. Many philosophers, especially those of the Frankfurt school (Gebhardt, 1987; Fee, 1986) have and are contributing to the reunification of the subject and the object in order to both develop new ways of conducting science and technology and to explain the reality of what is happening as science is conducted and technology is created (Bernstein, 1978). A continual revolution of scientific thinking as described by Kuhn (1970) is taking place. To this revolution, feminists have much to contribute to the dispelling of the Cartesian duality in philosophy and science, and eventually, in daily life (Donovan, 1994, Fox Keller, 1985). Feminist theories can influence how educators conduct education in general and how technology educators specifically conduct their classes in order to be inclusive.

Women's Ways of Knowing

The current discussion of women's ways of knowing in feminist literature represents a severe critique of liberal feminism. Essentially, the position of a number of current feminists is that women, constituted as the other, do function in different ways than men and that their ways of knowing have much to offer in the reconstruction of theory. Using the discussion of cultural differences, contemporary feminists are trying to create an alternate theory and scientific methodology based upon the differences of women. The purpose of this is not to destroy science, but to continue the evolution of science (Fox Keller, 1985; Fee, 1986; Rose, 1986).

Two thrusts are evident in women's literature about science: discussing the masculine bias as outlined above and arguing for a different, feminist influence in science. The framework of ideas for a more inclusive form of science include:

> One in which no rigid boundary separates the subject of knowledge (the knower) and the natural object of that knowledge; where the subject/object split is not used to legitimize the domination of nature. Where nature itself is conceptualized as active rather than passive, a dynamic and complex totality requiring human cooperation and understanding rather than a dead mechanism, requiring only manipulation and control…the scientist is not seen as an impersonal authority standing outside and above nature and human concerns, but simply a person whose thoughts and feelings, logical capacities, and intuitions are all relevant and involved in the process of discovery. (Fee, 1986, p. 47)

This form of science is not considered to be the exclusive domain of women, but of both sexes. The purpose of such science is to enable scientists to continue to progress, revising faulty interpretations and theories which rested on the assumption of masculine power and domination (Bleir, 1986).

Harding (1987) characterizes such a science as having new empirical and theoretical resources of women's experiences, new purposes for social science as women, and new subject matter for inquiry by locating the researcher in the same critical plane as the overt subject matter. Essentially, this kind of science is being developed in many areas. One of the most famous illustrations of this change in the view of science has been detailed by Fox Keller (1986) in her biography of Barbara McClintock. As a Nobel Laureate for her pioneering work in the plant genetics, McClintock's approach to her study involved a more contextual research process by observing the growing of corn in fields, the natural environment; holding back on hypotheses and imposition of answers; and valuing the exceptions. Another area of research which has benefited from feminist conceptions of theory and paying attention to women's ways of knowing has been the work of primatologists as outlined by Reed (1978), Haraway (1986; 1989), and Hrdy (1986) and as given notoriety by the work of Dian Fossey with mountain gorillas. Fossey and other women have been able to reinterpret, explain, and develop more accurate primate theory by rejecting masculine theories of domination and control in primate societies and by observing, closely, the actual interactions and social behaviors of primates.

While women's participation has been changing the way in which science is conceptualized and conducted as illustrated by the previous examples, a specific area of behavioral science, psychology, is also being questioned and revised with a concern for eliminating the inherent gender bias in Western science. This revision is directly related to differences in women's ways of thinking and knowing.

Most important to this discussion has been the reinterpretation of moral development offered by Belenky, McVicker Clinchy, Rule Goldberger, and Mattuck Tarrule (1986) in psychology. Because of a growing interest in women and of science based upon women's lives, Belenky et al. (1986) took a new approach to the theoretical work of Kohlberg on moral development and repeated the research of Perry (1970) in order to investigate the moral development of women.

Perry's original work focused on the moral thinking of Harvard undergraduates who were at the time a predominantly male population. Perry's influential work describes "how students' conceptions of the nature and origins of knowledge evolve and how their understanding of themselves as knowers changes over time" (Belenky et al., 1986, p. 9). Perry traced a series of student perspectives which he called positions and categorized them as: position one, *basic duality*, where views are in opposition as in dichotomies of right/wrong, black/white, etc.; positions two through four, *multiplicity: pre-legitimate, subordinate, correlate or relativism subordinate,* where there is an incorporation and acceptance of other points of view and a realization that authorities may not have the "the right" answer leading to a growing dependency upon a personal interpretation; position five, *relativism: correlate, competing, or diffuse,* where an analytical view of knowledge is developed and perceived as a way of knowing without commitment; and finally, positions seven through nine, *commitment foreseen, orientation in implications of commitment, or developing commitments*, where the contextual nature of knowledge is accepted and commitment as a necessity for action is accepted (Perry, 1970; Belenky et al., 1986).

Belenky et al. revised Perry's research to incorporate a population of women and included in that population not only college students, but also women from various ages and occupations. Their research results were similar, yet different in that there were particular differences in the way in which women experienced knowing. Their perspectives were: *silence*, a condition in which women did not speak out; *received knowledge*, listening to the voices of others; *subjective knowledge*, listening to the inner voice and a quest for one's own identity; *procedural knowledge*, looking for reason and becoming aware of separate and connected knowledge; and *constructed knowledge*, integrating the voices of all with respect to context.

Perry's theories have been influential in psychology and in education, especially higher education, as faculty look toward helping students to grow intellectually. Belenky et al. (1986) offer an interesting and viable addition to Perry's (1970) theories as educators begin to adopt the cultural feminist argument that there are differences in the way in which women experience and, therefore, think about the world. Certainly, women as silent receivers of knowledge, rather than constructing their own knowledge, is an important factor in the education of women. These positions are not represented in Perry's (1970) theories, and while the next few positions identified by Belenky et al. (1986) are similar to Perry's (1970) positions, the final position of constructed knowledge which involves paying close attention to context, wanting to know and to represent the knowledge of others in order to inform thinking, is not as well represented either in Perry's (1970) theories or in the traditional conceptualizations of science.

If women do think and learn differently than men, then we need to address those differences in education, especially in the context of technology education where there is a severe lack of women. It could be that technology educators have not examined the philosophy and psychology of women's thinking in order to learn how to be more inclusive of women in both technology education and creating technology.

Technology Education and Women's Ways of Knowing

By the lack of numbers, it appears as though women are avoiding the study of technology education (Welty, 1996). Young girls view it as a male subject (Hendley, Stables, Parkinson, & Tanner, 1996; Bame, Dugger, & deVries, 1993; Bame & Dugger, 1990). Some of this effect is due to a history of exclusion and stereotyping with respect to course of study, yet we do not seem to be changing the traditional separation of girls into home economics and boys into technology education (Wellesley College Center for Research on Women, 1995; Deem, 1978). For those few technology educators who are concerned about this problem, the discussion has centered on the "chilly" classroom effect known to exist in subjects not traditionally studied by many women (Resnick Sandler, 1982) and the "add women and stir" method of resolving the problem. Unfortunately, "add women and stir" has not been known to be a successful cure in other subjects (Minnich, 1990). It appears as though the problem is much deeper than socializing girls and women into the existing hierarchy. Perhaps, we need to rethink the hierarchy and technology education content and practice.

The descriptions of women's ways of knowing have multiple meanings for technology educators. Some of the ideas help to cast doubt on and dispel the dominance of masculine thinking in science and technology. The arguments could lead to reconceptualizing science and technology as we now know it, incorporating a larger concern for context and environment and a diminishing concern for control and domination. As the school subject representing the study of technology, technology education has been a male controlled subject matter defined by males (Welty, 1996). Technology educators could revise their view of the role and purpose of technology, especially as they approach the study of technology in the classroom. Another way that this information could influence technology educators is the way in which they construct activities for children in classrooms. If women are to be attracted to a study of technology, both the value and purpose of technology and the way in which it is taught must be changed.

Several women in other educational fields have tried to provide direction in order to help teachers to implement feminist ideals in their pedagogy. Certainly, these ideas are not new and they are advocated by male educators seeking to improve the practice of education in general. The ideas focus on creating a critical pedagogy. Goals, based upon feminist theory include restructuring the subject matter (Welty, 1995, 1996; hooks, 1994; Miller, 1993; Minnich, 1990; Langland and Gore, 1981), revising language (Minnich, 1990; Rosser, 1986), creating a humane classroom (Miller, 1993; Weiler, 1988; Rosser, 1986), and integrating cognitive and affective learning (Welty, 1995, 1996; Rosser, 1986). These goals relate to the issues of revising the subject matter and recognizing women's ways of thinking and acting mentioned above, and, they go far beyond a simplistic add women and stir.

Restructuring the Subject Matter: A Revised and Critical View of Technology

Feminists as well as many men are suggesting alternatives to the traditional masculine models of power and domination for the reconstruction of technology (Wajcman, 1991; Franklin, 1990). In a series of lectures, Franklin described the current state of technology as a system and as practice linked to culture. She defined technology as prescriptive and depending upon compliance, leading to isolation, control, and planning to maximize efficiency. These thoughts are echoed by a number of women who have studied the interaction of women and technology (Wajcman, 1991; Kramarae, 1988; Davies, 1988; deLaurentis, 1987). Franklin (1990) noted the feminist critique of technology and its intent to revise, not destroy science and technology. As an engineer, herself, she does not seek to destroy technology as we know it, but to redefine technology. While noting that the technologies, advocates for change, and means to change exist, Franklin (1990) called for a conserver society in which technological decisions are made with humility by taking into account nature and people first. In order to do this she recommends that we listen to ecofeminists and cultural feminists and learn to communicate with each other in order to examine the costs and benefits of our technological choices to society. The purpose of this would be to develop technologies which are appropriate in scale and application. Finally, she suggests that, "We must protest until there is *change* in the structures and practices of the real world of technology, for only then can we hope to survive as a global community" (Franklin, 1990, p. 130).

More technology educators could begin to address the subject of technology education with a critical view focusing on the role of technology as a system and as practice in which there are choices about our future course of action. This approach to teaching about technology has been implemented in what I have previously called a social reconstruction curriculum design (Zuga, 1992) and it is being implemented by some of those who are advocating design and technology education as problem centered situated learning. It is not, however, inherent in the problem solving process in that many technology education problems are designed to be the antithesis of these ideas and advocate competition and efficiency first. Implementing a social reconstruction curriculum design in technology education encourages thoughtful critique of the status quo and existing practice with respect to technology.

Feminist theorists have created an interpretation of technology as a largely masculine enterprise, relying upon domination and control of the environment. Ecofeminists have critiqued patriarchy as being largely responsible for technological abuses of nature and suggest alternatives driven by feminist ideals for addressing environmental concerns (Donovan, 1994). Technology educators interested in studying the environment and discussing the nature of technology in our society can incorporate the feminist critique, as well as critiques based upon race and class, of technology into the curriculum of technology education (Welty, 1995, 1996).

Using feminist, racial, and class theory and critique would give voice to the concerns of not only women, but also other underrepresented groups in the content of what is taught as technology education. Comparing all of these critiques to the ongoing critique and discussion of technology would allow students to contrast thinking about technology in order to look for similarities and differences. More important, the critical discussion of technology and the way in which we, as a society, choose to implement technology, especially as a society in which gender, race, and class structures create inequities in power, would give students insight into how to subvert prescriptive technologies in favor of developing redemptive technologies. Addressing the critiques of technology would benefit all students by helping them to understand that technology is a debatable practice with both positive and negative consequences for the environment and different groups of people. Teaching about the critiques of technology and their corresponding philosophical rationales would add depth and rigor (hooks, 1994; Kalia, 1991; Weiler, 1988) to the study of technology.

Revising Language: Paying Closer Attention to Explanation and Context

According to Belenky et al. (1986) women generally need to understand the context of an idea and to have a thorough explanation. This is a way in which technology teachers can revise language which goes far beyond the concern for gender, race, and class biased language in the classroom. The initial and superficial remedy for a chilly classroom is to revise one's vocabulary to be inclusive, but actions must be revised, also. Adequate explanation and contextual description is an important way to improve instruction for a number of students.

While judging at a 4-H woodworking event one summer, a young girl told me that her technology teacher never helped her to learn about how to do things. She said, "He doesn't explain things well. I never get anything out of him and I follow him around all the time asking." I am sure that her teacher thinks he has adequately explained the processes to her. I suspect that she has a much higher need for human interaction than her teacher realizes. Some students will need to have a higher degree of explanation and contact with the teacher. Many of these students may be women who are exhibiting the characteristics of women's ways of thinking. However, all students would benefit from more attention to explanation and context from any teacher.

This idea can also be related to the way in which we each approach putting together a new item that has "some assembly required." Some of us need to read the directions and some of us just dive into the box, pulling out parts and putting them together. Some of us have a high need for explanation, others, do not. Using language involves providing adequate explanation and contextual information for students.

There is another aspect of using limited explanation that relates to power and control. Keeping information to oneself, through brief or omitted explanation, allows teachers to maintain a position of privilege as "expert" and keeper of the knowledge (Lewis and Simon, 1991). All students would benefit from more detailed explanation and knowledge sharing. Students, themselves, should be encouraged to share their own knowledge and expertise. Technology teachers need to rethink their use of language in the classroom to eliminate not only sexist, racist, and classicist language, but also to include adequate explanation rather than terse comments. Moreover, technology teachers need to include women and all students in the educational discourse, providing them with a voice in order to strengthen students' involvement and understanding of the subject matter (Lewis and Simon, 1991).

Creating a Humane Classroom: Recognizing Women's Ways of Knowing and Acting

In addition to the concerns presented above with respect to revising language, technology educators need to observe and think about how women use technology. Women as technology users often co-opt the technology as originally designed and utilize it to further their values, particularly their need to communicate (Wajcman, 1991; Kramarae, 1988). From the telephone to e-mail, as women have encountered communication technologies they have been quick to utilize them to maintain contact with other people, displaying characteristic women's ways of knowing such as having a need for context and explanation. Women as a group have also approached the use of computers, especially computer games, with some differences (Collis, 1991). Not as many girls as boys are as entertained by the "shoot 'em up" games, yet they do engage in the "building up" games and use the creative tool software. In recent research about gender differences with respect to technology, Welty (1996) found that women identified communication and medical technologies more frequently than men. Technology educators need to understand that women's values will enter into their valuing and use of technology and that women will find ways of using the technology for their own priorities, just as any one should.

Using design briefs as cooperative activities is a good way to initiate change based in feminist theories (Scott and McCollum, 1993). When technology teachers create activities such as design briefs for students, some knowledge and empathy with women's ways of knowing and acting could help them to create design briefs that might be of interest to girls and women. Not everyone wants to design a machine tool. Some women do, yes, but others may be more interested in designing a device to aid a handicap, a decorative item, toy, or other object that would require the same knowledge and skills as designing and making a machine tool. What seems to be valid and appealing to teachers may not always be appealing and valid to students, both females and males.

The ideal would be to identify the concept, processes, and skills, which need to be taught and cast them into a design brief which would allow each student to interpret the solution as she or he sees fit. A good example of this kind of activity is discussed in research on problem solving by McCormick, Murphy, Henessey, and Davidson (1996) where in a technology class students were to devise moisture sensors and to provide an application for them. One of the students in the class created a fake stocking to hang on a clothesline in order to sound an alarm when it rained. This application is unique to the student and not something that would be suggested by most technology teachers.

Integrating Cognitive and Affective Learning: Discussing Values Related to Technology

Based upon the discussion of the inherent masculine values in the creation and conduct of science and technology as presented by several feminist theorists, it is difficult to deny that values are not a part of the curriculum. It is from the feminist discussion that we can see that the denial of values, the separation of subject and object, leads us to reproducing default values of masculinity which influences science, technology, and the curriculum. In any human endeavor, values are inescapable. Teachers need to begin to address and to incorporate values in their curriculum through study of various value positions, discussion and critique of values, and value laden activities in order to avoid hegemony, the unconscious reproduction of values.

Technology education is often approached as a series of processes and techniques that are taught in isolation of the affective values which accompanies all human activity. There are many technology educators who are trying to revise the curriculum of the field in order to include a broader knowledge base and the values associated with technology, particularly the technological systems (DeVore, 1980; Snyder & Hales, 1981). More specifically, a number of technology educators are recommending the study of technology education from a social reconstruction perspective (Zuga, 1992; Gilberti, 1996). Social reconstruction curriculum confronts the value question by making the improvement of society, a value-laden activity, a fundamental principle of curriculum selection and organization. Technology educators need to continue to blend the cognitive and affective aspects of technology education in order to improve technology education for all children. Adopting a social reconstruction curriculum design is one way to do this.

In addition to addressing the values inherent in technology (Scott and McCollum, 1993) to begin creating a participative, inquiry driven classroom, Miller (1993) suggests:

> Situated narratives of educational experience and inquiry, expressed in multiple versions and forms, offer ways into examinations of such complex intersections and constructions of both identities and curriculum. Current versions of such studies point to work in autobiography, including dialogue journals, life histories of students and teachers, descriptions and analyses of situated pedagogies and curricular practices, 'teacher and student lore,' and 'teachers' personal practical knowledge.' Autobiographical work within reconceptualized versions of curriculum particularly emphasizes the multiple constructions and reading of ones' and others' stories. (p. 51)

Technology teachers need to experiment with unique ways of permitting students to express their values with respect to technology in non-threatening ways through a combination of learning activities. As mentioned above, journals and other forms of writing can permit students to confront and to write about values without having to speak in public.

Summary

Teaching technology education in order to incorporate women's ways of knowing and experiencing is not a revolutionary educational idea. It involves recognizing that subject matter structures need to be changed as humans continually recreate the disciplines upon which they are based; that human behavior evolves and is changing to meet the needs of everyone; that educators need to be in the vanguard of change by creating classrooms in which all students can learn; and that in order to address the needs of all students, teachers must use teaching styles which address those disparate needs. It is educators' roles in society, as facilitators of the educational growth of children, to keep up with societal change and to incorporate those ideas and attitudes into their classrooms.

In thinking about concrete examples of how technology educators might do these things in order to transform their own practice, one has to start from a base of knowledge. We need not be afraid of the idea of feminism. There are excellent ideas in feminist texts and those ideas are not in contradiction with what we all want in our lives. Technology educators need to study feminist texts related to science and technology and to rethink their own philosophies and views of technology. Then, these ideas will begin to be incorporated into their curriculum and their teaching practice through a change in their behavior.

References

Arrington, R. L. (1989). *Rationalism, realism, and relativism: Perspectives in contemporary and moral epistemology*. Ithaca, NY: Cornell University Press.

Bame, E. A., & Dugger, W. E. (1990). Pupils' attitudes and concepts of technology. *The Technology Teacher, 49*(8), 10-11.

Bame, E. A., Dugger, W. E., & deVries, M. (1993). Pupils' attitudes toward technology—PATT-USA. *Journal of Technology Studies*, *19*(1), 40-48.

Belenky, M. F.; McVicker Clinchy, B.; Rule Golberger, N.; Mattuck Tarule, J. (1986). *Women's ways of knowing: The development of self, voice, and mind*. New York: Basic Books.

Bernstein, R. J. (1978). *The restructuring of social and political theory*. University Park, PA: University of Pennsylvania Press.

Bleir, R. (1986). Sex differences research: Science or belief? In R. Bleir (Ed.) *Feminist Approaches to Science*. Elmsford, NY: Pergammon Press, pp. 147-164.

Bordo, S. (1987). The Cartesian masculinization of thought. In Harding, S. and O'Barr, J. F. (Eds.) *Sex and Scientific Inquiry*. Chicago: University of Chicago Press, pp. 247- 264.

Collis, B. (1991). Adolescent females and computers: Real and perceived barriers. In J. Gaskell and A. McLaren (Eds.) *Women and Education*. Calgary, AL: Detselig, pp. 147-162.

Davies, M. W. (1988). Women clerical workers and the typewriter: The writing machine. In C. Kramarae (Ed.) *Technology and Women's Voices: Keeping in Touch*. New York: Routledge and Kegan Paul, pp. 29-40.

Deem, R. (1978). *Women and schooling*. Boston, MA. Routledge & Kegan Paul.

de Laurentis, T. (1987). *Technologies of gender*. Bloomington, IN: Indiana University Press.

DeVore, P. W. (1980). *Technology: An introduction*. Worcester, MA: Davis.

Donovan, J. (1994). *Feminist theory: Intellectual traditions of American feminism*. New York: Continuum.

Fee, E. (1986). Critiques of modern science: The relationship of feminism to other radical epistemologies. In R. Bleir (Ed.) *Feminist Approaches to Science*. Elmsford, NY: Pergammon Press, pp. 42-56.

Fox Keller, E. (1985). *Reflections on gender and science*. New Haven, CT: Yale University Press.

Franklin, U. (1990). *The real world of technology*. New York: CBC Enterprises. Gaskell, J. & McLaren, A. (1991). *Women and education*. Calgary, Alberta: Detselig Enterprises.

Gebhardt, E. (1987). A critique of methodology. In A. Arato and E. Gebhardt (Eds.) *The Essential Frankfurt School Reader*. New York: Continuum Publishing.

Gilberti, A. (1996, June). *A technology education curriculum of the future*. Paper presented at the Technology Education Issues Symposium in Maui, Hawaii.

Harding, S. (1987). Introduction: Is there a feminist method? In S. Harding (Ed.) *Feminism and Methodology*. Bloomington, IN: Indiana University Press, pp. 1-14.

Harding, S. (1986). *The science question in feminism*. Ithaca, NY: Cornell University Press.

Haraway, D. (1989). *Primate visions: Gender, race, and nature in the world of modern science*. New York: Routledge.

Haraway, D. (1986). Primatology is politics. In R. Bleir (Ed.) *Feminist Approaches to Science*. Elmsford, NY: Pergammon Press.

Hrdy, S. B. (1986). Empathy, polyandry, and the myth of the coy female. In R. Bleir (Ed.) *Feminist Approaches to Science*. Elmsford, NY: Pergammon Press, pp. 119-146.

Hendley, D.; Stables, A.; Parkinson, J.; and Tanner, H. (1996). Pupils' attitudes to technology in key stage 3 of the national curriculum: A study of pupils in south Wales. *International Journal of Technology and Design Education*, *6*(1), 15-19.

hooks, b. (1994). *Teaching to transgress: Education as the practice of freedom*. New York: Routledge.

Kalia, S. (1991). Addressing race in the feminist classroom. In J. Gaskell and A. McLaren (Eds.) *Women and Education*. Calgary, AL: Detselig, pp. 275-282.

Kramarae, C. (1988). Gotta go Myrtle, technology's at the door. In C. Kramarae (Ed.) *Technology and Women's Voices: Keeping in Touch*. New York: Routledge and Kegan Paul, pp. 1-14.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Langland, E. & Gove, W. (Eds.) (1981). *A feminist perspective in the academy: The difference it makes*. Chicago: University of Chicago Press.

Lewis, M. & Simon, R. I. (1991). A discourse not intended for her: Learning and teaching within patriarchy. In J. Gaskell and A. McLaren (Eds.) *Women and Education*. Calgary, AL: Detselig, pp. 257-274.

Longino, H. (1990). *Science as social knowledge*. Princeton, NJ: Princeton University Press.

McCormick, R., Murphy, P., Henessey, S., Davidson, M. (1996, April). *Research on student learning of design and technology activity in school in England*. Paper presented at the American Educational Research Association in New York City.

Miller, J. L. (1993). Constructions of curriculum and gender. In S. Knopp Biklen and D. Pollard (Eds.). *Gender and Education*. Chicago: University of Chicago, pp. 43-63.

Minnich, E. K. (1990). *Transforming knowledge*. Philadelphia, PA: Temple University Press.

Perry, W. (1970). *Forms of intellectual and ethical development in the college years*. New York: Holt, Rinehart & Winston.

Resnick Sandler, B. (1982). The classroom climate: A chilly one for women? Washington, D. C.: Association of American Colleges.

Reed, E. (1978). *Sexism and science*. New York: Pathfinder.

Robertson, J. H. (1905). Valerius terminus of the interpretation of nature. In *the Philosophical Works of Francis Bacon*. London: Routledge and Sons.
Rose, H. (1986). Beyond masculinist realities: A feminist epistemology for the sciences. In R. Bleir (Ed.) *Feminist Approaches to Science*. Elmsford, NY: Pergammon Press, pp. 57-76.
Rosser, S. V. (1986). *Teaching science and health from a feminist perspective: A practical guide*. Elmsford, NY: Pergammon Press.
Snyder, L & Hales, J. (1981). *Jackson's mill industrial arts curriculum theory*. Charleston, WV: West Virginia Department of Education.
Wajcman, J. (1991). *Feminism confronts technology*. University Park, PA: The Pennsylvania State University Press.
Wellesley College Center for Research on Women. (1995). *How schools shortchange girls: The AAUW report*. New York: Marlowe & Company.
Weiler, K. (1988). *Women teaching for change.* South Hadley, MA: Bergin & Garvey Publishers.
Welty, K. (1996, April). *Identifying women's perspectives on technology.* Paper presented at the International Technology Education Association Conference in Phoenix, AZ.
Welty, K. (1995, March). *Women: Technology education's forgotten half*. Paper presented at the International Technology Education Conference Association in Nashville, TN.
Wright, W. (1992). *Wild knowledge: Science, language, and social life in a fragile environment*. Minneapolis, MN: University of Minnesota Press.
Zuga, K. F. (1992). Social reconstruction curriculum and technology education. *Journal of Technology Education*, *3*(2), 53-63.

Book Review

Rifkin, J. (1998). *The Biotech Century*. New York, NY: Penguin Putnam, Inc. $25.00 (Hardcover), 272 pp.

Reviewed by Philip A. Reed

The Biotech Century discusses many of the biological processes, technologies, moral dilemmas, and political issues that now face humanity for the first time. This book is relevant to technology educators for several reasons. First, recent research shows that biotechnology is an important emerging field of study. The Technology for All Americans project has determined that biological systems is one of the three contexts of technology (International Technology Education Association, 1996). More recently, although on a smaller scale, Brown, Kemp, and Hall (1998) have determined that biotechnology is an emerging content area that should be addressed by teacher educators at the pre-service and in-service levels. Secondly, *The Biotech Century* can provide technology educators with a base knowledge as they look for ways to incorporate biotechnology into their curriculum.

Author Jeremy Rifkin begins by claiming that humanity is leaving the communication era and entering a biological revolution. Mr. Rifkin has compiled an impressive list of references to support his claims in *The Biotech Century* but writes in a style that allows readers to draw their own conclusions. Mr. Rifkin is the author of fourteen books relating science and technology to the economy. As founder and president of the Foundation on Economic Trends in Washington D.C., he often speaks and consults nationally and internationally on a wide range of topics dealing with science and technology.

According to Mr. Rifkin there are seven strands that make up the "operational matrix" of the Biotech Century. The first strand is recognizing the ability of science to identify, isolate and recombine DNA to be used as a raw material. Historically, plant cultivation and animal husbandry have been limited by species restraints that are put in place by nature. Now, man can completely manipulate and engineer new forms of life. Some of the new forms of life are impressive: mustard plants that grow chains of polymers, microorganisms that strip undesired elements from raw materials in mines ("bioleaching"), and the use of microorganisms to render waste and pollutants harmless ("bioremediation").

With this new ability to alter life come the issues of patenting and commercialization. This second strand of the Biotech Century has started a race by governments, private companies and individuals to lay claims on the building

---

Philip A. Reed (preed@vt.edu) is a doctoral student in the Technology Education Program, Department of Teaching & Learning, Virginia Polytechnic Institute and State University, Blacksburg, VA

blocks of life through billion dollar research projects and legal patents. Ironically, the nations of the southern hemisphere, which abound in natural resources, are the nations least informed about biotechnology. Already there are heated debates in world courtrooms and the United Nations about the extraction and use of these natural resources. Often, these resources are used by corporations to turn huge profits with little or no return to the nations who claim these regional forms of life.

The power of biotechnology is fully realized when one contemplates the release of some of these engineered life forms back into the natural environment. Mr. Rifkin calls this "a laboratory-conceived second Genesis." A historical review reflects how farming practices have domesticated certain crops and animals over the centuries. In India just fifty years ago, for example, there were over 30,000 varieties of rice. Now, there are ten dominant varieties. *The Biotech Century* asks what will happen to the balance of nature with the release of these "super" crops and microorganisms? Rifkin points out that many of the world's seed companies are already producing and marketing products that have been altered. Although these are altered to resist elements such as drought and pests, newer crops can be engineered to produce chemicals and medications. What will happen to the soil in which these crops are planted or the insects that feed on these new hybrids?

The fourth strand of the coming Biotech Century relates to eugenics and the human genome project that is being conducted by the National Institute of Health. This highly publicized project has already created discussions concerning human genetic screening for pre-natal, insurance, and employment purposes. Rifkin takes this issue one step further, however, by looking at the social and political histories of Nazi Germany and the United States prior to World War I. While most people are familiar with the atrocities of the Nazis, many are not familiar with the American Breeders Association or the immigration and sterilization laws in the United States during this time period. These laws, according to Rifkin, were put in place to allow the genetically fit aristocrats to maintain their power. Although this line of thinking in the United States finally faded during the events of World War II, Rifkin feels it could re-surface. Most people today would agree that diseases and birth defects should be eliminated from the human genome through negative eugenics. Going beyond the issue of human suffering however, Rifkin asks who should determine which genes are desirable and which are undesirable.

While genetic selection may be an issue of the future, some biotechnology issues are already affecting the social fabric of our culture. In California, for example, a PET Scan of a persons brain can be used as evidence in court to determine if a criminal is predisposed to recommit a crime. Rifkin feels that this new sociobiology that places nature over nurture is gaining widespread acceptance. A direct impact on education can be seen when we look at the history of labeling special education students. During the 1960's and 1970's, over-active students were thought to be a product of their environment and they needed special attention. In the 1980's and 1990's, however, Attention Deficit

Hyperactivity Disorder (ADHD or ADD) was diagnosed as a biological disorder that can be treated by drugs.

The paradigm shift from nurture to nature and the shift from the communication age to the bioindustrial age have not occurred overnight. Rifkin's sixth strand in the operational matrix explains how the Biotech Century would not be possible without the forbearing communication age and the use of computers. When fully complete, the *basic* human genome database will equal a telephone book that contains three billion entries. Once genetic differences are factored, the database will be ten thousand times the size of the original database. And this is just for the human species. Computer networks will allow similar databases for thousands of species to be stored and accessed all over the world. When new species are genetically mapped, this data can be accessed and mixed with other species electronically in virtual reality environments.

The computer itself could be drastically changed through the use of DNA instead of silicon in microchips. DNA chips are created through photolithography just like silicon chips. The basic structure of DNA can be programmed to emulate the gates of a silicon computer chip. The advantage of DNA over silicon however, is the fact that it naturally handles data in a parallel manner and therefore is immensely faster than silicon. This discovery helped the first DNA computer solve a simple math problem in 1994 .

Rifkin's final operational matrix for the Biotech Century talks about a new cosmology that is challenging the Darwinian view of nature:

> The ability to reduce all biological organisms and ecosystems to information and then to use that information to overcome the limitations of time and space is the ultimate dream of biotechnology (p. 217).

This new cosmology pictures nature, on every level, as a gatherer of information. Even the smallest organisms respond and evolve according to information. The circular model of cybernetic interaction, feedback, and adjustment is how this new cosmology views all life forms. Rifkin elaborates this cosmology on the human level by explaining how the gene has become a cultural icon that is used as a social force for determining where diseases come from, who is a genius, and even who has the potential of being a criminal.

The Biotech Century leaves the reader with two rather bipolar possibilities for the future. One is the possibility of large scale genetic engineering. The second is the use of more conservative ecological and preventative health practices. Rifkin selected the second option as the obvious path for biotechnology in the future and turns again to history for support. By comparing the fear of nuclear abuse to the fear of biological abuse, Rifkin concluded that the development of biotechnology will be swift but its implementation will be closely monitored. Emerging international regulations for both of these technologies clearly support Rifkin's theory.

The Biotech Century is an informative book for all, but it has special implications for the technology educator. As Wells (1994) pointed out, biotechnology has become too large and too influential in our society to be taught solely in the physical science curriculum. The technologies, issues, and vocabulary introduced by Rifkin can aid technology educators as they work biotechnology into their curriculums. While biotechnology is currently taught in some technology education programs (see Johnson, McAdams, and Pontarolo, 1998), these programs are exceptions to the norm. By reviewing works such as *The Biotech Century* and Wells' (1995) taxonomy, technology educators will be better informed and equipped to implement sound classroom instruction on biotechnology.

References

Brown, D. C., Kemp, M. C., & Hall, J. (1998). On Teaching Biotechnology in Kentucky. *Journal of Industrial Teacher Education*, *35*(4). 44-60.

International Technology Education Association. (1996). *Technology for All Americans: A Rationale and Structure for the Study of Technology*. Reston, VA: Author.

Johnson, M., McAdams, B., & Pontarolo, R. (1998). Biotechnology Meets Power and Transportation. *Tech Directions, 58*(3), 14-17.

Wells, J. (1995). Defining Biotechnology. *The Technology Teacher, 54*(7), 11-14.

Wells, J. G. (1994). Establishment of a Taxonometric Structure for the Study of Biotechnology in Secondary School Technology Education. *Journal of Technology Education, 6*(1).

Miscellany

Scope of the JTE

The *Journal of Technology Education* provides a forum for scholarly discussion on topics relating to technology education. Manuscripts should focus on technology education research, philosophy, and theory. In addition, the *Journal* publishes book reviews, editorials, guest articles, comprehensive literature reviews, and reactions to previously published articles.

Editorial/Review Process

Manuscripts that appear in the *Articles* section have been subjected to a blind review by three or more members of the Editorial Board. This process generally takes from six to eight weeks, at which time authors are promptly notified of the status of their manuscript. Book reviews, editorials, and reactions are reviewed by the Editor and Associate Editor, which generally takes about two weeks.

Manuscript Submission Guidelines

1. Five copies of each manuscript *and an electronic version on floppy disk* should be submitted to: James E. LaPorte, JTE Editor, 144 Smyth Hall, Virginia Tech, Blacksburg, VA 24061-0432 (703) 231-8169. Overseas submissions may be submitted electronically via the Internet (to laporte@vt.edu) to expedite the review process, but if submitted only in ASCII format (e.g. as an email message), a fully formatted version on floppy disk must also be sent via conventional mail.

2. All manuscripts must be double-spaced and must adhere strictly to the guidelines published in *Publication Guidelines of the American Psychological Association* (4th Edition).

3. Manuscripts that are accepted for publication must be resubmitted (following any necessary revisions) both in hard copy and on a floppy disk saved in the native word processor format (such as Microsoft Word) *and* in ASCII format.

4. Manuscripts for articles should generally be 15-20 pages (22,000-36,000 characters in length, with 36,000 characters an absolute maximum). Book reviews, editorials, and reactions should be approximately four to eight manuscript pages (approx. 6,000-12,000 characters).

5. All figures and artwork must be scaled to fit on the JTE pages and be submitted both in camera-ready and electronic formats.

Subscription Information

The *Journal of Technology Education* is published twice annually (Fall and Spring issues). New and renewing subscribers should copy and mail the form below:

Name (please print) ____

Mailing Address (please print)____

____

Email address: ________________________ Fax: _______________________

❑ New Subscription ❑ Renewal Subscription

Make checks payable to: *Journal of Technology Education*. All checks *must* list a US bank on the check.

Regular (USA): $12
Regular (Canada/Overseas): $16
Library (USA): $20
Library (Canada/Overseas): $25
Individual Back Issues (USA): $7 each
Individual Back Issues (Canada/Overseas): $9 each

Return check and this form to:

James E. LaPorte, JTE Editor
144 Smyth Hall
Virginia Tech
Blacksburg, VA 24061-0432

JTE Co-Sponsors & Membership Information

The International Technology Education Association (ITEA) is a non-profit educational association concerned with advancing technological literacy. The Association functions at many levels—from international to local—in responding to member concerns. The Council on Technology Teacher Education (CTTE), affiliated with the ITEA, is concerned primarily with technology teacher education issues and activities. For membership information, contact: ITEA, 1914 Association Drive, Reston, VA 22091 (703) 860-2100.

Electronic Access to the JTE

All issues of the *Journal of Technology Education* may be accessed on the World Wide Web at: http://scholar.lib.vt.edu/ejournals/JTE/jte.html (Note: this URL *is* case sensitive).

Errata

The following are corrections for Vol. 10, #1, Fall 1998 issue:

1) Contents, pg. 1, first article title should read—

   Students' Attitudes Toward Technology in Selected Technology Education Programs by Richard A. Boser, James D. Palmer, and Michael K. Daugherty

   Our apology to James D. Palmer for the omission of his name.

2) pg. 50, first paragraph following information given in VII, sentence beginning in line 6 should read—

   …Every "Teacher Educator of the Year" award given by the CTTE and ITEA for 43 of the past 44 years has gone to a white man. …