Practice Meets Theory in Technology Education: A Case of Authentic Learning in the High School Setting

Ann Marie Hill and Howard A. Smith

Introduction

Recent reports (Premier's Council, 1988, 1990) emphasizing the low level of science and technology literacy among Canadians imply that schools have not responded to the challenges before them. However, pioneering and apparently successful programs in technology education are being offered currently in some secondary schools in the province of Ontario. These programs support learning about technological problems that involves, among other things, interdisciplinary approaches to curriculum and the active involvement of both students in their learning and community partners who provide real world design experiences for students. These features comprise the core of a recently revised curriculum guideline for secondary school technology education entitled *Broad-based Technological Education: Grades 10, 11, and 12* (Ontario Ministry of Education and Training, 1995b).

Before 1989 the study of technology in Ontario schools occurred only in grades 9 to 13 through Technological Studies courses. About 75 distinct technology specializations existed. Since 1989, increased dialogue about the need for students to study technology from kindergarten to secondary school graduation has led to the development of a continuum of technology education (Hill & Salter, 1991). Today, technology education is part of all elementary school children's education (Ontario Ministry of Education and Training, 1995a), after which it becomes an elective in secondary school as *Broad-based Technological Education Programs* (Ontario Ministry of Education and Training, 1995b). These latter technology programs represent a move from the earlier specializations approach to seven comprehensive technology clusters: (a) Communication Technology, (b) Construction Technology, (c) Technological Design, (d) Hospitality Services, (e) Manufacturing Technology, (f) Personal Care, and (g) Transportation Technology.

In Ontario's approach to technology education, regardless of grade level, the design process is used to acquire skills in and knowledge about technology (for example, technological concepts such as structures, materials, fabrication, mechanisms, power and energy, control, systems, function, aesthetics, and ergonomics). This open-ended problem-solving approach addresses the

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Ann Marie Hill and Howard A. Smith are on the Faculty of Education, Queen's University, Kingston, Ontario, Canada.

technological process of creating, inventing, and modifying for real world needs. Human factors, societal factors, and environmental concerns are crucial to this design process.

This article reports research findings from a secondary school in Ontario. While *Broad-based Technological Education* is the official name of these programs here, the term "technology education" shall be used hereafter for a more international understanding. The aim of this article is to summarize some of the major results of a larger case study. This case study examined the attributes of one highly regarded secondary school program in technology education that featured student projects and involvement with the local community. The results will focus on that part of the research which proposed to: (a) identify the major attributes of one apparently successful program in technology education in an Ontario secondary school, and (b) link the program's characteristics to recent advances in social, learning, and motivational theory. Finally, the article presents some implications for educational practice and future research.

Research Questions

Although most secondary schools in Ontario are still in the process of adjusting to the new shape of technology education in the province, several schools have embraced the recent changes with apparent success. The main objective of the research reported here was to examine one such program already in operation and to seek answers to several main questions: (a) What are the key attributes of classrooms where technology education is taught successfully? More specifically, what elements have contributed to the acknowledged success of a particular program in Manufacturing Technology that incorporates apparently successful partnerships between the school and business? (b) What theories of learning, motivation, and education are supported by the program's attributes? This article reports practice before theory since the goal of the research was to identify key attributes of classrooms where technology education is taught successfully and then to link the program's attributes to current research theories. Thereby, successful practice could be given its deserved recognition in theory building and confirmation.

Method

Because of the exploratory and complex nature of the present inquiry, we chose to use a case study employing multiple methods of data collection (e.g., Bogdan & Biklen, 1998; Stake, 1994; Yin, 1994). As is true of all research methodologies, case studies have both strengths and weaknesses. One perceived weakness, the inability to generalize findings to other settings, was not a concern given the prime objective of the present research: to specify how multiple factors function together in a particular dynamic situation to produce an apparently successful program in technology education. Instead, the strength of the case study approach was emphasized so as to promote an understanding of this unexamined approach to technology education and to raise questions for further research.

The study took place in a secondary school in eastern Ontario where graduates and others familiar with the setting spoke in the most favorable terms about a particular program and teacher, a teacher who had also received national recognition and teaching awards for his work in the school. The teacher's program in technology education consisted of courses in Manufacturing Technology, grades 9 through 12. For the purposes of this investigation, one grade 10 and one grade 11 were studied intensively during the 5-month semester that began in September 1995.

The data for this case study were obtained from: (a) interviews with selected students (both male and female, both more and less successful in the courses), the teacher, the school principal, and representatives from local business and industry; (b) the teacher's reflective journal; (c) details of curriculum; (d) student reports; (e) student achievement measures, mainly from in-school assessments; (f) in-class observations supported by researcher notes, photographs, and videotapes; and (g) evidence of participation in activities such as science and technology fairs (cf., Kirby & McKenna, 1989; Yin, 1994). Classroom data were collected in the fall term when the course was offered, from September 1995 to January 1996. However, interviews were conducted well into March 1996. Individual anonymity was maintained to the extent possible in written and visual reporting.

In accordance with the two aims of the research, the following two sections, Major Results and Practice Meets Theory, were purposefully placed in reversed order from the traditional theory first and then findings. We saw this atypical ordering as essential to reinforce two premises: (a) theory is at least as dependent on practice as vice versa; and (b) teachers' practice is both implicitly and explicitly based on theory and may be used to validate existing theories of learning and instruction.

Major Results

The Classroom Laboratory

The physical setting consisted of a very large, well-lit room with high ceilings and one complete row of high windows across the rear wall. About 25% of the room, at the right side of the front, was devoted to a more formal teaching area. This area contained the chalkboard, overhead projector, reference materials, a computer connected to a printer, teacher's desk, and several rows of drafting tables and stools for about 20 students. Class periods began in this area for housekeeping matters and for the regular, usually brief (10 to 15 minutes) periods of instruction by the teacher. This area of the room was also used for written tests, homework completion, and student discussion and report writing of projects.

The remaining 75% of the floor area served two main functions: as a working area containing several work benches and a wide variety of hand and power tools, and as a storage area for both materials and partially-completed projects. Students spent the majority of their 76-minute periods in this area as they worked on their projects. The teacher circulated among the students, checking their progress, giving suggestions, and discussing options and next steps. During this time, the class radio was usually tuned to the type of rock music so highly regarded by adolescents.

Program-Centered Findings

Each of the grade 10 and 11 Manufacturing Technology courses that were part of the study began and ended in the fall term, from September 1995 to January 1996. In grade 10, students were presented with two required projects, an air conveyor system and a pneumatics system, before being allowed to work on projects of choice. In grade 11, students chose projects from a list of possibilities prepared by both the teacher and students. Typically a group of students completed one large project or several small projects per term. When content in the course outline was not covered by class projects, a small teacher-centered project was provided that focused on skills and knowledge acquisition to fill this gap. Table 1 represents a partial list of projects for both grades in 1995-1996. Clearly, projects based on community needs are in abundance on the list.

Involvement with business and the community. Education for the new millennium must provide authentic educational experiences for our youth. Closing the gap between school life and workplace life is an important step in this direction. Community involvement in school programs is an integral part of the restructuring of technology education in Ontario (Ontario Ministry of Education and Training, 1991, 1992, 1995b) and of the evaluation of the newly funded Broad-based Technological Education programs (Ontario Ministry of Education and Training, 1993a, 1993b). The courses described in this study involved the community in a variety of ways through projects

Student-Centered Findings

The students. The students in these two classes were both male and female with a wide range of interests and abilities. The grade 10 Manufacturing Technology class consisted of 14 students: 12 male and 2 female. Grades on completed courses leading to an Ontario Secondary School Diploma (OSSD), across all subjects, ranged from 51% to 95% for the males and 78% to 96% for the females. The students' ages varied from 16 to 19 years. The grade 11 class consisted of 19 students: 14 male and 5 female. Their grades on completed courses toward an OSSD ranged from 23% to 97% for the males and 62% to 100% for the females. Considerably more OSSD courses had been completed by this group and their age range was more uniform: from 17 to 18 years. Student interviews from both grades revealed that students enrolled in the course for a variety of reasons, from gainful employment related directly to the technology course to continuing on to university engineering programs.

Thus, the classes examined here were comprised of students with wide variations in academic background, achievement, and interests. The classes recognized distinct forms of human capability, valued different kinds of knowledge, and supported students who brought different kinds of experiences into the school setting. In Ontario, government policy supports the abolition of ability grouped classes up to grade 9 (Ontario Ministry of Education and

Table 1
Partial List of 1995-1996 Projects

Project	Community Partner
Bike Cart	Gerry's Recycled Bikes
Spool Rewind System	Goodyear Canada
Handicapped Garden Center	Lenadco
Laundry Tub Back Savers	Lenadco
12 Foot Globe	Town Council
Lectern	Lions Club
Kitchen Unit	Baker
Garden Trailer	Community Resident
Refurbished Wood Splitter	Community Resident
Utility Trailer	Community Resident
Garden Trailer	Community Resident
24' x 24' Garage	Community Resident
Storage Shed	Community Resident
Customized Snow Machine	Community Resident
Eight Foot Dinosaur	Elementary School
Abacus Sets	Elementary Schools
Firefighter Pole	Elementary Schools
Playground Equipment	Elementary School
Geodesic Dome	Secondary School
Bolt Modifier	Secondary School Custodian Service
Benches	Secondary School
Mutuality Sound Speakers	School Teacher
Bikecars	Students
Lawnmower Powered Boats	Students
Glass Table Tops	Students
Magnetic Levitation Vehicle	Students

Training, 1993a). Ability grouping has been found to emphasize class differences, discriminate against minority children, and enforce undesired and unwarranted claims of superiority among students, teachers, and parents (Oakes, 1992; Slavin, 1990).

Project teams. Students were encouraged to work in teams of from two to four persons rather than individually, although the latter option was possible when circumstances seemed appropriate. Over time, a series of different working arrangements evolved among the assorted project teams.

One major result was that grade 11 teams tended to be formed among students who had already worked together in previous grades. One team of female students explained that they were also friends outside school. "Well, we have been friends before this and we wanted to work together obviously...We are sort of good friends out of the classroom so we knew each other well so there are no surprises...if we are compatible then it's a lot less work." It appeared that students preferred to work on novel, enduring, and significant projects with friends or acquaintances whom they liked and trusted. This finding suggests that teachers, by themselves, may not have enough information to create maximally-productive student project teams.

The advantages of working on projects in teams was mentioned repeatedly by the students. They spoke of team work as more enjoyable than working by themselves. One grade 10 female student indicated that she liked "...it better than working by yourself because it's kind of boring just doing things by yourself." Another student, a grade 10 male said: "At first I was like, okay, I don't know if I really like working with other people. But now, I'm working on my trailer by myself, and like, this is really boring!" Working in teams taught them how to work with other people and to resolve conflicts among themselves. A grade 11 male student describes his perspective of his team's process of working together:

> There's a lot of arguing in the group but that's to be expected. You know, when something does go right, you feel really good about yourselves. It's really rewarding...It teaches you how to work with other people and how to resolve conflicts by yourself without having someone step in all the time.

They recognized the value of sharing and learning from the range of ideas proposed by team members, as one grade 11 female student explained: "...when you have two or three people working they have lots of ideas." Another student's explanation, a grade 10 male, provides insight into how this sharing of ideas took place in a bikecar project, a motorized vehicle using a bicycle and other parts:

> You have, like here, we'll have three different ideas coming in. Like [a student] had some good ideas about how we should set up the seats, and then he worked on the coring spike, the front end of the coring spike to the steering. Got all that done. And then I had the idea of taking, cutting a handlebar in half and then taking those two and hooking them on to our original handlebars to make them longer.

Students also realized that several people working together can complete much larger and more sophisticated projects than persons working alone. In interviews, a grade 11 female student who chose to work by herself on two community projects explained that she did so because "...it's just easier to do designs when you are alone than having other people's ideas and trying to communicate without a drawing." Two months later, she was glad to have the help of three other classmates to do most of the construction "...because I would never have gotten much finished." Another grade 11 female student talked about this aspect of group work as well. "If one of us had decided to take this project on by ourselves we could never have done it. It's just too big for us."

Design. The design element referred to by the above students was a requirement for the grade 11 projects. As part of the course content, the teacher incorporated instruction about the design process into his lessons at the start of class. This provided students with a guideline for both the process of their projects and their design reports. Three major findings concerning design emerged from observing and interviewing the different project teams.

Firstly, design was a dynamic and evolving feature of authentic projects. Teams that created sketches or models changed their creations from 6 to 10 times during the course of construction as they determined what did and did not work. Rough sketches and rough three-dimensional models were used to work out design ideas before finishing prototypes of their projects. A comparison of sketches, model, and prototype illustrated that frequently there are differences in initial design ideas and a completed design.

Secondly, meaningful design for most students began more as a lived, bodily experience than as a mental creation. Students needed to engage their senses in their planning. For example, a grade 11 male student spoke of laying out pool cues at home and adjusting chairs on the classroom floor in order to establish proper dimensions for his team's bikecar. A grade 11 girl sat in a wheelchair while constructing her three dimensional model of a handicapped garden table. To acquire further understanding of wheelchair users' lives, this student also spent several weeks of class time working in the wheelchair. Thus, a major challenge for students in the design component was to translate their experiential knowledge into abstract rational form. This knowledge was used together with ergonomic charts providing precise measurements to guide their project dimensions.

Thirdly, the purpose of the final representations and descriptions of the projects (i. e., three-dimensional models and design reports that include both two-dimensional visual and textual documentation) should be cast in the value that the information has for others rather than for the students themselves. The latter have already learned what works, and what does not work, in their own projects. During the initial stages of design, these representations were used for effective communication of design ideas. For example, a grade 11 student presented her sketches and model for the handicapped garden table to a community patron. Also, the community partner for the spool rewind system was able to visit the school and provide feedback to the group about its initial design ideas based on the group's sketches and models.

Responsibility and learning. Students spoke frequently of the value of working things out for themselves rather than being told what to do. They began their projects with what they already knew, both individually and collectively, and then worked to supplement their knowledge as they encountered new problems and challenges. The comment of a grade 11 female student represents the views of many of the students who were interviewed: "I think you learn more with the hands-on projects because you have to figure things out as you go. I had to find out a lot of things for myself and it wasn't written in the textbook." Comments from grade 10 males also reinforced this idea:

> Well, I think it, like, it works. You learn how to work with stuff you know. You don't have to see everything on the board first. You sort of just go at it. You learn on the way.

> Trial and error. So what you don't get at first you re-try it until you get it. And I think its a lot better than learning from a blackboard, because that's hands-on, and you remember what's been done wrong, and what you have done to correct it.

The brief formal class lessons on, for example, gear ratios also provided meaningful theory in the context of real-life problems for the students working on bikecars. The projects stimulated in students a dynamic interchange between lived practice and relevant theory. One grade 11 female student's comment portrayed this point: "I think it's a very valuable way to do the course. We have our class work...and then you take that knowledge that you just learned in class and you do a project.…you use that knowledge as a learning experience." They spoke of relating what they were learning in class to solving problems in everyday life.

Motivation. Student motivation concerns most teachers. However, in the project-based classes, students demonstrated high levels of involvement and activity with their work. One grade 11 female student reported: "I like it better than just sitting down and doing the design thing on paper. You actually work on them and build them and you can see what you have built. It's very gratifying." This same student added insight into the value and additional motivation of projects that are derived from the community: "...the last couple of years I have been doing projects which went out into the community and its a good feeling when you finally see it done and in its place and sitting in front of you. With the help of a few teachers...we actually built this." In other interviews, two grade 11 male students reported that these classes were "a lot more fun, actually building, doing hands-on, than just sitting there learning out of a book or something" and "I'd rather do hands-on work too than just sitting and taking notes." A grade 10 female added: "Well, its fun. I like it...and it's real life too." This same student reported that other classes were uninteresting, "...they're kind of boring. Well they are actually boring. You just sit there day after day and you don't really do anything, but like, write and look stuff up."

Student motivation was also apparent in their recounting that they rarely if ever skipped Manufacturing Technology class. As the end of term approached, students showed a strong desire to complete their work, especially if they were working on community projects. The latter seemed to prompt extra accountability from the students, who were also willing to lend a hand to other projects needing momentary or longer-term assistance.

Project completion was encouraged but not essential for course completion. Students unable to complete their projects on time were able to work in their spare time during the following semester, particularly in the case of large scale projects. However, students preferred to finish their projects within the course time. They indicated that they spent too much time on the initial design phase and that more frequent meetings with community patrons at the beginning of the project could improve communication and thus solve this problem. The teacher's flexibility in allowing for project completion after the end of course was critical in maintaining student motivation and preventing frustration.

Teacher-Centered Findings

A grade 10 female student, grade 11 female student, and grade 10 male student respectively, talked about their teacher:

He treats you like a person, and not like a student.

He is a very comfortable person. He is very nice to be around.

He never puts you on the spot.

Repeatedly in interviews, students reported that their success and enjoyment in the class was due to the teacher, who displayed the following major characteristics: (a) he respected students as individuals, (b) he knew the students' home lives, (c) he demonstrated to students that he did not know everything, that he was always learning, and that students' project ideas might be better than his, (d) he was highly flexible in terms of what was achieved or not in class and he worked with students to determine some of the course content, and (e) he was a moderate risk-taker without the need for formal closure on some matters.

Outside the classroom, the teacher reflected often about ongoing projects and the peaks and valleys that students encountered in the process of designing, making, and testing their products. In an after class interview during the third week of school, he talked about this aspect of project work:

> Well you have to be quick at the beginning. There will come a stage later where things will slow down, but one of the things that is really important to note...is you have to get off to a flying start. You do not have time to do anything else...or else you will fail because you will run out of time and energy. You've really got to get over a big hump [at the beginning of the year], and then you go down, and then it will come back up again as everything finishes. But there's a down time with these kids when you get through the excitement of design and the initial stages, [when] you get into the bull work of getting it up and running, and it's failing and you're fiddling and it seems very boring. And then [the projects] start to work and you come out again on a high. So there's a cycle to this.

The attention needed in the beginning weeks of school is evident in notes from the teachers audio tape journal below:

> It is the morning of September 6, and I am on the way to work. Lots of worry last night about the projects and I kept waking up all last night. This is the time of year when teachers have to do a lot of worrying - not all of it, but a big part of it because getting these things set up and organized is probably the most important thing you can do; getting a proper definition of what the technology project is, getting a good relationship with the clients that is going to be effective with kids, getting the kids to understand the size and definition of the project.

For his classes, he sought out and used human and non-human community resources of all kinds and described these in interviews, as in the four examples below:

> An example of getting new stuff and scrounging things…I had the kids a week ago call around and just sort of get the word out we wanted used bikes and [a small business owner] called…and I called him back and he said, 'I've got a bunch of them here'…and I went up there on Wednesday afternoon and there was about 40 old bikes.
>
> We had the gentleman who gave us the bikes bring us a bunch of bike magazines that had pictures of three wheel bike things in there so there was a lot of ideas struck from that and it is probably appropriate to mention that yesterday I invited [an engineer]...I met him first at Alcan…who has been working on electric vehicles.
>
> After school I've been trying to call [the contact person] from Goodyear. He is the engineering contact we have there. He is back from holidays and he called me and I paged him after school. He has quite a big, interesting project which he described on the phone.
>
> [A student]...has done a lot of thinking lately about the Lenadco projects...She and I are talking about what day to go back and see [the contact person], and we are talking in terms of the second or third day of the week right now.

He had established routines for ordering and paying for the materials needed by the students, and described these in an after class interview in the fourth week of school:

> Monday I give out a material list. That's what I do every Monday. I give out a list and say 'What do you need to keep working this week?' I designate my Monday afternoons, [after class], to chasing stuff for kids. So the list comes in and if they don't get it in until Tuesday they have to wait until next week and that becomes a problem.

In addition, his classes had to satisfy the prevailing insurance and safety requirements. In his role as Department Head, he invited an expert from the Ontario Insurance Exchange to the school to talk to all the department teachers. In an interview after class he indicated that:

> ...the bottom line is that you have to...particularly in this project stuff, you have to protect yourself and the way you protect yourself is through safety training. The sign off sheet that I used is a good very good example in that any judge that had any sense would look at that and say there's been conversation with the kids. The one thing that we don't do that we are going to do...is send a liability form home to the parents that indicates, you know, your Johnny is taking a technology course that involves using a variety of machinery.

Besides all this, he was active in extracurricular activities, professional and administrative responsibilities, and family life. Overall, it was apparent that more time and energy were expended by the teacher in this project-based course than in the standard teacher-controlled, teacher-paced offering, but that he saw more plusses than minuses in his approach to student learning.

Community-Centered Findings

The teacher, who enjoyed strong support from the school's administration for his unique offerings, served as the major contact person with outside agencies. The major community partners from business and industry for the semester in question were a retirement home and a major tire manufacturer. Both settings had contact persons who believed in the community-oriented and project-based courses. In an interview, one contact person from one of the above partnerships provided insight into this commitment:

> I think the kids get a different perspective on learning or a different approach to learning. That's kind of where I fit in. I was more interested in how I could help the students learn, more than what they could give back to me...I think it's a unique program...you've got a different angle on learning in a project-based learning program. Instead of giving information or having it regurgitated, you've got a problem solving situation going on and I like to be part of that.

The contact persons maintained the school portfolio as an extra to their regular job requirements. As one contact said: "My workload, that's not part of, or should I say that doesn't subtract from the workload that I have at the plant. I've got to make the effort, make the time." In the other major partnership, the contact person carried out work with the school under the umbrella of her role as chair of a charitable organization within her work establishment:

> It sure does [add to your workload]. Some days you don't find time. Like today for example, this is my lunch hour, and I don't really mind. But some days it really puts you behind. So when I know I have a resident care meeting and I have [the teacher and students] coming up, I have to hurry my work along in order to meet the appointments and things. That's part of that though. I mean becoming involved with any charity, it becomes part of it.

These individuals also had access to budgets that supported costs for project materials. The budgets came from diverse sources. For example in one case, the company provided a line item in their budget for these educational purposes: "There was some money put into a particular budget to be used." In another case, the staff had a fundraising committee, a charitable organization, and the funding for projects came directly from the staff account: "We have to do things through our own funding that the staff do here independent of the home."

Both persons saw the need for students to develop flexibility in problem-solving, to acquire experience in solving open and undefined problems, and to work cooperatively and harmoniously with others. As one contact person said: "Flexibility, the ability to solve problems, to be able to take a situation, any situation, and deal with it effectively and in a timely manner. Being able to react to a different situation in solving problems is very important." Both settings conducted ceremonies when the completed and fully-operational projects (garden tables and special laundry hampers for the retirement home, and a spool rewind system for the tire manufacturer) moved from the school to the community setting.

Practice Meets Theory

While the above section identified major attributes of the program in Manufacturing Technology, this section links the program's characteristics to current research and is divided into six segments. The purpose of each segment is to provide an introduction to, rather than an extensive explanation of, the relevant area of research.

The Development of Many Human Capacities

Traditional schooling has long been linked with reading, writing, and arithmetic. These emphases are apparent in student remarks reported earlier in this article about writing and looking things up in other classes. However, it is well-established that humans have a number of other capabilities that are equally important to society (e. g., "Teaching," 1997). According to Gardner (1983, 1993), these systems or intelligences include the musical, bodily-kinesthetic, spatial, intrapersonal, interpersonal, and perhaps the naturalistic (Gardner, 1995), as well as the linguistic and logical-mathematical. Each intelligence is developed by becoming competent in the sign system unique to it (Smith, 1992).

Because successful school programs pay attention to many such sign systems, not just two or three, the assessment of learning should be carried out in a number of different ways (Armstrong, 1994; Campbell, Campbell & Dickinson, 1996; Herman, Ascbacher, & Winters, 1992; Perrone, 1991). One relevant and current approach is called "authentic assessment" (Wolf, Bixby, Glenn, & Gardner, 1991). Both the grade 10 and 11 Manufacturing Technology courses examined here demanded much more of students than language and logic, and student assessment was based on a variety of achievements, such as weekly reports and portfolios, final design reports, final product assessment of the projects, formative quizzes, a summative exam, and class and group participation.

Learning as Social and Distributed

Traditional formal schooling has treated learning as individual and private, where students complete individual assignments, readings, exercises, and tests. However, many successful school programs have viewed learning as cooperative where group, rather than individual, products are important and where knowledge is distributed among all class members (Rogoff, 1990; Vygotsky, 1978). This latter perspective conforms with that of industry and most other work places (Premier's Council, 1988, 1990) where individuals must work cooperatively to pursue common goals and where different abilities are needed to complete projects. This was evident in interviews with community partners. As one contact person indicated, "I can't think of any job here that doesn't involve teamwork. All our teams are composed of maintenance, housekeeping, health care aides,...right up to the administration." In these settings, no one person has a monopoly on knowledge. This same contact person continued on this point:

> We sit down and we look at like my goals for this person, [a resident], and what they, [the other team members], would do…So everyone puts their goals together and we try to maintain [the resident's] emotional well being. And actually, maintenance and housekeeping play a very important role in that because we're there every day. Now, we're not a nurse. If somebody's got a problem they usually don't go to a nurse...So sometimes it gives us a back door to a problem…So it does take a whole team.

This perspective was evident in this particular program with its team approach to projects (see Loney, 1995, for project design principles that emphasize team work).

Learning as Constructed Knowledge

Most classrooms continue to employ the model of teacher as information transmitter and student as passive recipient of knowledge (e. g., Davis, Maher, & Noddings, 1990; Dreyfus, 1995). Although the teacher-student relationship can be understood from perspectives of behaviorism, information processing, and constructivism, only the latter seeks to embrace cognitive, emotional, and social dimensions (Epstein, 1994; Hutchins, 1995; Smith, 1997). Modern views of student learning presume learning to be a social constructivist phenomenon that focusses on direct student involvement and meaning-making within a sociocultural setting (Bruner, 1990; Dewey, 1938; Hill, 1994, 1997; Smith, 1995). Interviews with students, the teacher, and the school principal revealed that the Manufacturing Technology courses provided students with the opportunity to make meaning in groups for community needs - and this was very powerful for student learning as revealed particularly through student interviews cited earlier.

Learning in Context

Generally, students are expected to learn abstract and universal principles for transfer to many settings (e.g., Brown, Collins, & Duguid, 1989; Cole, 1990; Rogoff & Lave, 1984). However, this approach to learning is not congruent with that of pragmatic philosophers such as Peirce (e.g., Savan, 1988) and Dewey (1916, 1938) nor is it compatible with research that has been conducted over many years (Brown et al., 1989; Lave, 1988; Rogoff & Lave, 1984; Saxe, 1991). Findings from such research have shown consistently just how situation-specific most knowledge is and just how little transfer takes place automatically. In completing the "same" tasks both inside and outside school, students can show marked discrepancies between performances. As a grade 11 female student explained: "It has taught us a lot of things that we normally wouldn't have gotten by just sitting in class at a desk and doing assignment work. It gives you experience and you learn to incorporate that kind of thing not just in your job but in everyday life." This research into Manufacturing Technology courses found that engaging students in such community-inspired projects, as in our two examples of garden tables and a spool rewind system, provided a context for student learning and thus enhanced learning.

Student Motivation to Learn

Over the past century, many explanations have been advanced to explain student motivation (or its absence) in school. However, most motivation is based on the will to survive as a biological and cultural entity. On the cultural side, survival is enhanced by becoming competent in culturally-valued signs (Smith, 1992). In school, this desire for competence is shown by students becoming informed about matters that concern them (White, 1959). Generally, these matters are essentially social and should be placed in the context of meaningful classroom tasks while recognizing the need to support students' self-esteem and autonomy in learning (Beane & Lipka, 1984; Harter, 1986). Student and teacher interview data provided earlier in this article demonstrate that these motivational characteristics in students were supported by the technology courses examined here.

Technology Education as a Project-based Enterprise

In summary, technology education programs based in community projects are student-centered and rely on student-constructed rather than teacher-presented knowledge (Hill, 1994). These programs take advantage of multiple human abilities (Smith, 1992), recognize the social basis of learning (Vygotsky, 1978), and value learning in context (Lave, 1988). These programs are activity-based and both process- and product-oriented through the use of strategies such as Project Design (Loney, 1995). The Manufacturing Technology courses examined in this research is an exemplar of this approach to technology education.

Implications for Educational Practice and Future Research

Without claiming to generalize the results of this case study to other settings, we were able to generate a number of questions and implications for educational practice and theory. For example, many modern educational theories are supported by the project and the community-based learning model used in the technology education program examined here. Other school subjects might apply this model to see if student attitudes and learning are enhanced in their content areas. This model requires that schools and communities support and communicate with each other. This communication leads to a better understanding of life inside and outside school for everyone involved, and may soften the transition into life after school for students.

Technology education as practiced in the program studied here offers the educational system a way to expand the traditional focus in schools. When identified with research on multiple intelligences (Gardner, 1983, 1995) and other pluralistic views of learning and knowing, technology education moves us towards a more inclusive educational system for our children and a more holistic view of what it means to be a fully contributing member of society.

The project-based courses in technology education use design processes. Because design does not happen by default, a design process must become part of the course curriculum and students must be guided through the process. Students need to obtain as much information as possible from community partners about design problems at the very beginning of a course. This information is needed for students to begin to conceptualize their ideas in two and three dimensional forms. The findings of this study also showed the heavy reliance by students on experiential information as they moved toward representation in two dimensions.

These courses provided an environment that fostered student risk-taking. This risk-taking increased student self-confidence, motivation to learn, creative abilities, and self-esteem. Other school subjects could examine the benefits of the move from teacher-centered to student-centered courses and apply this model in their courses.

The findings from this case study provide initial insight into the attributes of a community project-based approach to technology education, the benefits to student learning, implications of this approach for teachers, schools and school partners, and educational theory that operates within this framework. Further research is needed to examine other such programs to document additional evidence and to confirm the findings of this study.

As well, further research would provide additional answers to important questions such as: What approaches to design best bridge the gap in technology education between school and real-life design situations? Is the transfer of student knowledge to new situations greater if initial learning is in context? If so, how is this best accommodated in technology education and other subject areas? How does this approach to teaching and learning meet the need of a wide range of learners and respond to modern theories of intelligence? And how can it be replicated by other teachers and subject areas? How does group or team work and the social dynamics it creates add to student learning? How does student construction of knowledge affect student learning compared to teacher presentation of knowledge? And what is the relationship of these two approaches? How does this approach to learning technology education meet the needs of female students as opposed to more teacher-directed courses? Does this approach to technology education foster integration of other subjects? If so, what are the benefits to students? What planning and organization are required for teachers to successfully implement this approach? What planning and organization are required of community partners? What are successful models for school, teacher, and community partnerships? And of course there the questions of whose need is being met when the community outside of the school becomes involved in school life. These are but some questions for future research in technology education, particularly programs that incorporate characteristics of the project- and community-based learning model examined in this article.

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article may be sent to the following email addresses: HillA@Educ.QueensU.Ca and SmithH@Educ.QueensU.Ca.

References

Armstrong, T. (1994). *Multiple intelligences in the classroom*. Alexandria, VA: Association for Supervision and Curriculum Development.

Beane, J. A., & Lipka, R. P. (1984). *Self-concept, self-esteem, and the curriculum*. Boston: Allyn & Bacon.

Bogdan, R. C., & Biklen, S. K. (1998). *Qualitative research for education: An introduction to theory and methods* (3rd ed.). Boston, MA: Allyn & Bacon.

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

Bruner, J. (1990). *Acts of meaning.* Cambridge, MA: Harvard University Press.

Campbell, L., Campbell, B., & Dickinson, D. (1996). *Teaching and learning through multiple intelligences*. Needham Heights, MA: Allyn & Bacon.

Cole, M. (1990). Cognitive development and formal schooling: The evidence from cross-cultural research. In L. C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of sociohistorical psychology* (pp. 89-110). Cambridge: Cambridge University Press.

Davis, R. B., Maher, C. A., & Noddings, N. (Eds.) (1990). Constructivist views on the teaching and learning of mathematics [Special issue]. *Journal for Research in Mathematics Education Monograph, 4*.

Dewey, J. (1916). *Democracy and education*. New York: Free Press.

Dewey, J. (1938). *Experience and education*. New York: Collier.

Dreyfus, H. L. (1995). Cognitivism abandoned. In P. Baumgartner & S. Payr (Eds.), *Speaking minds: Interviews with twenty eminent cognitive scientists* (p. 70-83). Princeton NJ: Princeton University Press.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist, 49*, 709-724.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Gardner, H. (1993). *Multiple intelligences: The theory in practice*. New York: BasicBooks.

Gardner, H. (1995). Reflections on multiple intelligences: Myths and messages. *Phi Delta Kappan, 77*, 200-209.

Harter, S. (1986). Cognitive-developmental processes in the integration of concepts about emotions and the self. *Social Cognition, 4*, 119-151.

Herman, J.L., Aschbacher, P.R., & Winters, L. (1992). *A practical guide to alternative assessment*. Alexandria, VA: Association for Supervision and Curriculum Development.

Hill, A. M. (1994). Perspectives on philosophical shifts in vocational education: From realism to pragmatism and reconstructionism. *Journal of Vocational and Technical Education, 10*(2), 37-45.

Hill, A. M. (1997). Reconstructionism in technology education. *International Journal of Technology and Design Education, 7*(1-2), 121-139.

Hill, A. M., & Salter, H. (1991). *Technological Education: A new definition for Ontario*. Kingston, ON: Queen's University, Faculty of Education.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.
Kirby, S., & McKenna, K. (1989). *Experience, research, social change: Methods from the margins*. Toronto, ON: Garamond Press.
Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge: Cambridge University Press.
Loney, D. E. (1995). *Project Design*. Scarborough, ON: Prentice-Hall.
Oakes, J. (1992). Can tracking research inform practice? Technical, normative, and political considerations. *Educational Researcher*, *21*(4), 12-21.
Ontario Ministry of Education and Training. (1991). *Technological Education consultation paper*. Toronto, ON: Queen's Printer.
Ontario Ministry of Education and Training. (1992). *Technological Education, early years to specialization years: Draft internal discussion paper*. Toronto, ON: Queen's Printer.
Ontario Ministry of Education and Training. (1993a). *Policy and program memorandum No. 115, 115a and 115c*. Toronto, ON: Queen's Printer.
Ontario Ministry of Education and Training. (1993b). *Technological Education program and equipment renewal fund: Annual report*. Toronto, ON: Queen's Printer.
Ontario Ministry of Education and Training. (1995a). *The Common Curriculum*. Toronto, ON: Queen's Printer.
Ontario Ministry of Education and Training. (1995b). *Broad-based Technological Education. Grades 10, 11, and 12*. Toronto, ON: Queen's Printer.
Perrone, V. (1991). *Expanding student assessment*. Alexandria, VA: Association for Supervision and Curriculum Development.
Premier's Council. (1988). *Competing in the new global economy*. Toronto, ON: Queen's Printer for Ontario.
Premier's Council. (1990). *People and skills in the new global economy*. Toronto, ON: Queen's Printer for Ontario.
Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.
Rogoff, B., & Lave. J. (Eds.). (1984). *Everyday cognition: Its development in social context*. Cambridge: Harvard University Press.
Savan, D. (1988). *An introduction to C. S. Peirce's full system of semeiotic* (TSC Monograph No. 1). Toronto, ON: University of Toronto, Toronto Semiotic Circle.
Saxe, G. B. (1991). *Culture and cognitive development*. Hillsdale, NJ: Erlbaum.
Slavin, R. E. (1990). *Achievement effects of ability grouping in secondary schools: A best-evidence synthesis*. Madison, WI: Wisconsin Center for Education Research.
Smith, H. A. (1992). Semiotics and modern schooling. In M. Balat & J. Deledalle-Rhodes (Eds.), *Signs of humanity* (Vol. 1, pp. 121-126). Berlin: Mouton de Gruyter.
Smith, H. A. (1995). Cultural psychology and semiotics: Confronting meaning in educational practice. *Canadian Journal of Education*, *20*, 407-414.