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Contents

From the Editor

Nine Years Back and Looking Ahead

Just about nine years ago, a meeting occurred at James Madison University, attended by William E. Dugger, Kendall Starkweather, Mark Sanders, and yours truly. The purpose of the meeting was to pursue an idea that Mark had of publishing a scholarly journal for technology education. Thus occurred the genesis of the *Journal of Technology Education*. From its inception, Mark has provided consistently high quality, innovative leadership to the *JTE*. Particularly noteworthy was his foresight in anticipating the pervasiveness of electronic journals and establishing the *JTE* as the first scholarly journal in the world (from the information we have collected) with all issues available electronically, on-line. In preparing this, my first issue as editor, I realize even more the tremendous contribution of time, effort, and creativity that Mark has made to scholarship in technology education around the world. Mark will continue as Associate Editor, the position I have held since the beginning.

Though coincidental, it is nonetheless timely that the editorial on research by James Haynie appears in this issue. In developing his argument that more experimental research needs to be conducted by the profession, Haynie analyzed the articles that have appeared in the *JTE*, from volume one, number one. He mentions the need for qualitative research as well. Again coincidentally, four of the five regular articles in this issue are qualitative studies. Using Haynie's data, this means that 40% of all the qualitative articles published in the *JTE* appear between the covers of this issue. This is consistent with the dramatic swing of the pendulum within the social sciences toward qualitative inquiry. Courses in qualitative research methodology at institutions like Virginia Tech have started to become more popular among doctoral students than their quantitative counterparts.

When the name of the *American* Industrial Arts Association was changed to the *International* Technology Education Association, there was a concomitant hope by the leadership that its sphere of influence would grow significantly beyond the boundaries of the United States. From the beginning, the *JTE* has had international representation on its Editorial Board. Four of the five regular articles in this issue were penned by international authors, far more than in any of the past issues. Based on the articles currently in the review process, this international trend may continue.

Over the years, a number of articles have appeared in the *JTE* that either focused on the teacher shortage issue or cited it within another context. As this issue goes to press, it is the height of the hiring season for higher education. There are more positions available in the U. S. in technology teacher education this year than I can remember in my entire career in higher education. Even more remarkable is the number of these positions that specify primary responsibilities in technology *teacher education*. I have also learned that several of these positions are “new,” thus potentially expanding the resources nationally that we have to prepare teachers and reducing the teacher shortage.

All of these rather disjointed happenings could simply be flashes in the pan. However, it is interesting to conjecture about our future if they were valid indices of the direction in which we are heading. First, the surge of qualitative research could finally lead us to a solid rationale for technology education, perhaps even getting at the unique and significant contributions that we make to the lives of our students in the affective domain of knowledge. Second, we could truly become an international profession in which the global sharing of ideas and research becomes natural behavior and is unimpeded by political or cultural borders. Through our rapidly developing communication networks, scholars and researchers could become equal partners with practitioners and parents in providing the most exciting and sound technology education experiences for our students. Finally, if the number of positions available represents a resurgence in technology teacher education, we could have the human power necessary to do the research about which Jim Haynie and others have long lamented, as well as sufficient numbers of teachers to put the research into practice. The prospects are refreshing.

Articles

Aspects of Teamwork Observed in a Technological Task in Junior High Schools

Moshe Barak and Tsipora Maymon

One of the proclaimed goals of technology education is to provide pupils with teamwork skills (Barlex, 1994; Denton, 1994; Dyrenfurth, 1996; Raizen et al., 1995; Williams & Williams, 1997). Team performance surpasses that of the individual, particularly when the issue under consideration requires a variety of capabilities, experience, and judgment skills (Katzenbach & Smith, 1993). The importance of teamwork has become more widely recognized in recent years, corresponding with the information explosion and the need to solve more and more complex and interdisciplinary problems. Global competition in high-tech areas forces organizations to adopt sophisticated and effective methods of work and management. Teamwork has become one of the focuses of interest among new approaches to the management of technological projects and general organizational management, such as TQM and QWL (Goodman et al., 1987). The rapid development of communication systems, the ability to transfer information with speed, and the availability of video-conferencing, create new possibilities for people to work together even at a distance of thousands of kilometers. As a consequence of these developments, it is necessary to devote further attention to the provision of teamwork skills in the framework of technology education. The present study examines different aspects of pupils' teamwork that develop during a technological task, with an aim to cast additional light on teamwork in technology and to contribute information for the establishment of a methodology for teamwork in technology education.

Theoretical Background

Different aspects of teamwork in the world of high-tech industry will be examined and, where relevant, adapted to technology education. Katzenbach and Smith's (1993) definition of team is: "A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable." Therefore the first aspect of teamwork is identified: a team cannot operate without a *goal*. In the world of technology, the team's goal will usually be the

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design and construction of a product that meets human requirements and improves the quality-of-life. It should be emphasized that in the technological-business world, successful teamwork is measured mainly in terms of the quality of the developed product. This is not necessarily applicable to education, where primacy is given to learning and the processes associated with it.

The second aspect of teamwork is the *composition* of the team. A team will function effectively only when the members complement each other's abilities, skills, and expertise. It is the interaction processes, the mutual inspiration and enrichment, that turn the group of individuals into a team. Team members must complement each other not only in terms of their professional capabilities, but also in their work style. Parker (1991) identified four "team player styles": A *contributor* who is task oriented, a *collaborator* who is goal oriented, a *communicator* who is process oriented and a *challenger* who is question oriented.

The third aspect is the *decision-making process and leadership development* in the team**.** The growing emphasis on teamwork focuses the question concerning decision-making processes and the development of leadership in the team itself. Various ways of decision-making in the team can be identified: *Random*, opting for one of the ideas suggested by the team members; *Minority opinion* (imposed in various ways); *Majority Decision or Consensus*; and *Leader's Decision* (Barak, Maymon & Harel, in preparation).

A distinction between a manager and a leader is currently emerging in organizations. The manager is typically appointed by higher management and represents a link between management and work teams. The manager's role is to ensure that the team has available the skills and the technical means required for the job (Janz & Harel, 1993; Parker, 1991). The leader, on the other hand, may emerge from among the team members, on the basis of his/her professional expertise and charismatic personality. The leader's role is to clarify the goals, strengthen the professional skills, and nurture the cooperation among team members (Katzenbach & Smith, 1993).

The fourth aspect is *team development*. A team develops from individuals through a series of stages in accordance with the shared experiences of its members. Tuckman (1965) identified four stages of team development that have been adopted by other researchers (Baired et al, 1990; Jaques, 1984; Parker, 1991):

Forming	Team members become acquainted with each other. Information such as personal schedules is exchanged. Determining each team member's main strength and assignment of roles and responsibilities.
Storming	Members jockey for position. Dissatisfaction, competition and conflict surface. Members become aware of their differences and try to determine how they will work together.
Norming	A group consensus emerges. The group comes to agreement on its purpose or function. Members are clear what their

	roles and responsibilities are. The group has a sense of identity and members strive to work together.
Performing	Group structure, norms, and behavior are understood and accepted. Members know how to work with each other. They can handle disagreements and misunderstandings effectively. The group is focused on accomplishing its purpose.

The above characteristics of teamwork are drawn from the workplace; what can be extrapolated to technology education? An apparent consensus is that in order to impart teamwork skills to pupils, they need hands-on experience in teamwork concerning a technological project, under conditions as similar as possible to those found in high-tech industries. Theoretically, in a school technology project, the pupils can themselves go through the processes of constructing the team, various decision-making circumstances, and team development. However, a fundamental difference exists between teamwork in the workplace and at school. In the workplace, the team's main goal is to complete the task of producing a product according to predetermined targets. At school, the main aim is to teach the pupils how to operate as a team, and the technological project is of much less importance.

Teamwork in technology education has similarities to the methods for cooperative learning. Slavin (1990) surveyed a range of methods for cooperative learning. An example of one of the methods of cooperative group learning is Student Teams-Achievement Divisions (STAD). This method employs competition between groups while encouraging cooperation within groups. The team score is based on individual improvement on quiz scores in a way that enables even the low achievers to contribute the maximum amount of points to the group. Another known method for cooperative learning is Group Investigation (Sharan and Sharan, 1992). The groups choose topics from a unit being studied by the entire class, and carry out cooperative inquiry, discussion and projects. Each group presents or displays to the entire class. One more example is the JIGSAW method (Aronson et al., 1978): students are assigned to six-member teams to work on academic material that has been broken into sections. Next, members from different groups meet in expert groups to discuss their section. Then the students return to their teams and take turns teaching their teammates about their section. Most of these types of cooperative learning structures have been well researched and consistently show significant gains in achievements and other outputs such as inter-group relations, pupils' self-esteem, locus-of-control, time-on-task, and classroom behavior (Slavin, 1990; Whicker et al. 1997). Qin, Johnson, & Johnson (1995) compared the impacts of cooperative versus competitive learning on problem solving through a meta-analysis of 46 studies published between 1929-1993. They found that members of cooperative teams outperformed individuals competing with each other on different types of problem solving, where superiority was greater on nonlinguistic than on linguistic problems. This finding reinforces the belief that technology studies are a particularly suitable frame for promoting teamwork in the schools.

The distinguishing feature of the technological task is that pupils' efforts are focused on design and production, which impinges on the goal presented to the team, the skills required of the team members, the sort of decisions that have to be made, and the criteria of success. There is a range of opportunities in technology to present the pupils with stimulating tasks that culminate in the construction of a product or system whose properties can be tested according to objective criteria. Therefore, there is less need in technology studies as compared with other fields, for teacher intervention for the purpose of creating motivation by means of quizzes, points, ranks, or student presentations.

The Study

Background

The general aim of this study was to increase the understanding of pupils' teamwork behavior within a technological task. To this end, a four-hour workshop was developed in which pupils designed and constructed an envelope for a hot-air balloon from tissue paper. This workshop was part of the "hot-air balloon" year project, which is described briefly below to clarify the context in which the research took place. Nevertheless, the workshop can be performed on its own as a technological project.

As part of an overall effort to promote and renew science and technology education in junior-high schools in Israel, an integrated physics and technology learning program that involved the design and construction of hot-air balloons was developed in the Technion (Barak, M., Raz, E., & Karniel, B., 1996). The seven schools in which the workshops took place were selected from among 22 schools that were involved over the previous three years in this program in the Galilee. The hot-air balloon educational project was planned for an entire school year. Pupils study physics for approximately 100 hours and technology for approximately 80 hours, together providing the theoretical background for designing the hot-air balloon. In the final trimester, pupils devoted about 30 hours to constructing and flying the hot-air balloon. A group of ten pupils was sub-divided into smaller teams, each building a different part of the hot-air balloon: the basket, the electronic control system, and the gas system and burner. Due to technical limitations and its size (eight meters in height and five meters in diameter), the pupils did not sew the balloon envelope themselves; rather, it was manufactured commercially. As a substitute, in this workshop the pupils constructed a smaller model of the envelope (two meters in height and 1.25 meters in diameter).

The teachers participated in in-service courses in which they studied both subject matter and didactics. Each school was allocated a tutor who worked individually and collectively with the teachers, with an emphasis on non-evaluative help to the teacher. This supervision was matched to the individual needs of each teacher (Barak et al., 1997; Glickman, 1990).

The Balloon Envelope Assignment

The pupils' task was to design and construct a scale model of the hot-air balloon envelope using tissue paper. Teamwork is essential for completing the task. The workshop was designed to enable pupils to attain most of the requisite goals of teamwork in the technological realm in accordance with the workplace model. The workshop stages were:

1. *Presenting the problem.* The pupils confront the issue of constructing a 3-D body from 2-D material. Peeling an orange was used, for example, to present the idea of constructing the envelope from sections.
2. *Planning.* Issues deliberated by the pupils included the balloon's radius and height, angle at the apex, and the number of vertical sections (6 to 12). The latter has significance for the balloon's circumference and radius since the greater the number of sections, the larger the balloon. Pupils coped with issues of shape, stability, and amount of work involved. A typical envelope designed by pupils is shown in Figure 1. During the planning stage, each group prepared a template from a sheet of Bristol board, fitting it to the dimensions of the available sheets of tissue paper. This template was used for cutting the tissue paper sections that form the envelope.
3. *Constructing.* The actions carried out in this stage were: choosing the colors and combinations of tissue paper to be used; gluing the sheets of tissue paper together in order to obtain long strips; positioning and cutting the tissue paper using the template; sticking the sheets of paper in a particular order; sticking a strip of Bristol board to stabilize the lower opening; gluing the open end; and correcting defects such as open seams, tears in the paper, and faults in the decorations. This task required the whole team to solve various technical problems such as how to apply glue and in what order it should be applied, how to prevent the cut-outs from sticking together, how to correct an error made in the order of assembly, and so forth. On completion of this activity, the model hot-air balloon envelope was ready for flying.
4. *Testing and evaluating the product.* A trial launch was carried out in the classroom using a blower heater. Subsequently the envelope was launched outdoors using a gas burner. The evaluation related to performance and aesthetic aspects: Did the envelope rise? How high did it go? Was it stable? Are the colors attractive? Were the materials accurately assembled? The evaluation is informal, made by the pupils themselves and the teacher.

The workshop was designed such that each of the four stages of the technological task advanced the pupils to a higher level of teamwork, as illustrated in Figure 2.

The assignment comprised four technical stages, which paralleled the phases of teamwork development. This enabled close examination of the dynamics and interactions in each area, within a relatively brief assignment, without expecting pupils to gain all the skills in every field.

Purpose of the Study

The purpose of this study was to examine the processes of teamwork that emerge during a short workshop, the aim of which was the completion of a technological task. Several questions were addressed: To what extent can a short

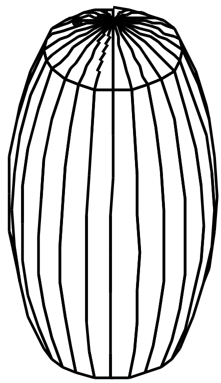

Figure 1. A hot-air balloon envelope

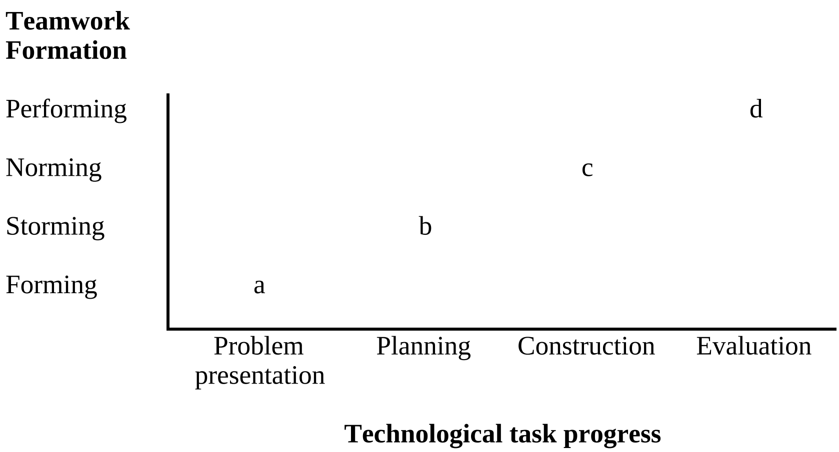

Figure 2. Stages in teamwork development in relation to task progress.

workshop promote teamwork among pupils working on a technological task? What are the factors that promote pupils' motivation for the task? How are teams composed? How do teams develop and function in relation to the progress on the technological task? Which patterns of decision-making and leadership occur during teamwork? What function do teachers play in their pupils' teamwork? Through observing the pupils at work, we sought insights for the development of teaching and learning methods to provide pupils with teamwork skills in the field of technology.

Population

The workshop was implemented at the 9th grade level in seven schools (A-G) in northern Israel. The schools were diverse in the socioeconomic populations they served. Table 1 illustrates that 45 pupil teams were observed in nine workshops, each team composed of three to five pupils (total 172 pupils). Each team designed and constructed its own balloon envelope. Sixteen technology and physics teachers guided their pupils in the workshops.

Table 1
Research Population

School	Girls	Boys	Number of Teams
A1		16	4
A2	31		7
B	5	8	4
C1	8	8	4
C2	7	5	3
D		21	7
E	8	7	4
F	4	17	5
G	12	15	7
Total	75	97	45

Methodology

Open-ended observations were employed throughout the workshops to examine the processes taking place in the class with respect to teamwork. To overcome the weaknesses associated with such observations, several observers were used: the researcher as a non-participant observer, the school's tutor, and the class teacher(s) as participant observers.

On the basis of the trusting relationship between the teachers and the research team, the research team believed that they could learn more about classroom processes from a qualitative study in the classroom rather than to attempt to measure the complex phenomena of teamwork by quantitative means. The researcher tried to merge into the background so that her presence would not be felt. The teachers worked directly with the pupils. The five tutors, who had met the pupils on previous school visits, conducted, in effect, informal interviews with the pupils. These observers thus complemented each other in their degree of familiarity with the pupils and their involvement with them. The observations took place on different occasions in schools that were differentiated by their location, the socioeconomic background of the pupils, the composition of the teaching staff, and the experience of the teaching staff in teaching science and technology.

Data were collected using the method of triangulation (Cohen & Manion, 1980) for observers, method (observations, interviews and questionnaires), and time and place (seven schools). All three observers took written notes on processes that occurred during the workshop. The next stage involved methodical analysis of the information collected by the observers, with an aim to identify the characteristics of each team's work in terms of the theoretical model. The functioning of each team was grouped according to the following categories: motivation, team composition, decision-making processes and leadership, stages of team development in relation to the progress made on the balloon envelope, and group cohesiveness.

Results

Pupils' motivation towards the goal

Pupils' motivation on a task can be measured (according to Sharan & Shaulov, 1990) by the degree of involvement and the level of purpose and energy the pupils demonstrate in relation to their work, and the degree to which they are prepared to devote extra time beyond regular school hours in order to achieve the goal. The balloon envelope workshop was planned for four hours, the average time needed to complete the task in earlier trial runs. Cases were observed where the pupils argued with the teacher about the time limit for the workshop and whether they would manage to finish the task on the same day. These arguments abated as pupils became engrossed in their work. In 44 out of the 45 observed groups, pupils worked continuously and without time constraints, staying behind to work during recesses and after school hours until such time as the last group had completed its envelope and had flown its balloon. Both teachers and observers noted the high degree of involvement of pupils in the workshop. High motivation was perceived among all the pupils to complete the task of constructing the hot-air balloon envelope, despite the differences between the groups in terms of pupils' background, level and style of teamwork obtained and extent of teacher intervention. Interviews with the pupils and teachers revealed four main sources of this motivation:

- The intrinsic interest the subject held for the pupils.
- The challenge with which they were presented.
- The practical work, leading to an attractive product.
- The change in classroom atmosphere, pupil-pupil and pupil-teacher relations.

In some cases, the high-level of motivation to complete the task contributed to high cooperation among group members, and to mutual assistance between groups. However, other cases of high motivation among group members found spontaneous expression in competitiveness towards other groups.

Team composition

In all workshops but one, the pupils organized their own groups. Freedom of choice in group formation led most pupils to single-gender groups. It can be seen from Table 2 that 38 of the 45 groups were single-gender. In a few cases, teachers transferred a pupil from one group to another, generally to make the groups comparable in size. Only one teacher determined the groups himself, and in that particular class, three of the five groups were of mixed gender.

Table 2
Group Composition by Gender

School	Girls Only	Boys Only	Mainly Girls	Mainly Boys	Number of Groups
A1		4			4
A2	7				7
B	1	2		1	4
C1	2	2			4
C2	1	1	1		3
D		7			7
E	2	2			4
F		2		3	5
G	2	3	1	1	7
Total	15	23	2	5	45

Observations of the single-gender groups revealed that girls were less argumentative and aggressive within their groups than were the boys. The boys were more competitive and less willing to offer help to other groups. One girls-only group that finished the construction first was the last group to launch their envelope because they helped other groups and held back at the flying stage. The researchers concluded that when groups are formed spontaneously, their composition tends to be homogeneous to the exclusion of pupils possessing the different skills necessary for performing the task. This should come as no surprise: when the groups are formed prior to the pupils being aware of the ensuing task, they prefer to work with their friends or same-gender peers. From this perspective, the teacher must ensure that the groups are balanced in relation to gender, skills and expertise so that students of different backgrounds learn to work with each other, similar to the workplace. To achieve this, the teacher should involve the pupils in the considerations employed to create the groups by first presenting them with the kind of activities which the group will need to perform and the skills required to attain the goal.

Stages in Team Development

Teams develop in stages and the workshop was designed such that in each phase of progress on the balloon envelope, pupils' teamwork also developed. It was easy to keep track of task performance via the tutors' observations because the pupils' sketches, envelope sections, and finally the finished product were readily visible. In contrast, monitoring the group's functioning as a team was far more complex because the passage from one stage to the next was not clear-cut. The findings from the observations are summarized in Table 3 in which the pupils' activities on the technological task are presented in conjunction with their behaviors relating to teamwork in the four anticipated stages of development.

The stages of progress on task performance and the development of teamwork described in Table 3 are a summary of the processes observed among the 45 teams who built their own envelopes. Clearly, there were differences among the groups in terms of proficiency on the task as well as interpersonal relations among group members. The researchers hoped to identify, at the very least, the stage at which the group began to show rudimentary signs of teamwork in performing the technological task such as group discussions, joint decision-making, acceptable role assignment, joint activity, and interdependence of the group members for performing the task. Table 4 presents the number of groups in which teamwork was observed according to at least one of the above features, at different stages of task performance.

Table 4 illustrates that most groups began to function as teams during the planning or construction stage, namely the second and third stages. Only a minority acted as teams within the initial stage of presenting the problem, and two teams achieved this level of cohesion only in the final stages of the project. Out of the 45 groups observed, only one group failed to function as a team by the end of the workshop, due to arguments among group members and negative leadership.

Table 3
Teamwork Development Matched to Progress on the Technological Task

Stage	Pupils' activity on task	Teamwork characteristics
a	*Problem presentation*: Pupils receive their first information concerning the envelope task, project targets and restrictions. They review the theoretical background.	*Forming*: Pupils do not yet know how much they must work with others. Pupils need encouragement from the teacher to begin to work as a group.
b	*Planning*: Each group makes decisions about their envelope's colors, dimensions, and number of sections. They prepare the template from paper board.	*Storming*: The task requires several joint decisions. The group has its first experience in decision making and joint problem solving.
c	*Construction*: The team selects paper sheets, connects them in layers, cuts, glues and assembles the envelope. This is hard to achieve individually.	*Norming*: Pupils work together, share tasks, help each other, and exchange information. Each pupil has a role in the teamwork, but cooperation is essential.
d	*Testing and evaluation*: All teams fly their balloons, comparing their envelopes.	*Performing*: The team presents its product jointly. Outwardly, the team appears cohesive. Each member has a place in the team.

Leadership and Decision-making

The team had to make decisions while working on different topics such as the number of sections for constructing the envelope, the shape of the Bristol board, the colors and decoration of the envelope, and the assignment of duties. The observers monitored the decision-making patterns within the teams and sorted them into four categories: Consensus Decision, Random Decision, Teacher Intervention Decision, and Leader Decision.

The most prevalent pattern of decision-making was consensus (44.4%), followed by random decision (24.4%), teacher intervention (20%), and leadership (11.1%). Groups operating under consensus lacked a dominant leader who imposed his/her decisions on everyone. In those few groups in which such a leader was present, the other group members perceived this charismatic personality to be more able, and they were willing to accept this leadership. Teacher intervention occurred when the group got involved in lengthy arguments and was unable to reach a decision. In some cases, the teacher joined the group and considered himself to be part of the group, becoming a dominant figure in the group. These outcomes demonstrate that in a group task such as this, spontaneous leadership development should not be anticipated. If we want to provide pupils with the skills for assuming leadership and functioning as a team under a leader, we have to initiate situations in which pupils can have hands-on experience. It should be pointed out that although the schools represent different socioeconomic backgrounds, all the patterns of decision-making were found in most of the schools; no particular pattern of decision-making is associated with a particular population.

Table 4
Number of Groups Exhibiting Initial Teamwork at Stage of Progress on Task Performance

Stage / School	Presenting the problem	Planning the envelope	Constructing the envelope	Flying and evaluation	Teamwork not achieved	Total # of groups
A1	1	2	1			4
A2		2	5			7
B	3	1				4
C1	1	1	1	1		4
C2		2	1			3
D		2	4	1		7
E		3	1			4
F		5				5
G		3	3		1	7
Total	5	21	16	2	1	45

Group Cohesiveness

Another feature of teamwork in school is the *cohesiveness* of the team. Group cohesion is defined as “the relation of individual group members to the group as a whole” (Schmuck & Schmuck, 1978), and the degree of interest held for what happens in the group as opposed to that which occurs in other groups.

Cohesion expresses the commitment of individual group members to the group. The main criterion chosen to indicate cohesiveness was the existence of between-group competitiveness. The competition among the various groups in each class developed spontaneously, even though no competition was declared and no prizes of any kind were promised for excellence. Competition focused on questions such as: Who will finish first? Whose balloon will be the biggest/have the prettiest colors/be free of holes? Whose balloon will fly best/highest/longest? Pupils invested much effort in choosing unique colors for the envelope and its decoration.

The observers ranked the cohesiveness of a team as *high* (37.8%) when all group members cooperated so that their group would succeed in the competition with other groups, as *moderate* (42.2%) when some of the members stood to one side, and as *low* (20%) when group members showed no interest in what the group was doing nor in the competition against other groups. While 80% of the groups functioned with moderate or high cohesiveness, at least one group in most of the classes exhibited low cohesiveness. In most cases, the competition between the groups was subtle, and a positive atmosphere was maintained in the class. Despite the competition, there were cases of groups helping each other. The pupils' solidarity sometimes affected the whole class and was not limited to their own team. In contrast, some groups invested much effort not to be outdone by other groups, despite tension among its own members. Even in the absence of extrinsic rewards, such as declaring the winner or awarding prizes, inter-group competition develops naturally when the task stimulates the pupils.

The Teachers

Sixteen teachers participated in this study. Most workshops involved two teachers working in collaboration on the hot-air balloon project: the physics teacher and the technology teacher. Prior to conducting the school workshops, the teachers participated in a special four-hour workshop, identical in format to the pupils' workshop: they split into teams and worked on the design and construction of balloon envelopes. The lessons learned from the teachers' workshop were used to improve the module; the teachers were partners in the development of the idea, and its implementation in the classes.

Three profiles describing the teachers' function in the pupils' workshops were identified:

1. *The Facilitator*. Some teachers were subtly involved in the teams' work. They clarified technical issues, helped groups to overcome difficulties, and handled interpersonal problems, but avoided intervening in final group decisions or assignment of duties to the pupils.
2. *The Manager*. Some teachers found it difficult to allow autonomy to their pupils, and they became involved as managers in the decisions, assignment of duties, and performing the task, but they did not stay in one particular group.
3. *The Foreman*. A few teachers became dominant figures in the teams. They worked alongside a particular group throughout, and guided them

> closely. They made the decisions, gave instructions, and assigned duties, thus preventing the pupils from functioning autonomously. A teacher-run group achieved well, often being the first to complete the task, but its development as a team was doubtful.

Many teachers experienced difficulty in changing their traditional role. Teachers must learn to "let go" and become facilitators so that autonomous teamwork can develop in the groups.

Conclusions

This research attempted to uncover aspects of teamwork crystallization and development among pupils engaged in a short technological task. The advantage of a short task, which the pupils begin and end in a single session (4-6 hours), is that the work is performed intensively, an effort is made to complete the task, and the pupils receive immediate feedback. Such a task enabled us to uncover a number of processes connected with teamwork.

The first outcome relates to the effectiveness of a short technological task as a means for promoting teamwork. The present study shows that a relatively short technological task which is open-ended and requires pupils' shared decision-making and mutual dependence, can result in teamwork development. High motivation among pupils, which is a key to creating teamwork, can be achieved by presenting a technological task that combines intellectual challenge with practical ability, and allows pupils to experience the process that terminates in a desired product. The changes in classroom atmosphere as well as pupil-pupil and pupil-teacher relationships are also sources for increasing pupils' motivation.

When pupils are highly motivated, competitiveness develops spontaneously among different teams in the same class, or alternatively the teams operate with mutual aid, and the entire class becomes one team. In both cases, investing effort in planning a technological task that stimulates challenge is preferable to the teacher initiating competition or ranking among the groups.

The second outcome concerns teamwork development. It would be a mistake to think that the mere assignment of pupils to a work-group leads to meaningful teamwork. The theories that address the development of teamwork in the workplace describe the phases through which the group passes, from the stage group members become acquainted with each other, through consolidating an efficient form of teamwork. In the field of technology it is common to identify several phases of the "design process," from the presentation of a problem or a human need, through the production of an artifact or a system, and its evaluation and improvement. We have shown that a technological task at school can be based on interaction between these two dimensions. Curriculum planners and teachers can design technology projects so that the pupils will develop teamwork gradually and practice the necessary behavior patterns for teamwork in conjunction with progress on the task. In our example, groups functioned as teams at earlier or later stages, but on completion of the task most of the groups were functioning as teams.

Another aspect that was uncovered in the present study was the potential for groups to develop different patterns of role assignment and decision-making such as consensus, random decisions or teacher intervention. The fact that in our case, spontaneous development of leadership within groups was rare can be explained partially by the fact that the groups managed to complete the task without a leader. In a long-term technological project, the team may require leadership. Pupils can be trained in leadership by appointing a leader to the group via democratic ballot within the group, for instance. Further research is required to expose the processes of leadership development and to compare the dynamics of groups that function with or without a leader. Cross-cultural research may enlighten us with regard to how cultural differences affect leadership, decision-making in the group, and the gender composition of the group.

Finally, concerning the teacher's role: after years of teaching by traditional methods, teachers face difficulties in promoting significant teamwork in class, mainly because this means transferring more autonomy and responsibility to the pupils. This seems to be especially difficult in technology, where the teacher has to supervise pupils' proper use of tools and materials. On the one hand, teachers have to select pupils' projects and oversee the groups' composition in order to ensure that pupils with different abilities and academic achievements, boys and girls, will learn to work together. This is not only a matter of educational value, but also an essential aspect of preparing pupils for teamwork in "real life." On the other hand, teachers have to detach themselves from the traditional role in which they are the center of attention in the classroom.

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Developing a Disposition to Teaching Design and Technology: A Case Study

R. Hansen & D. Davies

Introduction

Literature in the field of technological education has attempted, in recent years, to define technology and technological education (e.g., Dyrenfurth & Mihalevich, 1987; Layton, 1993; Ortega, 1962; Staudenmaier, 1985; Wiens, 1988). These definitions emerge, typically, from analyses of what philosophers, sociologists, historians, and educators have written about the subject (Hansen & Froelich, 1994). Reference to what technologists actually do in their work (Rophol, 1991) has also contributed to definition material but to a lesser extent. Missing from the mix of material for a definition is an analysis of what technology instructors do in their classrooms. The following case study provides readers and the emerging literature in technological education with a different viewpoint of technology which is powerful and compelling. The Martin Rivers (a pseudonym) case challenges our understanding of what constitutes effective teaching and learning. It explores the connection between technology and the act of learning. What are the human problem solving instincts and emotions associated with learning something from experience in the technological world? Intentionally, the case also highlights a difficulty which faces technology teachers. That difficulty is the assimilation into several potentially alien cultures made by these teachers. Firstly, there is the culture of the school with its complex hierarchy of relationships and meanings concealed by educational jargon. Secondly, and perhaps more crucially for the technology teacher, is the culture of the subject itself: a new field of study in curriculum terms; fighting for recognition and academic respectability (Goodson, 1994); blurred at the edges by its relationship with design, science, art and mathematics. It is unsurprising that new teachers take time to orient themselves within this new world. How can they be helped to achieve successful enculturation?

Technology is defined by Ortega y Gassett (1962) as the extra-natural program that is man [sic] himself. What Gassett described in his essay "Man the Technician" is a simple but also obscure idea. Human beings are programmed, Gassett would argue, to meet their needs, the most prevalent of which is to use natural and manufactured resources to solve problems. Martin Rivers'

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experience is relevant to understanding technology and also science, especially the contextualization of scientific concepts through design and technological activity. His schooling as well as his early career development in teaching underscores the creative problem solving dimension of technology teaching and learning. Martin proves it is possible to help students understand the multi-faceted nature of technology through imaginative projects in schools. His life-story traces how he became a teacher and acquired the orientation to learning that characterizes his teaching. In short, the character and substance of his disposition to the profession and to learning is featured.

In life-story research (Cole, 1991), the conversation between the investigator and the interviewee is usually dominated by the participant who is asked to freely recall and reflect on life experiences. The researcher, Cole asserts, maintains a passive role, merely probing these recollections and reflections. The purity of such accounts can range from strictly autobiographical to what Connelly and Clandinin (1990) call “collaborative stories.” “And in our story telling, the stories of our participants merged with our own to create new stories, ones that we have labeled ‘collaborative stories’.” (p. 12).

This manuscript takes as its focus the process of reflective career autobiography as a means of making sense of the culture shifts we all have to undertake in education. It makes use of the personal writing of a case-study subject who was selected because, although his career has been set entirely within a United Kingdom context and is in many ways atypical, he has articulated some of the difficulties in adjustment which many technology teachers would acknowledge to be universal. He has analyzed “critical incidents” (Tripp, 1993) which have influenced his career path, and has developed an awareness of his disposition, both towards technology teaching and towards the nature of the subject itself. The manuscript analyzes the stages of this autobiographical process and invites other technology educators to engage in similar reflection upon their own enculturation.

The purpose of case study research is to create insights and understanding rather than to generalize to a larger population. The purpose of this particular case study is to better understand how one teacher, who chose to experiment with his teaching and learning activities, came to grips with the complex territory between his instincts and tendencies and the norms/values which characterize what is thought, within the profession, to constitute effective teaching. The technology teacher perspective into the nature of technology, interestingly, is unique and can take different forms as the case which follows conveys.

The Importance and Place of Creative Thinking: The Martin Rivers Case

I am neither a designer nor a secondary school technology teacher, yet I have experienced some of the socialization problems facing new teachers entering the ‘alien culture’ of the school staffroom. In my case it was as a scientist making the transition between the dry academia of a traditional undergraduate physics course, and the complex social context of an inner city primary school. Although it was a shock, in some ways it was a little like *'coming home,' and recapturing a lost part of myself. To explain this statement I need to briefly revisit some childhood learning experiences.*

As a child, I was an obsessive designer-maker. In addition to the traditional construction toys, I consumed vast quantities of cardboard and sticky tape in grand projects to construct whole model towns, suits of armour and life-size robots. This would fall under the heading of 'junk-modeling,' or more recently 'modeling with reclaimed materials' in contemporary primary practice, but I had comparatively few opportunities to exercise my making skills at school. One notable exception was the teacher who, in 1968, involved my class in making paper mache electric guitars and drum kits, in order to mime along to the Beatles' recently issued Sergeant Peppers album.

One can sense that at an early stage in Martin's life he yearned for immediate and real experience with any materials he could find. His mind was alive with scenarios to be explored and ideas to be put into practice. He was already establishing values with respect to the practical or manufactured world, presumably stimulated by events around him as well as by his bountiful imagination. However, these tendencies were not often nurtured at school. The exception was a memorable project conceived by one of his teachers. What did this teacher do and know that triggered such enthusiasm in his/her students? What was Martin learning in this instance? What goal did the teacher have in mind when he/she designed the learning exercise?

I received a carpentry set for my seventh birthday, and proceeded to build a two storey tree-house with electric lighting, and a helicopter in the back garden using a rotary clothes-line. Like most pre-pubescent boys, I flirted briefly with model aeroplane kits, but never possessed the patience and attention to detail required for carefully painting each part before assembly. Making other people's designs bored me, but drawing elaborately annotated (and completely impractical) schemes for underwater cities and bizarre factories fascinated me.

At my selective state grammar school, an outlet was provided for a limited form of artistic expression in the context of traditional fine art classes. The situation with regard to designing and making was, however, very different. The 'craft workshop' in which our woodwork and metalwork lessons took place was a small prefabricated hut at the far end of the playground, a situation indicative of its low status within the academic hierarchy of the school. No mention was ever made of the words 'design' or 'technology' and it was clear that, unless we were to take the 'technical drawing' 'O' Level, our brief and occasional visits to the craft workshop would soon cease. Instead I was channeled along traditional academic subject routes, with an emphasis on the sciences; regarded as having the highest status of all. I did manage to retain my art, taking it to 'O' level, but without great success.

It appears that Martin's desire and aptitude for "making and doing" was not being recognized or channeled in his schooling. If anything he was being asked to defer his apparently natural and deep tendencies to "design and make" activities while in school. Mention of the "academic route" is a familiar refrain in his writing.

I transferred to a sixth-form college at age 16, determined to take an 'A' level in design, alongside my maths, physics and chemistry. However, even here the design was looked down upon, seen as a dubious university entry qualification and a distraction from my real work. Reluctantly, I agreed to replace the design with further maths, turning myself into a narrowly focused physical scientist. I soon discovered, however, that I could use some of my creativity and three-dimensional mental modeling in the physics course, and became excited about the increasingly beautiful pictures of atomic structure to which we were being introduced. This realization of the intuitive and creative aspects within scientific thinking determined me to pursue physics at a higher level.

The creative and intuitive aspects of scientific thinking, (presumably inspired by the colorful illustrations used in print materials describing how something works in three-dimensional space) were obviously very much a part of Martin's make-up albeit in the abstract world of physics. Little did he know that such abstractions and the mathematics required to understand them would dominate his energies in higher education.

The university physics department in which I took my first degree has an international reputation, but not for the quality of its undergraduate teaching. The lectures were dry and didactic, delivered by academics who clearly resented this interruption to their research, in large, dimly lit lecture theatres. For the bleary-eyed undergraduates who squinted to read the spidery hieroglyphics covering several blackboards, it shattered many illusions. Interaction was minimal even in tutorial groups, during which our professor would insist upon deriving every equation used from first principles, hence failing to cover the set problems and losing everyone in the process. As I became bogged down in the mathematical minutiae of relativistic quantum mechanics, the beautiful models in my head began to become blurred and hazy, and I finished three years of university study determined never to read another physics textbook.

The one highlight in an otherwise disillusioning experience was a project at the end of our first year intended to introduce us to the design and manufacture of experimental apparatus. We were given a short metalwork course in the departmental technicians' workshop, and the brief to design a sun-sensor to enable a satellite to orientate itself in orbit. The selected design was to be built by the technicians for demonstration to succeeding years of students. My design was chosen, and I felt again the tremendous sense of satisfaction which designing had given me as a child. Again, fleetingly in my final year I had the opportunity of designing a wave energy collection device, sparking an enthusiasm for alternative energy sources which was to be frustrated by the lack of research funding for such 'trivial' projects.

Despite my frustration at the unimaginative approach to degree-level physics, I still felt an excitement about the ideas I had acquired at secondary school, and applied for a Post Graduate Certificate in Education (PGCE) to become a physics teacher. As a part of this course we were required to spend two weeks in a primary school, my first visit in ten years The experience was to have a profound affect on my subsequent career. I realized that the non-scientific aspects of my nature, which had been gradually suppressed by my *convergent education, could actually be rediscovered and find expression in working with young children. Restricting myself to being a 'teacher of physics' was becoming an artificial strait-jacket, and I resolved to reapply for the primary PGCE course, which I completed in 1986 before taking up a post in the Inner London Education Authority (ILEA).*

Inner London primary schools in the mid-1980s were very much influenced by the informal, integrated curriculum and child-centered approach reflecting the work of developmental psychologists from the 1960s onwards. This was before the long slide back to 'traditional teaching methods' under successive Secretaries of State for Education and the accompanying successive waves of legislation. I was appointed to work in a mixed-age, open-plan infant area, team-teaching sixty 4-7 year olds. The culture shock was profound. I found myself unfamiliar with the cultures of the children, and with the mind-set of my colleagues. There was little which I could recognize as a curriculum; the children each following their own interests in different 'areas' of the learning environment: construction, role-play, sand and water, reading and writing. The depth of appreciation required of child development and the ways in which different subject areas contributed to a holistic approach was frightening, and I found myself deferring to my more experienced arts-trained colleagues. My educational background seemed largely irrelevant - I did not even feel confident in teaching primary science.

Life as a professional teacher was beginning to take on more meaning for Martin. He could see an opportunity to express some of his intrinsic needs for a more imaginative and progressive curriculum in which children could experiment more freely with the materials and objects in the world around them.

Gradually I began to orientate (sic) myself and find my feet in this strange new world. In particular I became fascinated by young children's behavior when making things; the way they projected a wealth of meaning and significance into a seemingly simple cardboard construction. I marveled at their ad-hoc and ingenious methods for joining materials, and the painstaking care they took in choosing the right shape of box or scrap of fabric for their needs. The empathy children showed for toys or story characters could find expression in designing for imaginary needs, and the emerging subject area of primary design and technology in the late 1980s had a vibrancy that excited me, in the same way that physics once had.

A major career opportunity came my way with the legitimacy given to design and technology in the National Curriculum for England and Wales in 1989. Suddenly there was a huge demand from primary teachers for inservice training, and I found myself regularly running courses at my local teachers' centre. In many ways design and technology was less familiar to many primary teachers than science, and despite the fact that many of them had been involving children in 'design and make' activities for years, they felt intimidated by the concept of a 'design process,' and the negative associations of the word 'technology.' The National Curriculum for Design and Technology was at this stage heavily influenced by the design education lobby, in particular the Design Council, a government funded design-promotion body, which had published the *report 'Design and Primary Education' in 1987. Through this report, and the subsequent 'Signs of Design' series, the policy of the Design Council education section was to highlight the design activities already taking place across the primary curriculum, and encourage teachers to recognize and build on them. This approach very much appealed to me, by then a fully paid up 'integrationist' in primary curriculum terms, and I took up a post as Education Officer at The Design Council in 1990.*

The design activity that appealed to Martin may represent a more significant development than he realizes. Are elementary school teachers unique in their preference for "design and make" activities? How widespread is this approach to learning? Their willingness to explore topics of interest and appeal to young children would seem to be more needs-based than subject-based. More important, is it an approach to learning which complements rather than complicates children's instincts and desires to learn? If so, are there any implications for the technology teacher who practices a similar pedagogy at the secondary school level? The "design and make" mindset is certainly fresh in Martin's mind and foremost in his career and personal development.

Lacking any formal design background, and with only four years primary classroom experience behind me, I encountered once again the profound 'fish out of water' sensation which had greeted my entry to the teaching profession. My learning curve was steep, visiting many professional design consultancies and dozens of schools across the South of England in the search for design-related classroom projects for publication or exhibition. I brought with me an aptitude for quickly assimilating information - borne of many mystifying physics lectures - and an instinctive feeling for quality in primary children's designing and making. It was a privileged position to be in, and gave me many ideas for when I eventually returned to the classroom. For return I did, for a variety of reasons. The climate of opinion with regard to primary design and technology was shifting - the vocational/engineering lobby was beginning to make loud noises about the lack of rigour in contemporary classroom practice - and the design educators were in retreat. The National Curriculum Orders were subsequently changed, emphasizing 'structures and mechanisms,' and the Design Council's influence waned considerably. Soon my post was to be abolished, but fortunately I had seen the writing on the wall and managed to secure a position as Science and Technology co-ordinator in a local primary school.

One can sense the imminence of a turning point in Martin's teaching career. The need for a more flexible way to learn and help others learn is crystallizing for him. His effort to alter the didactic instructional approach so dominant in his own schooling is a challenge from which he did not want to back away.

In the period I had spent away from teaching, much had changed. The National Curriculum, with its detailed requirements for three core and six foundation subjects, was now fully in place, and given extra coercive power by the structure of testing at ages 7 and 11. I found that the flexibility I had previously enjoyed in structuring my own design topics was considerably reduced, and was forced to consider how to keep within strict time allowances for each subject area. This did not prevent me from pursuing some of the lines of *interest I had developed at the Design Council, such as the use of professional designers working in the classroom with children. I undertook a project with the Royal Opera House, involving children in writing, designing and producing their own opera over a period of a school term. The children worked closely with a professional theatre set and costume designer, resulting in a spectacular visual extravaganza which I was able to write up as a Masters dissertation.*

The project was not without its costs, both in terms of my stress and the gaps in coverage of the curriculum. I determined to concentrate once more on science, the 'core' subject which I had neglected for so long. As I took my co-ordinator's job more seriously I found myself once more becoming excited by scientific concepts, and particular by the constructivist approach of building upon children's existing ideas. I began to explore ways in which scientific learning and design capability could be linked more closely in the classroom, discovering that children frequently failed to transfer knowledge and skills between one context and another. In a sense I had come full circle, trying to integrate the two essential parts of my make-up. It is a struggle in which I am still actively engaged!

What are the essential parts of Martin's disposition to learning? This question is central to understanding how learning and technology are interrelated. It helps explicate the relation between technology and one's instinct to learn. In this instance Martin's desire and capacity to learn through experience (an essential feature of learning in the practical world), while dampened and stifled in his formal schooling, is very much a constant in his "informal" learning. The acquisition of new experiences and the complementary activity of learning associated with those experiences are delicately and usefully balanced. Knowledge is not an end in itself for Martin. His disposition to learning is existential - it is fresh and on-going. His disposition to learning uses divergent as well convergent thought processes to comprehend, inductive as well as deductive learning methods to reflect/contemplate.

How widespread is such eclectic learning? More widespread than the literature on "learning" would have us believe? The very fact that Martin's story is one of unease with the formal school system in which he and many like him endure, is telling. To what extent does every young learner possess the instinct and tools to learn that Martin exhibits? To what extent are those tendencies extended or denied within the formal school curriculum?

Once again my career was about to enter a period of flux. The opportunity to become involved in the initial training of student teachers arose, and I applied for a post at a reputable University, lecturing in primary science education. Suddenly I was once again a 'specialist scientist' with only one area of the curriculum upon which to focus, and I had to readjust to a very different academic world from the one I had experienced as an undergraduate. This university is dedicated to the arts and education, and I became one of very few science-related staff in the entire institution. My fascination with the links between primary science and design became my 'research interest' as I entered the academic's publication 'rat-race,' despite being primarily a trainer of teachers. I regained a degree of autonomy in planning my own courses and *managing my own time; midway between the rigid timetable of the primary school and the self-managed agenda of the education officer. I have decided that, at present, a scholar is what I definitely aspire to be!*

Having matured and found a career in which he could extend his capabilities and express his views, Martin had reached a state of self-actualization - a stage of achievement not often documented in the professional education literature. His final reflections serve as an epilogue to his life-story and as a lesson to others who recognize themselves and/or their experiences in this documentation.

My (to date) varied career in education has taught me that it is often the institutional culture of a workplace which requires time for adjustment, possibly to a greater degree than the actual daily demands of the job. Another recurring theme is that skills which appear at first glance to be redundant in a particular context have a way of re-surfacing later, often in an unexpected way. No experience or learning is ever wasted, all that is required is the mental flexibility to re-work it for a fresh set of circumstances. In the case of science and design, they seem almost to belong to two separate cultures until we perceive that the mental processes involved have distinct parallels, demonstrated many times in my career from childhood to the present moment. I appear to be groping towards a position which sees the two areas as distinct yet inextricably linked, equal in partnership for the needs of society and the education of children.

Discussion

Martin's development as a teacher and his socialization into the profession reminds teacher educators of an important premise upon which teacher development hinges. Teachers can only come to understand what it means for a student to be educated when they think first of themselves as learners and reflect on the nature and course of their own education (Hansen, 1998). Martin Rivers has done this. The tensions which characterized his own schooling and his career as a teacher gave him the chance to confirm the beliefs and values associated with learning which he cherishes and which are explicated in this case study. Is this development the substance of one's progress and success as a teacher? His development as a learner and as a professional educator was quite a turbulent one.

Philip Jackson's (1968) classic book "Life in Classrooms" testifies to the many aspects of school and classroom life which become an integral part of each teachers' experience base but which are seldom analyzed. Jackson's rich descriptions of what really happens in schools demonstrate how one's values and competencies can match with or diverge from the predominant ideology about learning in a school setting and what is thought to be good teaching. The implications for teacher development and socialization are considerable. A teacher's development and subsequent socialization involve a reconciliation between the informal and formal cultures of the classroom and school. That reconciliation process is critical to understand for all who choose to practice in the profession.

Martin's case, in addition to describing an awkward but successful adjustment within the profession, uncovers an important element of personal development for teachers. This aspiring professional made adjustments to accommodate the predominant norms and values held by a system or school within a system. His work as a teacher and his willingness to be a reflective practitioner challenge those norms and set a new standard for teachers who aspire to practice effectively and critically in the profession. Had the system itself been more receptive to Martin's experiences and tendencies his adjustment process might have been an easier one, but would it have been less problematic? Teachers who prepare for the profession today are asked to embrace a rather narrow conception of how students learn which is based on the wisdom of educational psychology scholars. Their [teacher candidates] preparation and the learning of their students is seldom based on a comprehensive analysis of individual experiences and needs, teacher or student. The human development and learning goals characterized in Martin's autobiography are not articulated much less pursued. Yet a more relevant and meaningful curriculum, the most widely discussed and analyzed problem in the education literature today (in technology as well as other subject areas), may depend on the voices and critical analysis skills of reflective teachers like Martin.

The Martin Rivers case demonstrates, above all else, that technology and learning can be thought of as synonymous activities. Martin had an appetite for new experiences and knowledge which was as natural and unencumbered as eating and sleeping. Its roots were instinctual for him. Designing and making, for Martin, was and is a way of learning and knowing. His desire (the extra-natural program that Ortega y Gassett describes) to explore and alter the natural and manufactured world (the world of technology) is unending. In short, Martin's instinct to learn is an instinct to "experience." That "experiencing" is a technological phenomenon.

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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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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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The Lego/Logo Learning Environment in Technology Education: An Experiment in a Finnish Context

Esa-Matti Järvinen

Introduction

According to constructivist theory, learning is an active, continuous process whereby the learner takes information from the environment and constructs personal interpretations and meaning based on prior knowledge and experience (von Glasersfeld, 1995). Personal interests and needs that arise from the learner have a great influence on the learning process. Learning is also seen as a social phenomenon in which learning is mediated through the social interactions among the members of the learning community as they engage in the learning activity (Konold, 1995; Rogoff, 1990; Vygotsky, 1986). Knowledge is seen to be social in nature. It is shared through the members of the learning community by means of context dependent language (Gergen, 1995; Björkvist, 1994).

According to Rogoff (1990, p. 141) social interaction in cognitive development quite often resembles the apprenticeship situation, where novice and the expert are engaged in the same problem solving (Järvelä, 1996). Although social interaction is important in learning, in the end the knowledge and skills are constructed at the individual level from personal starting points and through spontaneous action (Tudge, 1990).

In the culture of schools, teachers often feel obliged to ensure that pupils learn socially accepted knowledge and skills (textbook knowledge assessed through tests) in the learning activity (Edwards & Mercer, 1987). This is epitomized in authoritative teaching methods (Wertsch, 1991), whereby the teacher controls the social interaction and other classroom actions. This mitigates against children's collaborative construction of understanding and individual pupils may feel that they are outsiders in the learning activity. Thus, the actions of many children are in response to what they perceive to be the teacher's expectations (Edwards & Mercer, 1987). In this kind of school setting the pupils do not necessarily feel the teaching and its content to be personally important or useful.

Effective teaching requires the creation of optimal learning opportunities through pedagogical means and also the encouragement and maintenance of a

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positive willingness to learn. Thus, a teacher's role changes to the role of a facilitator of learning and coordinator of learning environments. Since learning is social interaction to a great extent, the relationship between people and the interaction between a learner and a target of learning are emphasized in the planning of learning environments. Thus, teaching methods have a significant role in what and how pupils learn. Moreover, the present idea of learning emphasizes pupils' active role as constructors of their own information structure. Pupils' perceptions and expectations guide what they observe, what kind of information they accept, and what kind of interpretation they give to it.

Society poses demands for what is expected from schools. Instructional technology and its applications are considered to be essential to the teaching-learning process, starting as early as the primary school level. This priority is especially true in the teaching of mathematical and scientific subjects. The Finnish Ministry of Education has at least *planned* to equip all the schools with appropriate computer systems in the near future. This initiative is largely based on the felt need to get students interested in studying these mathematics and science and to assure that they master them well. At the same time, the development of teaching methods and approaches that are more meaningful and interesting for the pupils is far more important than the use of instructional technology alone. Technology education can provide a concrete method and context for the mathematical and scientific content.

In order for Finland to prosper economically and compete with the rest of the world industrially, the workforce of the future must be able to collaborate as a team and have basic skills in key areas of modern technology. Some contend that the ability to compete globally is a matter of national survival. Throughout history technology has enabled humans to survive (Hacker & Barden, 1988). What Finland faces is "modern survival" through technology.

Technology education in Finland developed in part in response to the demands just mentioned (Kananaoja & Tiusanen, 1991). Lindh (1997, p.133) defined the aim of Technology Education accordingly:

> The aim of Technology Education is that pupils could be more able to understand the logic and functional mechanism of 'everyday' technology and can solve technological problems applying technological knowledge and skills they have got.

The relationship between modern technology and mathematics and science is very close (Dugger & Yung, 1995, p. 10; Traebert, 1988). Thus, the three subjects must be considered together when developing technology education curriculum.

Purpose

The purpose of the project and resultant study reported herein was to support and further develop technology education curriculum. The study is based on the assumption that constructivistic-driven, open-ended problem solving and pupil-centered approaches are especially suitable for technology education. The objective of this study was to investigate the meaning and suitability of a teaching method that embodies these approaches in technology education. Learning as a social process has already been studied extensively; therefore this study does not provide great insights about the learning process at a general level; rather, it focuses specifically on technology education.

The study was directed by the following main problems: 1) To what extent do primary level students spontaneously generate problem solving situations and thereby create possibilities for the transfer of knowledge and skills within a group? and, 2) To what extent do primary level students learn technological content?

Secondary problems included: (1) to what extent and in what way does group work include the elements of science and mathematics? and, (2) what is the contribution of the teacher in group-oriented learning environments?

The Experiment

The goal of the experiment was to help pupils become familiar with some areas of modern technology, specifically control technology and programming skills. A secondary intention was to emphasize the importance and meaning of technology in their everyday lives. Teaching approaches were correspondingly developed to support both these goals as well as to provide pupil-centered, open-ended problem solving based upon the personal needs of the pupils and their past experiences (Hacker & Barden, 1988, p. 1).

The Lego/Logo Control Lab learning system was selected for the project with the costs underwritten by a local electrical power supply company, IVO Ltd. The materials were part of the Technic series of the Lego product line. They included sensors for light, touch, angle, and temperature; a control interface that connected to the computer; and the Lego/Logo language software which allowed the pupils to write control programs. The Lego/Logo programming language is based on the Logo language developed by Seymour Papert for the purpose of enhancing learning in mathematics. Papert (1980) believed pupils can solve problems and complete tasks that they thought were beyond their capabilities as long as they work in a learning environment that provides suitable emotional and intellectual support.

A series of activities were developed within the Lego/Logo learning environment. Six classes at the fifth and sixth grade level worked with the activities in groups of three to four members. Students were assigned to the groups by the teacher based on diversity rather than pre-established friendships. Both boys and girls were represented in nearly every group. The practice was to follow the modern teamwork model whereby the members of a team have to cooperate in order to accomplish the given tasks (Mortimer, 1996). While working in a group, however, the pupils were free to decide the assignment of roles (programmers, constructors, and so forth).

From the six classes, one class of 22 pupils at the fifth grade level was randomly selected for the study. There was no reason to believe, either before or after the study, that this class differed from the other five. All six classes were treated in the same way and were given similar instructions and arrangements, and followed a similar class schedule.

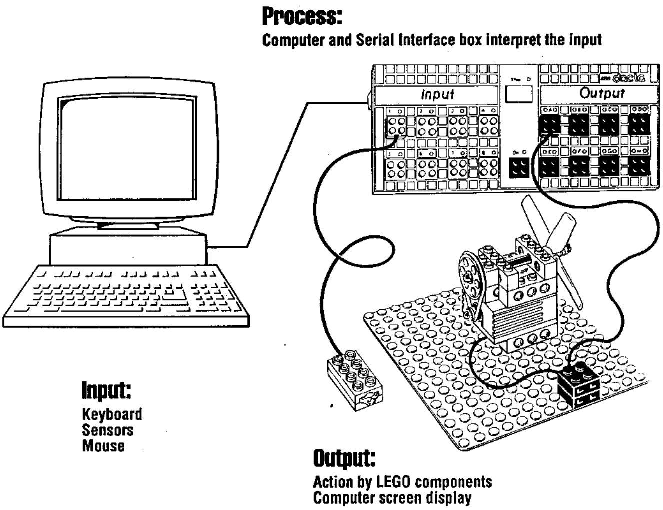

Figure 1. Principle of Lego/Logo Control Lab-learning environment. (LEGO DACTA , 1993, p. 5)

The experiment utilized three, six hour instructional time blocks. This time was taken from mathematics, science, technical/textile work, and English courses in which the pupils were enrolled. The project was arranged to fit into normal school routines by means of a workshop-like environment. The computer lab was reserved for the construction and testing of projects. A work station was provided to each group and consisted of a computer (Intel 486-66 MHz), the Lego/Logo materials, and adequate space in which to work.

Time Block One. The first two lessons of the experiment took place in the classroom. The pupils were told about the experimental project and its aims. After the introduction the pupils were divided into their working groups. The Lego components of the learning environment were introduced. The groups were given the challenge of constructing a Lego “soap-box” car as quickly as possible. The groups’ creations were also tested in competition. Once this was complete, the pupils moved to the computer lab where the Lego/Logo materials were shown as an intact system. Handout sheets that included some of the principles of programming and the main commands in the Logo computer language were distributed. The pupils were then allowed to freely investigate the possibilities of the learning environment.

Time Block Two. During the second time block the whole class visited a local peat-fired electrical generation plant. At the beginning of the visit a plant representative explained the operation of the power plant at an understandable level. Then half of the pupils (still organized in the working groups) went to investigate the functions of the main gate of the plant where the peat is feed into the fire box of the boilers while the other half observed the conveyors that transported the peat. The pupils were told to take notes to help them understand and remember what they had seen.

The remainder of the time was spent in the computer laboratory. The visit to the peat plant provided a theme for working. The students were told not to simply build a model of the plant. Instead they were encouraged to use their creativity and imagination to improve what they saw and implement it in a Lego/Logo model. For example, the students were encouraged to improve the peat delivery gate since this device did not function well in Finland's snowy winters.

Time Block 3. In the third time block the students were given the most open-ended problem to solve. Their challenge was to design and build a system that would enable a pet to survive at home while the family was away on vacation. Even the teachers didn't know beforehand what the groups might accomplish. Consistent with contemporary technology education, there were no single correct solutions. Rather, the viability of the solution was relative to what the students knew about the needs of their pets.

Method

The sociocultural constructivist perspective relative to learning requires a theoretical background that draws on both constructivism and interpretivism. Constructivism and interpretivism aim to understand the meanings constructed by pupils taking part in context-specific and socially situated activity through social interaction (Schwandt, 1994). This theoretical background required that the methodology of the study take into account social interaction between the group members as well as the context and substance of social interaction .

The methodological perspective of the study was qualitative in nature and based on interpretivist, inductive analysis. The study was guided by the a stated research problems. It involved direct group observations and employed a search for patterns within the data. (Patton, 1990)

This study focused mainly upon the small-group social interaction and its effect at the individual level. Therefore data collection procedures were aimed at capturing pupils' social interaction and actions in small-group settings. Data were collected by means of group observations recorded in a field diary and videotaped recordings of group social interaction. The field diary and video tapes represent the primary data sources. Videotaping was aimed at a single group throughout the study and this group was separated from the rest of the class. The field notes were written on all of the groups.

The researcher assumed the role of participant observer. During the study the researcher also acted as a tutor. This procedure enabled the researcher to be "inside" the study, true to the nature of qualitative research (Erickson, 1986).

There were no tests administered before, during, or after the treatment. It was assumed that multiple qualitative data collection would provide enough information relative to the research problems. Moreover this procedure was believed to enhance the motivation and relaxation of the pupils and thus supported the "authentic" nature of the work without all of the expectations usually connected with a research study or traditional school evaluation practices. (Patton, 1990: p. 132; Honebein et al , 1992: p. 89).

Verbatim transcriptions were derived from the initial viewing of the videotapes and were combined with the observation field notes. During the transcription process, irrelevant data were excluded such as discussions of boy friends and girl friends. This is consistent with the recommendations of Miles and Hubermann (1994, p. 11). The main focus of the data collection was on the technological content of the social interaction and its understanding at the individual level. Situations in which the pupils spontaneously generated technological problems to solve were included in the transcription, as well as situations in which mathematics or science were used as tools in technological problem solving. Secondary data sources also provided valuable information. They were used to supplement information in the search for emergent patterns on the data. To ensure validity and credibility of the research, multiple data collecting sources and strategies were employed, applying the concept of triangulation (Miles & Hubermann, 1994: p. 266).

During the first viewing of the videotapes, the researcher began to form an idea of the emergent categories relative to the theme of the study. The resultant categories are reported in Table 1. Before the second viewing of the videotapes and reading the field notes, these emergent categories were used to develop a matrix into which the number of action situations in social interaction could be placed during the second round of data analysis. These numerical data were collected mainly to determine the amount of pupil-centered work. Data analysis was, however, in accordance with qualitative methodology and therefore the numerical data in the matrices were not intended to be quantitatively analyzed further. The main emphasis was on the interpretations drawn out of primary data sources.

Results and Discussion

The inductive interpretative analysis process used in this study enabled the results to be framed as empirical assertions, with data as evidentiary warrants (Erickson, 1986: p. 145). Thus results are presented through three assertions supported by evidentiary examples taken from primary and secondary data sources. Examples presented to support assertions two and three were also "microanalysed" in order to clarify the interpretative analysis process, which consequently led to more general assertions.

Assertion 1. (Main problem 1 and Secondary Problem 2)
The working of the pupils was controlled and guided mostly by themselves and the teacher's role was more like tutor and adviser as needed.

The teacher's tutoring was needed but it was much less frequent than the learning that was facilitated by students working and solving problems by themselves. Nevertheless the teacher's advice was often indispensable. In many cases the teacher was truly a member of the group. In other cases the teacher or the researcher was in the role of a learner. The Group Action Occurences taken into account are represented in the form of exemplars supporting assertions 2 and 3.

Table 1
Emergent Categories and Operational Definitions

Categories	Definition
Actors	Pupil as an individual actor or the pupils in mutual social interaction. Includes also the teacher or the researcher participating in social interaction.
Technological content	Content consistent with the theme of the experimental project.
Mathematical-scientific content	Content emerging from the group work as a natural tool to solve technology-related problems.
Group action occurences	Discourse, mainly verbal, but also includes other noticeable action, which focuses on technological, mathematical, or scientific content. Also includes the pupil's independent action on behalf of the group and the final accomplishments (see Vygotsky in Wertsch and Toma, 1995, p. 163).

Table 2
Number of Group Action Occurrences by Time Block: Teacher or Researcher Not in Group (TA) Versus Teacher in Group (TP)

	Time Block 1		Time Block 2		Time Block 3	
	TA	TP	TA	TP	TA	TP
Technological Content						
Pupil Acting Alone	5	9	19	2	23	8
Pupil to Pupil Interaction	20	9	45	11	45	21
Pupil to Pupil to Pupil Interaction	2	1	20	10	11	15
Mathematical-Scientific Content						
Pupil Acting Alone	1	3	0	0	3	3
Pupil to Pupil Interaction	7	6	3	1	10	5
Pupil to Pupil to Pupil	5	1	1	0	1	1

The data in Table 2 clearly show that during the project work the pupils tended to handle technological and mathematical-scientific content mostly by themselves. This phenomena is especially obvious in action with the technological content and leads to the second assertion.

Assertion 2. (Main Problem 2.)
Technological content spontaneously handled by the pupils consisted of the elements of control technology, system planning, and at least rudimentary programming skills; this content can be commonly understood and transferred among the pupils acting in the social interaction.

The following examples illustrate situations where the pupils handled the content in accordance with the above assertion.

> Ulla is sitting in front of the computer and says: "Now we have to write those commands...motorb.." Kati advices Ulla and says, "Talkto matorb!" Ulla begins to write and speaks to herself, "Talkto.." Now Kati interrupts and writes the quotation mark in the right place (Talkto "motorb) and then she begins to ponder the connections made in the interface: "Motorb...is it really motorb?" Now the third member of the group, Juuso, says: "It's motorc" Kati investigates the wires and agrees with Juuso: "Yes it's motorc...hey Ulla it's motorc!"
>
> (Time block 2)

Ulla evidently understands the meaning of the commands in order to get the desired functions out of devices connected to the output section of the interface. Kati seems to know better the syntax of the programming language and thus helped Ulla in her writing. The whole group is involved in attempting to get the motor to operate in the desire manner.

> Lupu points to the gate and says, "Look!..touchsensor...when it's touched.. the gate opens…we have to place a touch sensor somehow here and when somebody touches it..." Now Hupu interrupts Lupu's reasoning and says: "It doesn't need a touch sensor...we can use lightsensor in order to open the gate."
>
> (Time block 2)

Lupu understands the meaning of touch sensor (input) in order to trigger the appropriate function (output). Hupu also understands the meaning of the sensors and, moreover, seems to be more aware of the possibilities of different sensors in this particular context. It was apparent that both Lupu and Hupu understand the principle of control technology and they were able to create a complete system (input-process-output).

The following example illustrates the situations when the teacher or researcher himself was participating in the group work.

> Kati says: "We have to write procedures for the other (motor) setright and for another (motor) setleft." I say: "Yes, that is pretty much it. Very good. …In which gate (output) is this motor (left)?" Kati answers: "It's in gate

> b." I continue, "Okay, then write the procedures there (on the gate b procedures page). Now you have to take into account how much time the motor has to rotate in order to open the gate. You know it doesn't has to rotate much, only a short time and then it stops."
>
> (Time block 2)

In this example the researcher was engaged in the problem solving with Kati. She already knew the meaning of the setright and setleft commands and also shows ability to apply them in this particular case. In this example the researcher seems to be more like a peer, not like an omniscient teacher who only dispenses knowledge. This particular example raises the question of whether the group has found out the short rotation time for the motor without the intervention of the tutor. If the information had not come from the tutor, it may have taken more time for trial and error to solve the problem. As Dugger and Young noted, however, trial and error is sometimes quite typical in the technological process (Dugger & Young, 1995 p.10).

During the afternoon of the third time block, the programming needed to be done for the devices that the students had constructed. The level of the challenge and the exhaustion that the students felt after lunch caused them to become frustrated more quickly and some almost gave up on the task. An interesting phenomenon appeared in these difficult situations. Almost without exception somebody in the group had enough energy and motivation to exhort and support the other pupils to continue working. At this time the teacher's advice was needed quite a lot, but significantly the idea to continue further despite the difficulties came from the pupils themselves! They apparently wanted to accomplish the assignment they had formulated.

Assertion 3. (Secondary Problem 1.)
Mathematical-scientific content appeared to be used as a tool in technological-oriented problem solving and it was naturally applied by the pupils.

Considering mathematics, the focus was now only in situations where the pupils used arithmetic. Though situations dealing with higher order mathematics concepts such as spatial perception, proportionality, inverse proportionality, and symmetry were not included in this study, they were clearly in evidence among the students. Mathematics and science tended to be naturally used as tools for problem solving in the context of technology. Contrary to the normal situation in mathematics classes, the students never asked why they were expected to learn certain content.

The following two examples illustrate the situations where scientific-mathematical content was used as a tool in problem solving.

> Marko looked toward the girls and said, "Hey...do you know what? Let's put more weight on this (Lego-car) and will accelerate better while going down the hill...and it would be nice to have some oil on the axle also." (though oil was not used because of it's messy nature.)
>
> (Time Block 1)

In this example Marko's statements indicate understanding of the meaning of increased mass in order to increase the speed of the vehicle, a scientific concept. He also seemed to know the significance of the lubrication in decreasing the friction, something he may have learned from science or from practical experience. He clearly applied his existing knowledge and experience to this particular situation as tools for technological problem solving. The girls are passive participants but they intently follow Marko's reasoning and it seemed evident that knowledge transfer took place. The pupil's deeper understanding of the phenomena behind the increased mass or lubrication is difficult to substantiate, however.

> Pirkko looks at the commands Marko has just written and stated, "Ten...you have programmed it (the motor) to operate for one second (ten equals ten tenths of a second or one second." Then Pirkko investigates the movement of the gate using her hand and measures the time by speaking aloud, "One, two…" Marko also tries the gate with his hand and then continues writing the program while speaking aloud, "Onfor 10...wait a minute...oh yes...talkto motorb onfor ten."
>
> (Time Block 3)

Here the conversation between Marko and Pirkko indicates their mutual understanding of the principles of the decimal system. Mathematics can be seen as an indispensable tool in technological problem solving dealing with programming. In this way mathematics appears to be natural and meaningful for the pupils; they do not question the need for it.

Conclusion

The results of this study support the notion that social interaction can be interpreted to promote technological problem solving and learning. The pupils taught themselves in an interactive social setting. Knowledge transfer among the pupils sometimes appeared to be apprenticeship-like in which expert know-how was transferred to the novice. This was not, however, the predominant phenomena. At least equally apparent were the situations in which the pupils acted more like peers and learned from one another. The teachers were not always in the role of omniscient experts but often were learners themselves.

Programming the computer appeared to be the most difficult and frustrating to the students. This is partly due to syntax sensitivity of the Logo-language but also to the limited amount of time that the students had overall. Despite the difficulties, programming was an essential part of the project. It gave possibilities to apply mathematics naturally in actual, pupil-driven problem solving situations. The programming also enabled a feeling of control over constructed devices and thus emphasized the meaning of appropriate commands and procedures in order to make automated systems. Even though the teachers played a more active role in the programming portion of the activity, it did not seem to lessen the constructivist nature of the learning situation. The children were not always able to proceed independently and had to be supported. This fits with the constructivistic notion in which an individual takes information from the environment and constructs personal interpretations based on prior knowledge and experience. The pupils used the knowledge they gained from the teacher by applying it in new situations. Moreover, the knowledge was transferred among the pupils.

According to the most radical idea of constructivism (von Glasersfeld, 1993; Schwandt, 1994) there is no reality that exists outside the individual; he/she has to perceive and experience the outside world personally in order to formulate it as his/her individual reality. In sociocultural interpretation this takes place in interaction with the social environment and the knowledge is commonly shared. This notion leads to the essence of technology. There would not be technological reality around us if we have not, literally, constructed it. Technological development has usually been driven by individual or social needs to sustain living and to make it easier or safer (Hacker & Barden, 1988; Suplee, 1997) or for other purposes that seem important. According to results of this study the sociocultural constructivist approach appears to be natural and effective in organizing learning, especially in technology education.

When participating in the project, the pupils were actors in the process where they constructed technological reality on the basis of their own needs and ideas. This behavior was especially prevalent in the third time block in which the problem was the most open-ended. The researcher felt confident that the pupils in the project were participating in the process of technology, a human endeavour which has existed since the dawn of the human race (Hacker & Barden, 1998).

Considering technology education in a larger context, the Lego/Logo-learning environment is in many ways handicapping. It does not introduce a very wide range of materials and the construction must be done within the limits of the Lego components. On the other hand, an advantage of the system is that it consists of components of which most students are already familiar from early childhood. The “Lego-world” of a child’s room at home appeared to transfer to the school, along with the comfortable, relaxed atmosphere that they had enjoyed with their family.

This phenomena was also undoubtedly due to the absence of conventional tests and the anxiety that accompanies them. This is consistent with the thoughts of Ausubel and Robinson (1973, p. 530) regarding the creation of an appropriate atmosphere for solving problems that is low in stress and allows concentration on the task at hand.

One of the most important things in education is to adjust the teaching methods to the nature of the content. When the content is technology, it is quite natural that the pupils solve open-ended problems on the basis of the their own needs and what is significant and meaningful to them. Regardless of the media used in technology education, it is essential that the pupils are encouraged to work and learn in a way that fosters creativity and discovery (Futschek, 1995, p. 724). To promote effective learning, the emphasis has to be on appropriate teaching methods and in relating the problems to the pupils themselves. The action itself and it’s understanding are most important. In technology education, pupils may be better at defining appropriate learning outcomes than are textbooks or teaching manuals. At least based on the limited scope experiment reported herein, traditional school evaluation methods may not be the most appropriate way to evaluate the pupil's outcome nor, perhaps, the process which led to it.

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Why They Enjoy Teaching: The Motivation of Outstanding Technology Teachers

Michael Wright and Rodney Custer

Technology education has undergone radical changes over the past decade. The content, instructional methodologies, and facilities are among the key indicators of change as is the background and motivation of people who choose to become technology teachers. Individuals interested in computers and electronic communication are seeking technology teaching positions, as contrasted with interests in woodworking and metalworking that typified the past.

The profession could benefit from information about how these changes have affected teachers' enjoyment of teaching. This information could inform the process of recruiting new teachers by better understanding the rewards and stresses associated with major programmatic change. What is it about the current teaching climate in technology education that outstanding teachers find most rewarding?

Technology education is having difficulty recruiting talented teachers. Current estimates place the number of job openings at six or more for each technology education baccalaureate graduate. Attractive salary and benefit packages accompany many of these openings. Why is it so difficult to attract and retain talented technology teachers? What is it about teaching technology education that makes outstanding teachers love their jobs?

In conjunction with an ITEA task force, a study was conducted to determine the factors associated with college students' decision to select technology teaching as a career. This research was designed to provide an information base for subsequent recruitment efforts (Wright & Custer, 1998). Another responsibility of the Task Force was to identify the specific aspects of teaching that outstanding, nationally-recognized technology education teachers find to be particularly rewarding and most distressing. Another goal was to obtain suggestions about changes necessary to make their jobs more enjoyable.

The focus of this study is on the perceptions of outstanding technology education teachers regarding the most rewarding aspects of teaching. This information could be useful in attracting others into technology teaching.

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Literature Review

Concerns about job satisfaction spawned numerous studies during the past several decades in nearly every occupational field. There was strong interest in job satisfaction and teacher satisfaction from the late 1960s to the early 1980s. Over the past decade little attention has been paid to teacher satisfaction or its effect on students.

Job Satisfaction Theories

During the first half of the 20th century, job satisfaction was viewed as a continuum. Certain factors, if present, contributed to job satisfaction; if absent, they contributed to job dissatisfaction. In contrast, Herzberg, Mausner, and Snyderman (1959) developed the Two-Factor Theory of job satisfaction, also called the Motivation-Hygiene Theory. They concluded that there were specific conditions of employment that are job satisfiers (motivators), while other conditions act as job dissatisfiers (hygiene factors).

Teacher Satisfaction and Student Learning

Research has established a relationship between teacher satisfaction and student achievement (Adams & Bailey, 1989; Doyle & Forsyth, 1973; Goodman, 1980; Stanton, 1974). The findings indicate that secondary school teacher morale depends in part on whether their students were relatively high scholastic achievers. Similarly, student achievement tended to increase as a function of high teacher morale (Leslie, 1989).

Teacher morale or satisfaction may be one of the most important factors affecting student achievement, and therefore, is a critical topic to be researched. The literature on teacher satisfaction indicates that job satisfaction is the result of many interrelated factors.

Job Satisfaction of Teachers

Studies of teacher satisfaction based on Maslow's (1954) hierarchy of needs theory have supported the connection between need-fulfillment and job satisfaction (Carver & Sergiovanni, 1971; Frances & Lebras, 1982; Sweeney, 1981; Trusty & Sergiovanni, 1966; Wright, 1985). These authors cited an absence of three higher-order needs (esteem, autonomy, and self-actualization) as major contributors to low teacher satisfaction.

Simmons (1970) has identified teacher satisfaction factors and has categorized them as *content* and *context*. Content factors relate to the teaching process itself (e.g., achievement in teaching, the nature of the work itself, and recognition), while context factors relate to the job situation (e.g., interpersonal relations, school policy, salary, etc.). The context serves only to reduce pain in the lower-order needs areas (e.g., physiological and safety) and cannot lead to satisfaction. The content aspects correspond to esteem and self-actualization, which are at the top of Maslow's hierarchy (Maslow, 1954). Those factors that are *content*-centered (i.e., intrinsic aspects of teaching) contribute most powerfully to satisfaction.

According to a recent national survey (USDOE, 1992), approximately 32% of new teachers chose the teaching profession because they enjoy working with children. Approximately 30% found the teaching process satisfying. The same report projected that the number of teachers would need to increase from 2.8 million in 1991 to 3.3 million in 2002 to meet the demand.

Clarke and Keating (1995) discovered that interaction with students was the most satisfying aspect for teachers, while lack of administrative support was the least satisfying aspect. Perkins (1991) observed that teacher satisfaction was not significantly affected by background variables such as teacher or principal gender, years of experience, or school-type assignment. Perkins also found that teachers are most satisfied with their co-workers and least satisfied with the monetary aspects of teaching. Inadequate salary, low status of the profession, and excessive paperwork are some common sources of distress that affect job satisfaction (Kyriacou & Sutcliffe, 1979).

Teachers' perception of locus of control is another factor influencing job satisfaction. Bein, Anderson, and Maes (1990) found a negative correlation between job satisfaction and teachers' perceptions of external control. Those with a greater sense of personal control were significantly more satisfied. This finding confirms the importance of teacher autonomy identified by Wright (1985).

Barkdoll (1991) found a differential connection between stress and job satisfaction. For example, the most satisfied teachers reported low stress and high job satisfaction, while the least satisfied teachers reported high stress and low satisfaction.

Reasons for Leaving Teaching

There is no predominant reason that teachers cite for leaving teaching. Among the reasons are salary, limited opportunities for advancement, and too much to do in too little time (Litt & Turk, 1985). According to Ladwig (1994), another common reason for leaving is lack of support from the principal. Principals may frequently (although not deliberately) reduce or eliminate a teacher's opportunities for intrinsic rewards (Kyriacou & Sutcliffe, 1979).

Furthermore, factors such as low salary, low status, and excessive paperwork were found to be major sources of stress among teachers. However, the intention to leave teaching was more related to their coping resources. Marlow, Inmar, and Betancourt-Smith (1996) indicated that common reasons for leaving included problems with student discipline, lack of student motivation, and lack of respect from community, parents, administrators, and students.

Job Satisfaction of Technology Teachers

Todd, Bame, Berry, Hacker, Hansen, Karsnitz, Radcliffe, Sanders, Ritz, & White (1996) addressed the problem of the teacher shortage in technology education. Several factors and recruitment strategies were suggested, but teacher satisfaction was not addressed. Information about "job-satisfiers" is essential if the technology education profession is to better understand the recruitment and preparation of new teachers. This is especially critical given the major changes that have occurred in technology education over the past 10-15 years.

Wright (1985), using an in-depth interview technique based on Maslow's hierarchy of needs, found a significant positive relationship between technology teachers' perceived esteem and their job satisfaction. Esteem was derived from several sources, including pride in the profession, student respect, principal recognition, program respect, community support, and professional respect. Wright's analysis, focusing on the discrepancy between *desired* and (perceived) *actual* esteem, found that satisfaction was closely related to principal recognition, satisfaction with teaching assignment, years in current assignment, and job "autonomy." Salary was *not* a factor related to job satisfaction. The higher-order needs for esteem were most related to satisfaction. Carvelli (1993) also found that technology education teachers place high value on and flexibility in curriculum matters.

Research by Dugger, French, Peckham, & Starkweather (1991) report that the positive aspects of teaching technology include course content, staffing, and facilities, while weaknesses include funding, enrollment, and administrative support. The greatest problem was increased academic requirements. Other problems included lack of financial support, quality of students, and lack of administrative support.

It is clear from the review that teacher satisfaction, although a complex phenomenon, affects student achievement, and vice versa. Teacher satisfaction findings tend to support Maslow's theory of needs-fulfillment. Specifically, esteem and self-actualization on the job are factors having a significant impact on teacher satisfaction. Conversely, it would appear that "non-teaching" duties are a major source of dissatisfaction.

Purpose and Research Questions

The purpose of this study was to explore outstanding technology education teachers' attitudes about the rewards and frustrations of teaching. The study addressed the following questions:

1. What are the demographic characteristics of outstanding technology education teachers?
2. What do outstanding technology education teachers identify as the most enjoyable and rewarding aspects of teaching?
3. What do outstanding technology education teachers identify as the most frustrating aspects of teaching?
4. What kinds of assistance or change do outstanding technology education teachers identify as necessary to reduce the frustrating aspects of teaching?
5. What relationships exist between technology teacher satisfaction and demographic variables?

Methodology

Population and Sample

The population was comprised of outstanding K-12 technology education teachers in the United States. Selection as an outstanding technology education teacher required that the individual meet at least one of the following criteria: (a) recognition as the 1996 ITEA Outstanding Technology Teacher for their state, (b) recognition as the 1996 ITEA Program Excellence Award, or (c) recommendation by their state supervisor as an outstanding technology teacher. A total of 278 teachers were identified.

Instrumentation

An instrument was developed by the authors based on the literature review and related studies conducted in the field of technology education. A panel of experts was asked to review and critique the instrument. A modest number of suggested modifications were made and the changes were incorporated into the final version of the instrument.

The instrument consisted of two sections: (a) a demographic section and (b) a series of three open-ended questions. The demographic section requested information about age, gender, grade level taught, size of school, courses taught, years of teaching experience, extracurricular involvement of the teacher, membership in professional associations, and conference attendance patterns. The second section solicited information regarding teachers' perceptions of aspects of their jobs that they found most enjoyable as well as what suggestions they would have to improve their jobs. The open-ended format was selected in order to minimize bias which would have been introduced by a preformulated response item set. The teachers were asked to provide three responses to each of the three questions in section two of the instrument. The questions were:

1. Please list the three most important and enjoyable aspects of being a technology teacher. In short, what aspects of your job do you find to be the most enjoyable? These could include the kinds of points that you might want to make to recruit a student, friend, sibling, etc. into the Technology Education profession.
2. Please identify the three most frustrating aspects of your job, those things which might cause you to consider making a career change.
3. What kinds of assistance or change would help to reduce the frustrating aspects of your job?

Procedures

The instruments were mailed to all 278 members of the population during the Spring of 1996. A follow-up mailing was sent to all non-respondents. One hundred nineteen (42.8%) useable instruments were returned.

Demographic data were entered into a database for subsequent analysis. Responses to the open-ended questions were compiled and entered into a database. All original wording was retained as was identification with individual demographic data. This was necessary in order to analyze satisfaction/ dissatisfaction patterns across the various demographic variables. For example, patterns of resource allocation and time demands are often quite different in large and small schools and could affect job satisfaction.

The compiled list of raw data collected in section two was individually reviewed and analyzed by the researchers. Both researchers independently compiled a summary list of items for each of the questions. The process was designed to reduce the large volume of raw data (932 responses) to a representative set of statements that would be (a) inclusive of all responses and (b) retain as much of the teachers' original phraseology as possible. After the independent consolidation process was completed, the two researchers reconciled differences in the lists and arrived at a final list consisting of 20 items in the "rewards" category, 31 in the "frustrations" category, and 27 in the "desired changes" category. This listing became the "key" for subsequent rating and analysis.

A team of three doctoral students[1] (all with background and expertise in technology education) were then asked to independently match each of the teachers' responses with the items in the response key. Ratings were conducted independently by the three raters and the three categories of the instrument were rated separately. After all 932 responses had been matched with items on the key, the raters were asked to meet to reconcile any differences in ratings and to attempt to arrive at consensus. The initial independent ratings yielded consensus on 57% of the total response set (532 out of 932 responses). After the consensus-building session, the number of non-consensus items was reduced to 2% (19 responses). The two researchers then completed the refinement process by either (a) making a judgment about the appropriate category for the remaining non-consensus items or (b) adding a new item to the response key. The rated response sets were then analyzed for response frequencies. Additionally, responses were analyzed across the demographic data in order to detect possible response patterns.

Findings and Discussion

The population was predominantly male (89.8%). Approximately 77% of the teachers fell within 36-50 years of age (Table 1) and had taught for 11-25 years (Table 2). Approximately one half of the teachers (50.4%) have 10 or less years left to teach before retirement (Table 3). The majority of the teachers (75%) taught in schools with enrollments of 501 or more, and were nearly evenly split between middle/junior and senior high schools (46.2% and 45.4% respectively). It should be noted that, after the second follow-up mailing, a study of the non-respondents was not conducted and could therefore represent a source of bias.

The courses taught by the outstanding teachers and offered at their schools are shown in Table 4. Exploring technology, computer aided drafting, and communication technology were the courses most frequently taught by the teachers. General metals, welding, and photography were the courses least frequently taught.

Most Enjoyable Aspects of Teaching

The two dominant "enjoyment" themes that emerged had to do with "excitement and stimulation of learning and working with new technologies,"

[1]The authors are indebted to Patrick Foster, Randall MacPherson, and Janet Paulson for their assistance. The process was intensive and required a major investment of time and energy.

and "the enjoyment of working with kids and making a meaningful difference in their lives" (see Table 5). The most frequently cited comments (20.5%) were classified as "enjoyment and stimulation of learning and using new technologies – continuous change." The second and third rated categories had to do with the enjoyment of working with students and the personal satisfaction of making meaningful differences in their lives.

Table 1
Age Distribution of Teachers in Sample

Age Range	*f*	%
25 or less	2	1.7
26-30	6	5.0
31-35	8	6.7
36-40	27	22.7
41-45	43	36.1
46-50	22	18.5
51-55	8	6.7
56-60	2	1.7
60 or more	1	0.8

n=119

Table 2
Years of Teaching Experience

Years Teaching Experience	*f*	%
less than 5	15	12.6
6-10	12	10.1
11-15	20	16.8
16-20	37	31.1
21-25	22	18.5
26-30	11	9.2
30 or more	2	1.7

n=119

Table 3
Years Planning to Continue Teaching

Years Yet to Teach	*f*	%
less than 5	32	26.9
6-10	28	23.5
11-15	29	24.4
16-20	18	15.1
21-25	8	6.7
26-30	4	3.4

n=119

The fourth and fifth most frequently cited reasons were the “freedom and flexibility to be creative in developing the curriculum, selecting activities, and delivering content” (what might be considered “autonomy” on the job) and “the hands-on, action-based nature of technology education.” The remainder of the responses ranged from the “authentic, relevant content of technology education” to “time off” and “job security.” It should be noted that nine of the 25 positive comments were related to students in some way, and six were related to the content area of technology education (see Table 6).

Frustrating Aspects of Teaching

The most frequently cited frustration (17.6%) was “lack of funding for equipment, supplies, and facilities.” This finding would tend to dispel the notion that outstanding teachers enjoy their jobs more because they have good budgets

Table 4
Classes Taught by the Teachers and Offered by their Schools

Course		Taught by Teacher		Offered at School	
		f	%	*f*	%
1.	Exploring technology	60	50.4	69	58.0
2.	Computer aided drafting	59	49.6	74	62.2
3.	Communication technology	53	44.5	70	58.8
4.	Manufacturing technology	48	40.3	66	55.5
5.	Transportation technology	43	36.1	57	47.9
6.	Drafting; general	42	35.3	57	47.9
7.	Construction	39	32.8	53	44.5
8.	Electricity/electronics	38	31.9	51	42.9
9.	Robotics	38	31.9	46	38.7
10.	Engineering technology	37	31.1	43	36.1
11.	Architectural drafting	34	28.6	51	42.9
12.	Energy & Power	32	26.9	50	42.0
13.	Computer technology	30	25.2	46	38.7
14.	Production technology	30	25.2	43	36.1
15.	Woodworking	28	23.5	46	38.7
16.	Materials/Processes	26	21.8	35	29.4
17.	Graphic arts	22	18.5	35	29.4
18.	Emerging technology	19	16.0	23	19.3
19.	Interdisciplinary studies	16	13.4	24	20.2
20.	Bio-technology	15	12.6	23	19.3
21.	Small engines	15	12.6	26	21.8
22.	Photography	14	11.8	30	25.2
23.	Welding	14	11.8	25	21.0
24.	Metals; general	10	8.4	23	19.3

n=119

Table 5
Why They Like to Teach

Positive Factors	*f*	%
1. Enjoyment and stimulation of learning and using new technologies	68	20.5
2. The rewards of making a meaningful difference in the lives of students	49	14.8
3. Enjoy the kids	34	10.3
4. Freedom and flexibility to be creative in developing the curriculum, selecting activities and delivering content	28	8.5
5. The hands-on, action based nature of technology education	20	6.0
6. Involving students in problem-solving and design activities	16	4.8
7. Engaging students in authentic and relevant content and activities	15	4.5
8. Opportunity to participate in professional technology education associations (ITEA, TSA, etc.)	14	4.2
9. Student interest in technology education	11	3.3
10. Collaborating with teachers from other academic areas (mathematics, science, etc.)	9	2.7
11. Teaching an important subject to students	7	2.1
12. Having equipment available for use	7	2.1
13. Time off for change of pace during summer and school vacations	7	2.1
14. Working with other technology education teachers	5	1.5
15. Community support for Technology Education programs	5	1.5
16. Working with computers	4	1.2
17. Teaching a subject that is growing in popularity	4	1.2
18. Motivating students to pursue technology-related educational programs after high school	4	1.2
19. Teaching a subject that increases the chances of success for students with diverse learning styles	3	0.9
20. Teaching a subject connected to developing job skills and exposing students to career options	3	0.9
21. It’s fun	3	0.9
22. Contacts with business and industry	2	0.6
23. Manageable class sizes	2	0.6
24. Job security	2	0.6
25. Other	35	10.3
Total	331	100%

n=331

and facilities. As perceived by the teachers, the lack of funding was the number one reason that could drive them from teaching. The second most frequent response (12.0%) was the (perceived) "decline in personal characteristics and attitudes of students."

At first glance, the latter finding is surprising. The teachers' greatest satisfaction is also their greatest dissatisfaction. That is, they derive the most enjoyment from their students, while at the same time their students are one of their greater frustrations. One possible explanation is that experienced teachers had chosen to remain in teaching for the satisfaction that comes from helping students grow. However, it is also possible that certain social and environmental factors over the past decade may have eroded the overall quality of the school climate, with corresponding declines in student behavior and attitudes toward school. Thus, it may be that only a few students provide the disruption that so distracts from the teachers' overall enjoyment.

"Lack of understanding and support of technology education by administrators/counselors" was the third most frequently cited, frustrating aspect of their jobs, followed by the "long hours required to deliver a quality program." The top four frustrating aspects of teaching technology education are consistent with the literature and would likely be anticipated by most professionals in the field. What is surprising is that "low pay for teachers" was not in the top three factors (only 5% of the total responses). This finding is contrary to many national studies where poor compensation is typically among the top three factors cited. This finding is consistent with Wright's (1985) conclusion that certain intrinsic rewards (esteem and autonomy) offset (perceived) low pay, and that salary only becomes a serious issue when these intrinsic rewards are not present, or are greatly reduced.

Changes Needed

The teachers listed "better funding for Technology Education programs" as the number one change needed by a factor of more than two-to-one over the second item, "public relations campaign to interpret what technology education is, its benefits, etc." This is consistent with the frustrations cited in the section above and with the findings of Dugger et al. (1991) that funding was the most serious challenge facing technology educators. The actual magnitude of the significance of the funding factor may even be greater among the teachers included in this study. Indeed, there were seven other categories of responses that pertained to funding. These included "better compensation for teachers," "additional staff (more aides, etc.)," "additional corporate sponsorship for technology education," "assistance in seeking and obtaining funding for technology education program needs," "additional support to maintain laboratories and equipment," "support and recognition of additional extracurricular responsibilities," and "how schools are funded." Taken together, these categories comprise over one-third of all the comments related to what changes are needed.

The second major concern area dealt with educating the public and/or school officials about what technology education is, its benefits, etc., as well as differentiating it from instructional technology or educational technology. These comments ranged from “clarifying the purpose of technology education in the schools” to “public relations campaign to interpret what technology education is.” The comments tended to focus on the lack of clarity and identification (and recognition of the) mission/purpose of technology education. The third broad area of concern was students, focusing on both student behavior and academic ability.

The balance of the suggestions (those cited more than once) are shown in Table 7. While it may not be a surprise that approximately one-third of the suggestions dealt with funding-related issues, it is surprising that there were so many other disparate suggestions (34.9%).

Factors That Were Not Frequently Cited

It is interesting to note some of the factors that were *not* frequently cited. In the “rewards of teaching” category, these included “working with computers” (4 comments) and “enjoy modular technology” (1 comment) both of which some would assume to be true of our recognized “best” teachers. It is also clear that the technology teachers identified as excellent by their peers and state supervisors are not restricting their teaching to “high-tech,” computer-based, or modular-based programs (Table 4).

In the “negative factors” category, the item “counselors/administrators using technology education as a dumping ground” was only noted twice. Just a decade ago, many industrial arts teachers considered this to be one of the most serious problems facing the profession (Wright, 1985). Other frustrations that were cited by only single individuals included “insufficient laboratory space,” “lack of pay differentiation between good and poor teachers,” and “heavy non-teaching responsibilities, meetings, and paperwork, etc.” The latter was a surprise because it was specifically identified in the literature review.

Finally, in the “suggestions” category, only one comment called for “a state-mandated credit for technology education.” This is in contrast to research by Dugger et al. (1991) that identified this as the most frequently cited suggestion. Other single suggestion items included “school-to-work programs,” “interdisciplinary units,” and “time for interdisciplinary units.”

Interaction Among Variables

Research question five sought to explore relationships that might exist among the various demographic variables and technology teacher satisfaction. T-tests were run for each demographic variable on the “positive factors.” Although the magnitudes varied widely, none was significantly different. This could be due, in part, to the low cell frequencies. What is particularly surprising, however, is that there was no significant difference by school size; the patterns of responses for “positive factors” and “frustrating aspects” were similar across all categories of respondents.

Table 6
The Frustrating Aspects of Teaching

Negative Factors		*f*	%
1.	Lack of funding for equipment, supplies and facilities	63	19.5
2.	Decline in personal characteristics and attitudes of students	43	13.3
3.	Lack of understanding and support of technology education by administrators/counselors	32	9.9
4.	Long hours required to deliver a quality program	25	7.7
5.	Low pay for teachers	18	5.6
6.	Excessively large class sizes	16	5.0
7.	Lack of planning and development time	16	5.0
8.	Lack of status of technology education profession	13	4.0
9.	Lack of established state/national guidelines for Technology Education	9	2.8
10.	Difficulties associated with trying to collaborate with other academic areas	8	2.5
11.	Excessive bureaucracy and red tape	8	2.5
12.	Difficulties with classroom management and student discipline	7	2.2
13.	Political problems within the community that negatively impact education	7	2.2
14.	Colleagues who don't care about the teaching profession and their students	6	1.9
15.	Stress and learning time associated with rapid pace of technological change	4	1.2
16.	Shortage of like-minded colleagues or other Technology Education teachers to interact with	4	1.2
17.	Lack of control and input into course scheduling	4	1.2
18.	Lack of parental understanding, interest and support of technology education	3	0.9
19.	Lack of parental involvement in children's education	3	0.9
20.	Changes related to educational goals and expectations of schools	3	0.9
21.	Need for lab maintenance; especially computer equipment	3	0.9
22.	Lack of sufficient technical support to learn new technologies	2	0.6
23.	Confusion of technology education with computers and educational technology	2	0.6

24.	Poor quality equipment and post-sales vendor support	2	0.6
25.	Students' lack of basic academic skills	2	0.6
26.	Counselors/administrators using Technology Education as a dumping ground	2	0.6
27.	Other	52	16.1
	Total	323	100%

n=323

Table 7
Recommended Changes

	Change Factors	*f*	%
1.	Better funding for Technology Education programs	48	17.3
2.	Public relations campaign to interpret what technology education is, its benefits, etc.	22	7.9
3.	Reduction in problems with student discipline	21	7.6
4.	Commitment of school district to Technology Education	18	6.5
5.	Reduction in class sizes	16	5.8
6.	Better compensation for teachers	15	5.4
7.	Additional staff (more faculty, teacher aides, etc.)	15	5.4
8.	Additional in-service and professional development for technology education teachers	15	5.4
9.	More control over scheduling and course offerings	13	4.7
10.	Reduction in paperwork, busywork, and non-teaching duties	11	4.0
11.	Additional corporate sponsorship for Technology Education	8	2.9
12.	Change public expectations of schooling toward education and away from parenting	7	2.5
13.	Increase communication and collaboration among technology educators	7	2.5
14.	Students who are stronger academically	6	2.2
15.	Assistance in seeking and obtaining funding for Technology Education program needs	5	1.8
16.	Additional support to maintain laboratories and equipment	5	1.8
17.	Increased parental involvement in the education of their children	5	1.8
18.	Clarify the purpose of technology education in the schools (general education, college prep., pre-technical, etc.)	4	1.4

19.	Additional time and resources for curriculum development	4	1.4
20.	Support and recognition of additional extracurricular responsibilities (TSA sponsorship, time spent maintaining equipment ,etc.)	4	1.4
21.	Complete the change from Industrial Arts to Technology Education	3	1.1
22.	Better vendor support of equipment they have sold to schools	3	1.1
23.	Clarification of confusion between technology education and educational technology	3	1.1
24.	Better university level support and leadership for Technology Education	2	0.7
25.	Other	97	35.3
	Total	278	100%

n=278

Implications and Recommendations

It is important to remember that this study dealt with "excellent" technology education teachers. Responses from the entire population of technology educators could likely have been quite different. However, it is quite clear that the teachers included in this study are committed to their students. The two primary reasons that these teachers like teaching technology is the excitement and stimulation of learning and working with new technologies, as well as the enjoyment of working with students. These teachers desire and receive a fair degree of autonomy in their daily jobs with regard to developing and implementing curriculum. The teachers in this study find the lack of funding and equipment, the decline in the personal characteristics of some students, and the lack of understanding and support of administrators and counselors to be the most frustrating aspects of their jobs.

The overwhelming majority of the suggestions offered by the outstanding teachers may be summarized in two broad categories: 1) better funding and support for technology education, and 2) educating the public (and school personnel) about technology education.

If the technology education profession is to successfully attract and retain outstanding teachers, results of this study suggest that action must be undertaken to address these concerns. Technology education professionals or their associations cannot directly address issues such as better funding for schools/teachers or issues related to student discipline. However, the profession can appropriately address the major misconceptions regarding technology education and enlist the support of business and industry in doing so. This may help alleviate the two major concerns expressed by the teachers. The following suggestions represent some practical and realistic steps for the technology education profession and its allied associations to take to address these concerns.

1. *In recruitment efforts, focus on the top three research findings: excitement of new technologies, enjoyment of working with kids, and independence and autonomy in daily routine.* The results of this study, and others, clearly indicate that the rewards of teaching technology are related to both the subject and the client! This information should be used by high school teachers and counselors, university programs, and our professional associations as we attack the critical shortage of teachers in technology education. Individuals who are "people-oriented," that is, those who enjoy working with young people, and are excited about learning and using new technologies are the best candidates for becoming successful technology teachers. We need to be bold about suggesting technology teaching as a career option to people who seem to possess these qualities.
2. The *Technology for All Americans Project* (ITEA, 1996) is an extremely valuable initiative to be used by the profession - not only for "standards" but also for educating school administrators, counselors, boards of education, civic groups, and technology professionals.
3. *Linkages with colleges and universities (technical, design, and/or engineering).* There is a great deal of activity occurring nationally with "2+2" articulation programs for trade and vocational programs. A similar model could be used for establishing linkages between technology education and teacher preparation programs.
4. *Local partnerships*. Partnerships can be established with many different organizations/agencies including business and industry, other schools (such as elementary schools), and civic groups. These partnerships could create awareness and support for technology education.
5. *Advisory committees.* Advisory committees have many uses in addition to providing technical expertise. They may also be a means of involving/informing the public in/about the technology education program. Consider the role of the Technology Education Advisory Committee of the ITEA as an example.
6. *Local public exhibits and presentations*. If the public and administrators are to better understand the purposes, scope, and sequence of technology education, then technology educators must assume the responsibility of "educating" them. This is a process that takes many years of conscientious effort, but there are numerous examples around the country where this has been done effectively. Exhibits may be set up at schools, shopping malls, and state fairs. Presentations can be made to the school board and local civic groups.
7. *Massive national public relations blitz.* This is an effort that is sorely needed, but one that is probably beyond the resources of technology education professional associations. However, the associations could enlist a few large corporate sponsors. A one-page advertisement in *USA Today* or a 30-second spot on *CNN Evening News* could have awesome effects on heightening the visibility and understanding of technology education.

8. *State, regional, and national grant writing workshops and support.* ITEA could provide a support structure for this initiative. Indeed, such an effort was initiated several years ago by Dr. Jane Liedtke with the support of the Technical Foundation of America. Such a program could be included at each state conference in addition to the national pre-conference workshops in order to assist teachers in obtaining additional resources.

We believe that these are logical, practical "next steps" for the profession. It is time to begin both large-scale and local initiatives. It is time to start carrying our message to those best able to help us, especially those in business and industry.

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Editorials

Experimental Research In Technology Education: Where is it?

W. J. Haynie, III

Any field of academic inquiry should be characterized by both breadth and depth in its research. This requires that:

1. A variety of research methods be applied.
2. Results be replicated before being accepted as truth, and
3. Results found via one method or in a given setting be attained in other settings and confirmed by other methods.

A journal which reflects this approach to discovering new knowledge and infusing it into a profession should be expected to include somewhat of a balance of articles from each of the several types of research. How does the *Journal of Technology Education* fair when scrutinized with these standards?

One answer, although an admittedly simplistic one, might be obtained by tabulating what sorts of articles have appeared in our journal. Table 1 shows the numbers of various types of articles in each of the issues of JTE since its inception in 1989. Table 1 shows that there have been a total of 75 refereed articles in the eight and one half volumes of the journal, from the inception of the Journal through the Fall 1997 issue. Of these, 34 (45%) were some form of library research in which the authors explored some aspects of the history, background, philosophy, relationship to other disciplines, or potential direction for technology education.

The second most often published form of research in JTE was surveys of various types. Most of these were attitudinal in some way and many explored perceptions of technology teachers. There were 13 such articles (17%) in the first eight and one half volumes of the *JTE*. Delphi and modified Delphi studies ranked 6th (4 articles, 5.3%). Observation research was reported in 2 articles (2.7%, ranking 8th). Surveys, Delphi's, and observations are all essentially methods of recording preferences, opinions, or perceptions of subjects or occurrences of specified behaviors. Thus, in effect, a total of 19 articles (25.3%) reported what existed currently or was anticipated, as perceived by various constituents.

An additional five articles were ethnographic or case studies (6.7%), and five more studies (6.7%) were post hoc analyses or causal comparative research.

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Table 1
Numbers and Types of Refereed Articles in JTE

		Type of Research							
Vol/ No.	No. Arti- cles	Experi- mental	Survey	Obser- vation	Delphi	Lib- rary	Case Study	Post Hoc Anal.	Curri- culum
1/1	3		1			2			
1/2	4	1	1			2			
2/1	3		1			2			
2/2	5		1		2	1			
3/1	6		2			3			1
3/2	5					5			
4/1	4	1				2		1	
4/2	4		2			1		1	
5/1	5				1	1	2		1
5/2	5	3		1		1			
6/1	5	1	1		1	2			
6/2	5					2	2	1	
7/1	5	1	1			3			
7/2	4		1	1		1		1	
8/1	4	1	1			2			
8/2	3					2		1	
9/1	5	1				2	1		1
Totals	75	9	12	2	4	34	5	5	3
		12.0%	17.3%	2.7%	5.3%	45.3%	6.7%	6.7%	4.0%

Reports of curriculum or test development efforts comprised three articles (4%). Experimental or quasi-experimental research was reported in nine articles (12%).

It is understandable that a profession which is perpetually in search of its identity, frequently trying to justify its own existence to unknowing critics, and embroiled in a good degree of infighting over what it should be, would have a lot of library paper/debate type articles in its premier professional journal. The question is, however, should this sort of discourse dominate nearly half of our only dedicated research journal? With nearly half of our journal invested in such discourse, and another 25% used to espouse perceptions and to report existing conditions (surveys, Delphi's, and observations), our profession has invested nearly 75% of its most scholarly research journal with little possibility of learning or discovering anything new or different. Even the 13% of the journal comprised of ethnographic or case studies and post hoc analysis or causal comparative works rarely will find new information on which to build. Only experiments and curriculum development articles find new data and the sum total of these efforts published in the first 17 issues of our major research journal was a meager 11 (16%).

How firm a foundation are we building when the largest body of research in our profession consists of authors digging into the past and the next largest segment merely reflects the opinions of our experts (surveys and Delphi's)? Is there a reason why we avoid doing or publishing experiments?

This editorial is an appeal for two things to occur which should upgrade our journal and result in a more well balanced body of professional research. It is somewhat self serving, because two of the nine experimental articles in JTE were my own works and I have been a reviewer of five of the others. The first is for more researchers to be brave enough to take the risks involved in conducting front line, original, experimental research in our field. The second appeal is for members of our referee panels to allow more freedom for experimenters to do their work.

Why are there so few experimental and quasi experimental articles in JTE? There are two primary answers to this question. First, experiments are difficult to do in education and therefore it is much quicker to do library or descriptive research—the road to publication is an easier one to travel and may be traveled at higher speed if the author avoids experimentation. Secondly, because it is impossible to avoid all risks of error in educational research, it is more difficult to get experimental research accepted via the referee process.

The Perils of Educational Experiments

Part of the problem is that some of the reviewers for scholarly journals may not be actively engaged in an organized experimental research effort. I suspect that many of them have never actually conducted and published an experiment, at least not recently. Yet, all took courses in graduate school in which they learned how to identify flaws in experimental research and criticize each detail of hypothetical experiments. These courses were intended to make them knowledgeable consumers of experimental research and to help them learn how to conduct it. But the regrettable effect of these fundamental classes is often to dissuade them from ever attempting to do experiments and make them super-critical of the efforts of others who try to do so.

When a single experiment is conducted, the researcher must weigh many factors in the design of the methodology. Often, some significant sources of potential error must be admitted into the design of a given experiment in order to avoid other extraneous factors perceived by the researcher as being equally hazardous or more so. So, there is a chance of error that must be accepted in that one experiment. If the researcher reports the results found in that experiment and the profession accepts them as truth, then both have fallen short of scientific integrity. But, if the researcher then follows this experiment with another one that avoids the potential errors of the first (while possibly accepting some of the other risks avoided the first time) and both experiments attain the same results, then there can be more confidence that some truth is being brought into focus. When still a third experiment, with yet different risks, confirms those same findings, more power is given to the argument. Even after several experiments confirm the same result, however, it cannot be acclaimed as factual and no boast of perfect understanding may be made. However, when several different experiments find the same result and other sorts of research later confirm that the effect found is predictively accurate in practice (as in new curriculum efforts, confirmation in surveys and Delphi studies, etc.), then we should accept it as usably true.

In a perfect world, from the experimental researcher's perspective, the above sequence would be typical. But that is not what happens in practice because the first experiment in the series may never get published! The reviewers are unable to understand that there must be some risk of error in every educational experiment involving human subjects. We simply cannot clone new human subjects, rear them in Skinner boxes, feed them a bland diet, control their every waking moment, and then make them sleep at prescribed times with drugs and shield them from the influences of others. Likewise, when conducting research in schools, we cannot always insure that each class has a wonderful teacher, is at a time of day conducive to learning for youth, is never interrupted by a fire drill or assembly, is comprised of a perfect mix of homogeneous students, is in an equally comfortable environment, etc. But some of the experiences I have had with the review process leads me to conclude that some referees are unwilling to accept any risk at all.

For example, a researcher wishes to test the effectiveness of a new method of teaching some particular skill. She sets up an experiment to do this in her school. She pits the new method against two traditionally accepted methods. Conveniently, there are nine sections of the same course in her school to use in conducting the experiment and three teachers willing to cooperate. Sounds rosy so far. Then she needs to make some decisions. Should she make certain that each teacher uses a method with which they are comfortable and competent risking that the "best" teacher or the "worst" teacher will be the one to employ the new method? Or, should she have each teacher teach one section with each method risking that the teachers will perform better when using their individually favorite methods? Or, should she randomly assign methods to each section regardless of teacher/time and risk that simple dumb luck results in the new methodology being taught first period while the others are used with those sleepy after-lunch students? What about establishing that the students are equal in ability? Should they be pretested, risking the possibility of presensitizing them to the treatment? Should they be grouped on the basis of some other scores (GPA, CAT test, etc.) risking that those are truly relevant to the factor under study? Should the dumb luck of randomization be trusted again to result in equivalent groups without any pretesting? There simply is not a correct answer! The researcher must design the experiment to avoid the risks she perceives as the most serious ones first and accept some risk of error from the opposing factors. If she stops after the one experiment and proclaims the results true, she lies and readers would be duped if they believed her results. But, if she publishes this article (acknowledging the risks she took) and follows it with two more experiments designed to avoid those risks while accepting others, then she can make a strong statement about what has been found. It must be assumed that the readers of scholarly journals are competent to recognize all of the pitfalls as well as the combined potential of a series of experimental studies—after all, most of them had those same introductory research course experiences.

My experience, however, has been that reviewers are either unknowledgeable about this logical progression towards truth or unwilling to trust that the readers of our top research journals have the good judgment to analyze experimental results. The view appears to be that they must act in a parental mode to protect the readers from seeing any experimental risk whatever. So, since all experiments accept some risk, it is very difficult to get one published. *JTE* is certainly not alone in this. I've had seven thematically progressive experimental research articles published, so I know a good bit about how experimental articles are treated by reviewers. In most cases there was at least one reviewer who was so disturbed by whatever risk had been taken that he or she asserted that the whole experiment was totally invalid and should have been done in some other way. In each case, however, that "other way" would have risked something else which I perceived to be equally problematic. Furthermore, there was a plan to try that other approach in another effort.

One experimental manuscript which received mixed reviews was rejected by an editor because he was so persuaded by the comment of one reviewer that the "results were predictable from the beginning." This points out another decision for a researcher to make. Should one design a tightly formed experiment to answer a very small question with good clarity or a large study that derives muddy answers to several questions? In this particular work, only a small question was asked and that led to the reviewer's comments. That reviewer did not understand that this study would certainly be followed by others and eventually a relationship of some importance would be found. The bigger the questions and more complicated an experiment gets, the less clear the answers can be. What about the assertion that results could be predicted? How far would the natural sciences have gotten in their aggressive experimental research agenda if Newton's work had been rejected so glibly—would he have even bothered to drop the apple realizing that his earnest and well conceived efforts would be marginalized and dismissed so lightly?

What does all of this illustrate? To me it shows that reviewers differ so vastly in their opinions of what is and is not good (or even acceptable) experimental research that there must be some general lack of understanding. Perhaps if more reviewers would take the risk of actually doing experimental research and experience firsthand the hazards and pains of decision making to conduct experiments in the real and imperfect world, they would learn that some risks must be taken in the search for truth. Further, they might also come to understand that a slight risk of possible error does not necessarily invalidate results, it merely draws them into question and readers of our scholarly research journals should be trusted to ask those questions for themselves rather than be protected from the evidence.

I am not promoting that our journals be cluttered with sloppy experiments. As a reviewer, I have heavily criticized several of the experiments I reviewed and rejected about half of them. Often, however, all that is needed is for the author to point out the risks taken, how those risks potentially could have fogged the results, and what caution must be used in interpreting them. It would be better to publish an experiment with a minor flaw handled in this way, and encourage the author or others to follow the work with other studies that avoid that risk, than to simply reject the article and lose the valuable findings which it may have made. Other researchers could then seek to replicate or expand the studies in different settings. This, however, cannot occur if the preliminary work is never published.

The editor also has some responsibility to weigh the input of the various reviewers. When one reviewer is an outlier who alone rejects, efforts should be made to seek another blind review or otherwise resolve the problem. Do editors and reviewers understand that it takes about a year and a half to conduct, analyze, and report an experiment and all of that effort might be wasted due to that one reviewer's minority opinion that the work is flawed? Shouldn't the editor err on the side of letting the readers see and judge controversial works for themselves? If all editors did this, there would be more experiments reported in our journals and colleagues would not be intimidated from attempting to experiment as they are now. Happily, my experience with most editors in our field (and especially JTE) is that they have been open minded enough to take a second look when these situations were revealed to them, but a single reviewer's input could easily slam the door on a basically sound experiment if the author is not ready to argue his or her case and make revisions which are justified.

I would like to see a larger percentage of our journal devoted to the development of new curricula and methodologies, a lot more of the case studies becoming prevalent in other fields, and certainly more experimental research. It appears to me that *JTE* is currently publishing about the right amount of attitudinal and perception work (roughly 25% surveys, observation, and Delphi's). I believe the search for our roots and direction is important, but I wonder aloud if half of our journal needs to be filled with this discourse while only 12% of the articles report experiments. I encourage others to do experiments in technology education. I hope others will come forward to make a strong argument for more case studies and other forms of primary research as well. And, as a reviewer, I vow to help authors who do submit reasonably sound experimental research manuscripts to get them into a form that is publishable and suggest options for future studies in their series rather than hide their good efforts in the rejection drawer. I implore my colleagues to do likewise for the health of our research knowledge base.

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).

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