IMPACTS OF TECHNOLOGY EDUCATION

PROCEEDINGS
PATT-9 conference
MARCH 27 – 29, 1999

Mottier/De Vries (eds.)

CONTENTS

PREFACE

In this publication you find the contributions to the PATT-9 conference that has been held in Indianapolis, Indiana, USA, March 27 – 29, 1999. The conference was organized in co-operation with the International Technology Education Association in the USA and held partly at the same time the annual ITEA conference was held. This enabled colleagues to combine participation in both conferences. In particular we want to thank dr. Kendall Starkweather, Michelle Judd and Moira Wickes for all the work they did on the conference. Both they and we felt that the combination of the two conferences worked out well and that it is worth exploring possibilities for more of such combinations. Therefore the PATT-10 conference will be held in 2000, again in conjunction with the annual ITEA conference, then in Salt Lake City, USA. In 2001 there will be a PATT conference in the Netherlands again, in the usual format, that became so characteristic for PATT and has attracted and still attracts new participants who want to become members of the 'PATT family'.

It is the first time that the Proceedings of a PATT conference will be published both in electronic format and on paper. This is possible thanks to the willingness of ITEA to put this pubication on their website (www.iteawww.org). We hope this combination will enable more readers to use the outcomes of the PATT conference, both those that have and those that have not (yet) access to the Internet.

We enjoyed meetings old friends and making new ones during the PATT-9 conference and we look forward to the next conference in 2000.

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Impacts of Technology Education: Introduction to the Conference

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Some of the readers of this publication are old friends and well acquainted with the concept of PATT, some are new. So let me briefly explain for the newcomers what PATT is.
PATT started as a conference for research into pupils' attitudes towards technology, which is the meaning of the acronym. But we expanded our interest to the whole of technology education, and now we like to call ourselves international forum for technology education.

Most of the PATT conferences take place in the Netherlands. But there have been conferences organised in Poland, Sweden, Kenia, South Africa. There was a PATT conference associated with ITEA in1992. And with the PATT-9 we were back again in the US, at the request of the ITEA.

The specific purpose of this conference was to give (young) researchers the opportunity to present their research, and to give teachers the opportunity to hear about very new research findings and ideas. Papers presented at PATT conferences were collected in this conference report.
The main aim of the small PATT foundation is to organise the PATT conferences. In between, we maintain a network among each other, we send a newsletter out about three times a year. You might be interested in joining our " PATT family" after the conference: you are most welcome.

The PATT conferences which we organise every two years always deal with a special theme. We have been meeting around technology education and industry, environment, entrepreneurship. Around the assessment of tech ed.
This year the conference is about 'Impacts of technology education'. This theme is puzzling me more and more. We have received a number of paper proposals, and they all seem to be positive about technology edcation. Since you will therefore be hearing a lot of positive stories, let me take the freedom to express some worries.
I will do so by taking the case of the Netherlands as an example, because this is what I know best. You may see if the situation in the US is different.
My worry is in brief:
the impact of technology on society is still increasing. Most of us live in total technological environments, but the younger generation does not recognise it as technical any more, and does not want to follow studies which permit to maintain this technological environment.
And it seems that the more we introduce technology in general education, the more students turn to other studies.

We have made an effort in the Netherlands since 1975 to introduce technology in all parts of general education. Older PATT friends know about it.
Technology was first introduced in secondary education for age 12-15. Compulsory and through legislation, so pupils have no choice. The results are not so bad, after years of experimentation. The quality of teaching is increasing, the subject is taught by qualified teachers, and students seem to like it.
Technology in primary education is not compulsory, but it is encouraged. Here introduction is therefore more difficult. It depends on extra efforts of the government and of support systems. There are no qualified teachers, the ordinary primary teacher does it. Most students like it.
Recently the upper secundary school has been reformed (age 15-18), the pre-college level. There are now four so-called " profiles": culture and society, society and economics, nature and health and nature and technology.

Let me concentrate on these last two: nature and health and nature and technology.
Nature and health is about natural sciences, and biology. Nature and technology is about..natural sciences and technology, you would suppose? No, there is no technology as separate subject, there is only 'technical' physics.
When the profiles were designed there first was a fear that more girls would opt for nature than for technology. The second fear was that engineering and medical studies would be open only for the technology profile, and that it would act as a selective filter.
The present situation is that both health and technology allow entrance to all fields of university study (so there is no special incentive to choose the technology profile), and secondly, not only young women but also young men are deserting technical studies.

This is worrying because most labour market researchers foresee a shortage in technology and information technology in a rather near future.

We have of course been looking for reasons. I mention briefly some possibilities:
1. study is too expensive.
2. study is too difficult.
No effect was found of these explanations, anyhow no increased effect during the last years.
As most relevant factor researchers claim that technical studies do not match the actual ' life feeling' of youngsters.
Students of Nature and technology are seen as less " trendy" than their peers. The present interest of non-technical students goes to :
taking responsibility;
organising your own life at home (cocooning);
survival;
personal involvement with others.
Technology students are attracted to a nice big house, luxury, values which are already more or less a past trend.

It leaves me puzzled. Not so much the fact that technology students seem to be more 'materialistic' than other students, but more the rapid trends. Trends seem to come and go at a more and more faster pace. This is influenced by globalizing mass media (result of technology!), and almost not by the education system. But what we do, and keep doing, is organising technology promotion campaigns in education. We know since 20 years that they have no effect, but we keep doing it. That is why I was puzzled about the title of our conference: Impacts of technology education.
Impacts of technology *education*? Hardly any.
Impacts of technology . . . yes, a lot of impact on our society, from the media to cloning to chip cards. But no one seems - yet- to recognize it as technology.
We have a lot to do.

Technological Instruction In Finnish Primary Schools

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Abstract

This paper focuses on practices of primary school teachers (N=212) in technology education. A clarification of the potential of developing technology education at the primary school level was also sought. The data were collected by means of a questionnaire. According to the study, woodworking is the most popular technological area. The obstacle to development mentioned most often was the lack of financial resources. This study shows that teachers suggest that technology education should include modernized technological content, while retaining traditional educational handwork.

Introduction

This study investigates technology education in the Finnish primary schools. Technology education (with "technical work" as the official name) is included as part of the "käsityö" subject group in primary education, which in the Finnish school system comprises education for pupils aged 7 to 13. The national core curriculum and curricular guidelines are very vague, providing only brief outlines. Though this allows for local flexibility, it also increases diversity in the way in which technology education is taught from one school to another. In the latest national core curriculum, the main emphasis is on the "idea-to-product" process with the pupil fully engaged in the design phase (Opetushallitus, 1994). Although the designing and making of products is a central part of the national curriculum guidelines, the need for a broader technological understanding and capability is also emphasized.

In primary school, all pupils are required to study technology education in the third grade. Thereafter pupils must choose either technology education or textile work. As one might expect, boys usually choose technology education. Those who have chosen technology education study it for at least two hours a week from the third through the sixth grade. In Finnish primary schools technology education is usually taught by regular classroom teachers. Today these teachers must hold a master's degree in education and most have studied technology education during their undergraduate studies. A separate technology education space is provided for instruction, with the number of students preferably not exceeding sixteen. The research questions of the study are summarized in the following way: a) What technology education teaching practices are in use in primary schools today? b) What technology education goals are met in primary school?

Method

The research questions were addressed by means of a survey instrument. The majority of the questions were close-ended. A few open-ended questions were included as well. The study included the provinces of Oulu and Varsinais-Suomi. The former lies in northern Finland and the latter in the southwestern part. The instrument was mailed to a sample of 300 primary schools, stratefied by geographic region, in the spring of 1997. After two mailings, 212 (70.7 %) completed questionnaires were received. By geographic strata, 104 of the responding teachers were in city schools, 28 in provincial towns, and 80 in rural areas.

The data showed that the vast majority (205) of the teachers in the study were male. The average age was 41.1 years (SD = 10.05). The average amount of teaching experience was 15.8 years (SD = 10.22 years), with 14.6 years (SD = 9.92 years) spent teaching technology education. On average, they taught technology education 5.3 hours (SD = 4.79 years) per week. Twelve of the teachers held a degree in technology education and all of the respondents except five had a bachelor's or master's degree in education. Ten of the teachers worked as a technology subject teacher, whereas rest of them worked as a class room teacher. All had at least studied technology education in the teacher preparation program since such study is compulsory.

The close-ended questions were analyzed quantitatively by using frequencies and averages. Chi-square testing, one-way ANOVA and Pearson correlation analysis were also applied to selected responses. The copying teaching method and the design teaching method were compared using a dependent sample t-test. The reliability coefficients of the variables relating to the goals of teaching and the teaching method ranged between .61 and .83 and were deemed acceptable. The open-ended questions were also analyzed quantitatively by using descriptive statistics, grouping similar responses together.

Results

The Practices of Technology Education

The analyses revealed that 15 % of the respondents had the potential of using a computer in technology education. There was not statistically significant difference in the potential of using a computer between cities, townships and rural. In the near future, 32 % of the respondents felt that they would have this potential. Yet the study indicates that there was not statistically significant difference in the future plan related to the potential of using a computer between cities, townships and rural. The most predominant use of computers in technology education was for drawing and planning. Using the World Wide Web or software developed for educational purposes was rarely mentioned.

Table 1.
The use of activities in technology education

	The use of activities							
Activities	never f(%)	seldom f(%)	sometimes f(%)	often f(%)	very often f(%)	total f(%)	M	SD
Woodwork	1(1)	0(0)	11(5)	92(44)	107(51)	211(100)	4.44	.64
Service and Repair	11(5)	46(22)	111(53)	33(16)	9(4)	210(100)	2.92	.87
Metalwork	10(5)	60(29)	100(48)	36(17)	4(2)	210(100)	2.83	.84
Plasticwork	14(7)	60(29)	88(42)	45(21)	3(1)	210(100)	2.82	.89
Electric-Mechanical equip.	20(10)	78(37)	88(42)	22(10)	3(1)	211(100)	2.57	.96
Electronic equipment	44(21)	55(26)	75(36)	31(15)	5(2)	210(100)	2.51	1.05
Familiarity with tech. equip.	124(59)	52(25)	26(12)	5(2)	2(1)	209(100)	1.61	.87
Construction kits	135(64)	51(24)	20(10)	3(1)	2(1)	211(100)	1.51	.80
Internal-Combustion engines	131(62)	56(27)	18(9)	5(2)	0(0)	210(100)	1.50	.75

The cooperation of local industry was examined with both closed-ended and open-ended question in the study. Nineteen % of the respondents indicated that they have cooperated with local industry. In most cases, this involved the donation of materials or providing field trips to students such as a visit to a sawmill, a fiberboard factory, or a fishing lure manufacturer. In some cases, the teachers also received expertise from the local industry. There was not statistically significant difference in the cooperation of local industry between cities, townships and rural.

The study also investigated the kinds of activities used in technology education and their suitability to students at the primary level. Respondents were asked to rate nine selected activities. These data are reported in Table 1. The respondents were allowed to include a single activity of their own. Each activity also included a description of what it included. For example, it was explained that in woodworking wood was the primary material with which the students worked. Relative to electrical equipment, it was explained that this task included topics such as transistors, IC-circuits, and construction kits for teaching electronics. Familiarity with technological equipment included topics such as exploring the function principles of radios or computers, and service and repair included topics such as the maintaining of students' bicycles and other equipment.

Woodwork is clearly the most popular technological activity in Finnish primary education. A middle group of activities in terms of popularity consisted of plastic work, metal work, service and repair of technical equipment and vehicles, electric-mechanical equipment, and electronic equipment. Least popular were construction kits, the internal-combustion engines, and familiarity with technological equipment. In addition to the nine listed activities, respondents were asked to list others. Leather, rattan, mosaic work, and building model airplanes were among those listed most often. However, this study indicates that the teachers generally felt that all of the nine prescribed activities could be suitable for technology education at the primary level.

The Goals of Teaching

The Finnish curriculum guidelines mention creativity, cultural heritage, environmental education, enterprise education, self-image, problem-solving skills, social skills, and readiness for work life as the general goals of a comprehensive education. In this study, there was investigated how these general goals were manifested in technology education. Therefore, on the questionnaire the teachers were asked to evaluate "how much the following statements correspond with your technology education, in other words, how much do the statements describe your pupils' work?" According to the results, the general goals in technology education focus the most on creativity of pupils. The development of problem solving skills, self-image, the Finnish cultural heritage and social skills are also often associated with technology education. However, readiness for work life, environmental education and enterprise education are only associated with technology education to some extent.

In addition to the general goals, this study subdivides the goals of technology education into product design based work and the development of technological literacy. The product design strongly involves creating products such as suggested in the 'idea to product' processes. The traditional product design based work includes the development of manual dexterity, product planning, work safety, work education and aesthetic education. The study indicates that manual dexterity was seen as most connected to the product design based work. In addition, work education, work safety and product planning are considered essential parts of this work. Aesthetics were only seen to be a part of teaching and pupils' work to some extent. The practical aspects of technological literacy (Dyrenfurth, Hatch, Jones & Kozak, 1991) were considered to be essential aspects of technology education. The utilization of technology refers to the acquisition of knowledge and skills to use and make technological products and solutions. The evaluation of technology refers to the critical evaluation of the impact and consequences of technological processes. The appreciation of technology refers to understanding the outcomes of technological innovations as they relate to a higher standard of living.

Table 2.
<u>The goals of teaching technology</u>

The goals of teaching	never f(%)	little f(%)	some extent f(%)	much f(%)	very much f(%)	total f(%)	M	SD
The general goals of primary education								
Creativity	1(1)	3(1)	53(25)	113(54)	41(19)	211(100)	3.90	.73
Problem solving skills	0(0)	14(7)	61(29)	114(54)	20(10)	209(100)	3.67	.74
Student's self-image	2(1)	10(5)	78(37)	90(43)	29(14)	209(100)	3.64	.82
Social skills	0(0)	19(9)	81(38)	95(45)	16(8)	211(100)	3.51	.77
Cultural heritage	2(1)	14(7)	85(41)	91(43)	17(8)	209(100)	3.51	.78
Work life	4(2)	39(18)	90(43)	66(31)	12(6)	211(100)	3.20	.87
Environment education	8(4)	57(27)	104(49)	39(18)	4(2)	212(100)	2.88	.82
Enterprise education	19(9)	77(37)	84(40)	26(12)	4(2)	210(100)	2.61	.89
The product design based goals								
Manual dexterity	0(0)	1(1)	5(2)	86(41)	119(56)	211(100)	4.53	.57
Work education	0(0)	4(2)	34(16)	106(50)	68(32)	212(100)	4.12	.74
Work safety	0(0)	1(1)	39(18)	118(56)	54(25)	212(100)	4.06	.68
Product planning	0(0)	4(2)	87(41)	96(45)	25(12)	212(100)	3.67	.71
Aesthetics	1(1)	16(7)	90(42)	99(47)	6(3)	212(100)	3.44	.70
The dimensions of technological literacy								
Utilization of Technology	1(1)	12(6)	92(43)	98(46)	9(4)	212(100)	3.48	.69
Evaluation of Technology	4(2)	45(21)	115(54)	44(21)	4(2)	212(100)	3.00	.76
Appreciation of Technology	4(2)	66(31)	101(48)	39(18)	2(1)	212(100)	2.85	.77

One approach used in technology education involves making products using prescribed drawings or plans. In this study, this approach is referred to as the "copying teaching method." Students can also invent, design and make products by themselves. This second method is referred to as the "design teaching method." Five statements with a five-point scale focused on each teaching method. According to the results, the teachers use significantly more the design teaching method than the copying teaching method [means = 3.12 and 2.85 respectively; $\underline{t}(212) = 5.22$, $\underline{p} = .000$]. Thus technology education in primary school is more design oriented, though both teaching methods are not clearly part of the current technology education. The study also investigated the obstacles to developing technology education in primary education with both closed-ended and open ended question. The respondents indicated that the three most significant obstacles, in order, were lack of financial resource, insufficient on how to teach technology education and other accompanying resources. The study showed that the teachers felt that technology education should include more modern technological content while, at the same time, retaining traditional educational handwork. It appears as though most of the teachers in primary schools understand the concept of technology from a broader perspective than simply new technological artifacts or computers.

General discussion and conclusions

Main findings of the study

According to this study, woodworking is the most popular technological area. The development of manual dexterity, work education, work safety, creativity and problem solving skills are most often mentioned as goals accomplished in technology education in Finnish primary education. These goals are more widespread than the ability to utilize and evaluate technological products and systems, for instance. The study showed, however, that teachers suggest that technology education should include more modernized technological content, while retaining traditional educational handwork. The design-based teaching method is more commonly used than the more antiquated and less educationally sound copying-based teaching method. The most often mentioned obstacles to development were the lack of financial resources and insufficient know-how in teaching technology education. The following chapters discuss what kind of impact technology education has on students in the Finnish primary schools.

How should the impact of technology education be reviewed?

It is a mistake to limit the impact of technology education to cognitive objectives. Lehtinen, Vauras, Salonen and Olkinuora (1995), for instance, have found that natural learning always involves a complicated interaction between cognitive, motivational, social and situational interpretations. Consequently, it is not possible to educate students to cope with the technological world by merely increasing their understanding of technology, in other words developing only the cognitive objectives which are very important for technological literacy.

An essential question in reviewing technology education's impact concerns the way in which learned material transmits within and across domains in technology education. At this stage of the presentation, I would state that I do not totally agree with situated learning theories (e.g. Lave, 1988). It seems that there are misperceptions about, or at least undue emphasis on, the context-dependence of learning in education (Anderson, Reder & Simon, 1996). I prefer to believe that transfer within and across domains is possible if students are taught appropriately. For example, degree of practice is a determining factor, and yet the amount of transfer depends on where attention is directed during learning or at transfer (Anderson et al., 1996; Bruer, 1994).

In fact, Anderson et al. (1996) argue that, from one domain to another, transfer varies directly with the number of symbolic components that are shared. Perkins and Salomon (1987) distinguish between two broad types of transfer, low road and high road transfer; low road transfer occurs as the automatic consequence of varied practices, whereas high road transfer reflects deliberate and mindful efforts to represent principles at a high level of generality. Hence, although good thinking depends on specific knowledge, many aspects of powerful thinking are shared across disciplines and situations (Resnick, 1987). For example, Chen and Klahr (1998) found that even young children were able to learn transferable scientific reasoning skills, and they were able to use those skills many months later in a biological context although they acquired the skills in a physical variable control situation.

The concept of schema (e.g. Norman, 1982; Schank & Abelson, 1977), i.e. a mental model, is an essential psychological term that assists in understanding the technological behavior of students, and, resultingly, the impacts of technology education on students as well. Therefore, in order to understand the impact of technology education on students, one should ask what students are able to think and do after the instruction, namely what kinds of conceptual and procedural schemas technology education develops. In other words, it is more important to discuss the kinds of cognitive and affective processes that reconstruct students' existing schemas than the real-world trappings, such as modular labs, that technology education includes. In fact, in order that students understand technological concepts, such as electronics, transportation and programmable logic, they have to construct conceptual schemas that represent these concepts. And yet technological activity requires procedural schemas that describe only appropriate sequences of action in a particular context.

The impacts of technology education in Finnish primary schools

This study indicates that the current modes of technology education in primary schools do not develop enough conceptual schemas relevant to modern technological world because learning focuses mainly on woodwork. Students do not necessarily design in a vacuum, but rather in an out-dated conceptual framework. In addition, there is not much transfer of learning across domain in woodwork. It is hard to believe that woodwork involves the same symbolic components that are required in dealing with control technology, for example. However, students are pretty young in primary schools and many technological principles are considered too abstract to them. In essence, what kind of impacts would design-based working have on students if it included a variety of materials but not many technological principles?

The key question is this: do design processes accomplished in primary school develop transferable thinking skills and general strategies? In informal discussions among teachers, there seems to be a understanding that technology education develops generic problem-solving skills. However, successful problem-solving is always dependent on domain-specific knowledge to some extent. Nevertheless, the transfer of problem solving skills across domains is possible if both domains include similar symbolic components. In fact, most problem-solving processes are based on the similar scripts of problem-solving, as a result of which they probably include at least a few common symbolic components. Thus students can learn the main idea of problem solving, i.e. the script of problem solving. I believe that we can create possibilities for our students to experience how to solve technological problems, or, in other words, how our technological world is formed. These positive learning experiences will serve strengthen their technological self-confidence, self-image and desire to take steps toward tasks which require learning and problem solving in the context of technology. Such affective learning outcomes are transferable, and in solving technological problems students also learn domain-specific knowledge. Thus problem solving should be seen rather as a teaching method and a way to develop technological thinking skills than merely an independent learning goal in technology education.

The study indicates that teachers expect their students to learn creativity and manual dexterity through design processes. Those skills are supposed to be generic life skills or transferable skills. I doubt that anybody would claim in earnest that "I became a dexterous and creative person in a technology lesson." Probably one would be more apt to say that "design processes in technology education got me think and reflect more on how to solve technological problems and this made me a creative designer in my work. And moreover, design activities helped me to become aware of my talent for manual dexterity." This example shows that it is difficult to prove all impacts of technology education empirically, and that some learning experiences might begin to have impact on thinking and behavior many years later.

Technology education should teach the knowledge and skills that students will not learn elsewhere. This task is nonetheless difficult; the latest psychological studies indicate more and more clearly that human cognition is a very complex system (Anderson et al., 1996). Technology is not "an exact and pure science," as math and science with a distinct content are, but technology is multidisciplinary and subject to the humans' cognitive, affective and psychomotor capabilities. The aim in developing technology education in Finnish primary schools should not be to organize a technology education classroom in which students merely read textbooks, watch videos, use computer software and modular labs, and complete worksheets. Why should it, when primary schools already have technology classrooms with tools, machines and worktables, in other words great possibilities for creating a unique self-directed learning environment for students?

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Personal and Social Impacts of Technology Education

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Introduction

When I began considering the theme, "Impacts of Technology Education" set forth by the PATT9 Conference leadership, my first thought was of a statement I often heard made by my mentor in graduate school, Dr. Delmar Olson. Dr. Olson is, among his many talents, a skilled potter. He liked to say that it is more important what the clay does to the student than what the student does to the clay. In this seemingly simple statement Dr. Olson recognized that a child's work with the materials of technology had a profound and lasting impact on the child. My immediate thought was "Wow", that is a thought that speaks volumes to an educator. Just putting this thought before this gathering of educational thinkers from around the world should be enough to spur thought and discussion far beyond the time allotted. With the demands of the normal university work day and the press of deadlines from several fronts, I was tempted to just present the thought, let discussion develop and try to record the thoughts for later reporting. But, I quickly realized that I had to do more than present the thought - profound though it might be- and let each of you ponder its meaning and importance. This would probably make for a much more interesting half-hour in your day, but it would result in a very short paper and presentation on my part

My approach to the topic was to begin with a look into the history of technology education in the United States looking for insights into the personal and social impacts of technology education. As most of you know, if you go back beyond 1985, our discipline was called industrial arts, so, this search into the past had to include that early name. I went to the writings of several of the early thinkers in industrial arts to find their thoughts on the impacts of industrial arts/technology education. Hopefully their thinking would provide some insights into the impacts of technology education today. I wanted to answer the question, What is the impact of technology education?, but, more importantly I wanted to gain some insight into the questions of what impact <u>can</u> technology education have and what impact it <u>should</u> have on the student. To a curriculum developer, such insight can come through a study of the stated goals and objectives of a discipline.

I began with one of the classic books in our field, Bonser & Mossman's , *Industrial Arts for Elementary Schools*. (Bonser & Mossman, 1923) Next I went to a book from which many of those of my age in the profession learned about industrial arts curriculum: Gordon Wilber's 1954 edition of *Industrial Arts in General Education*. (Wilber, 1954) And, of course, I went back to the source of my inspiration for this paper, the writings of Dr. Delmar Olson, particularly those works from the 60's and 70's. Olson's book, *Industrial Arts and Technology* (Olson, 1963) published in 1963 and his later monograph, "TECHNOL-O-GEE" (Olson, 1973) published in 1973 at North Carolina State University. With this historic perspective I then went to more contemporary literature in our field to gain some a modern insight.

Let me digress quickly to state that I fully realize that the answer to what impact today's education has on our youth is not for us to assess. Assessment of our successes and failures can only be made through the retrospective view of the historians. In looking at the present it is possible to only look at what we currently are saying <u>can</u> or <u>should</u> be the impacts of technology education on our youth.

Historical Perspective

So, let's begin with a look at the work of some of the early thinkers in industrial arts. The definition of Industrial Arts presented by Bonser and Mossman was considered to be forward thinking and suggestive of a new direction for the profession.

They stated, “The industrial arts are those occupations by which changes are made in the forms of materials to increase their values for human usage. As a subject for educative purposes, industrial arts is a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to those changes.” (Bonser & Mossman, 1923, p.5) This definition of industrial arts as a school subject includes a strong statement of social impact, “…and of the problems of life related to those changes.”

Bonser and Mossman also presented a list of values and objectives of industrial arts. (p. 7)

1. the health purpose
2. the economic purpose
3. the art or aesthetic purpose
4. the social purpose
5. the recreational purpose

They went a step farther and talked about the outcomes of industrial arts. These were statements that answered the question, “What effects as a result of the work are expected upon the behavior of one who has studied Industrial Arts.” They answered the question through six statements of outcomes. Two of these are pertinent to the topic of this paper.

1. Be aware of the general health needs, be able to select and use foods and clothing so that they will help to keep him well, and be intelligent about all phases of cleanliness and sanitation in and around the home. This is the health outcome.
2. Be sensitive to the well being of industrial workers, understand the conditions of the industries, and respond intelligently in all ways possible to help in regulating industry so that no one will suffer injustice or injury for the sake of unfair profits for employers, unfair wages for employees, or unfair prices for consumers. This is the social outcome. (Bonser & Mossman, 1923, p. 14)

The first statement is clearly a statement of personal impact. The second is recognized by the authors as a social outcome of impact.

Gordon Wilber, (Wilber, 1954) also included as one of his seven objectives for industrial arts the following statement, “To develop desirable social relationships, such as cooperation, tolerance, leadership and followership, and tact.” (p. 43) In this objective Wilber spelled out specific social traits to be developed. It can be argued that these social traits are also important aspects of personal development.

In the introductory portion of his book Wilber discussed the meeting of the individual needs of students. He wrote, “There are two groups of needs which can be especially well met by the industrial arts program. These are the need for a feeling of belonging to and being accepted by a group and the need for a feeling of success”. (p. 25) The first of these is clearly a social need, the latter a personal need. Wilber also made the statement: “The possibility of promoting this feeling of success for all children is of such importance that industrial arts might be justified on this basis alone”. (p. 27) This is a strong statement of the personal value of our discipline that is being ignored today.

In 1963 Delmar Olson’s book titled, *Industrial Arts and Technology* (Olson, 1963) had great and near instant impact on industrial arts education in the United States. In proposing an industrial arts for the whole child, Olson presented what he called the “functions of industrial arts”. He used the term functions in preference to that of objectives or purposes because he felt the term included objectives and purposes and at the same time suggested a program of action. He said, “It encompasses values, directions, measures for evaluation, and implications for means to the accomplishment of a mission.” (p. 165)

Olson’s six functions, presented in 1963 were:

1. the technical
2. the occupational
3. the consumer
4. the recreational
5. the cultural
6. the social

In 1973 Olson published a monograph titled, *TECNON-O-GEE* (Olson, 1973) in which he attempted to move his 1963 ideas forward and also project a modern role for industrial arts in the United States. In this publication he presented six slightly modified functions of industrial arts accompanied by statements of goals or purposes which he called outcomes.

Functions	Outcomes
1. The technical	Technical Literacy
2. The Consumer	Consumership
3. The Recreational	Recreational Expression
4. The Cultural	Cultural Efficiency
5. The Occupational	Careers Orientation
6. The Personal-Social	**Realization of Self**

Notice that in 1973 Olson expanded the earlier social function of industrial arts to include the personal impact as well as the social impact of the study of technology. Olson realized that, while people develop a social awareness and efficiency they are also developing an awareness of personal place and personal understanding. Here one sees the relevance of the earlier statement that it is more important what the clay does to the student than what the student does to the clay. When working with materials the students learn a great deal about themselves. They develop a personal awareness and understanding of person.

Incidentally, Olson, in his 1973 publication presented the idea of industrial arts as the interpreter of technology for the American school. He said in explanation of the title of this publication, “We call this total concept TECHNO-O-GEE to express the idea of technology and the excitement children find in its study.”

The intent of this brief look back into the history of our profession in the United States was to make the point that the pioneers in our field saw very definite social and personal impacts growing out of the educational study of technology.

Contemporary Technology Education

With this historical perspective let’s now go to contemporary literature in our field to gain a more modern insight into the personal and social impacts of technology education. It seemed appropriate to try to be consistent with the approach used in the historical perspective above, looking at definitions and stated objectives of technology education.

Let me digress quickly to state that I fully realize that the answer to what impact today’s education has on our youth is not for us to assess. Assessment of our successes and failures can only be made from the retrospective view of the historian. In looking at the present it is possible to only look at what we currently are saying can or should be the impacts of technology education on our youth. With that thought in mind, what are we saying in our current literature about the social and personal impacts of technology education?

Wright and Lauda (Wright & Lauda, 1993, p.4) defined technology education as, “…an educational program that assists people develop an understanding and competence in designing, producing, and using technology products and systems, and in assessing the appropriateness of technological actions”. This definition was followed by the statement that the technological literacy developed in technology education can be assessed through seven competence measures, one of which was a statement of social and personal impact: “ Assess the personal, social, economic and environmental impacts of technology.” (p. 4)

In 1985 the International Technology Education Association (ITEA) published a collection of papers written by prominent scholars in the field. The intent of the publication was “…to give the interested professional educator a broad perspective of the of the technology education emphasis that is becoming so prevalent in our schools today.” The personal and social impacts of technology education was recognized in this publication when it was stated that, “Technology education can help the student… uncover and develop individual talents. (ITEA, 1985, p. 25)

A similar ITEA publication in 1988 spoke of "technological literacy through technology education" including the belief "…that understanding of technology – its evolution, its utilization and its significance – which would enable the individual to function effectively as a citizen as well as in those specialized roles that one plays in a given society." (ITEA, 1988, p. 13)

The ITEA publication edited by Savage and Sterry titled, *A Conceptual Framework for Technology Education* includes several statements recognizing the existence of personal and social impacts in the study of technology. The authors stated that, "The results of implementing technology need to be assessed to determine their impacts on people and the environment." (Savage & Sterry, 1990, p. 18) In presenting suggested content characteristics of a quality technology education program the authors included the following personal/social statements: " Fundamental knowledge about the development of technology and its effect on people, the environment and culture" and "Developing student skills, creative abilities, positive self concepts, and individual potentials in technology." (Savage & Sterry, 1990, p. 26)

Johnson, in the Report of the Project 2061 Phase I Technology Panel discussed at some length the interface between technology and society with emphasis on the teaching of this interface. He stated, "Two principles must be developed, articulated and illustrated: (1) technology affects society, and (2) society affects technology." (Johnson, 1993, p. 9) Johnson emphasized the importance of understanding of the technology-society interface: "To live a fruitful and rewarding life in the twentieth-first [sic] century will require a knowledge of technology and society learned from historical examples, contemporary illustrations, and informed prognostications. It will be necessary to understand some of the basic precepts of the social sciences and their application to what occurs at the interface of technology and society."(Johnson, 1993, p. 12)

Included in the Raizen, et.al. list of Guiding Principles for Technology Education is the statement, "Develop the personal skills necessary for working effectively with other people." (Raizen, Sellwood, Todd, & Vickers, 1995, p.39) These authors also include in their list of goals for technology education curriculum: "Understand and reflect on the way technology supports and constrains personal and societal endeavors, and on how it in turn has been shaped by society and culture". (p. 41)

The Rationale and Structure for the Study of Technology document published by the ITEA (1996) was the final publication studied. Throughout the document there is ample evidence that both personal and social impacts are considered to be important concepts in the study of technology. For example, the authors include as one of several concepts and principles: "Technological activities have both positive and negative impacts on individuals, society and the environment." (p. 30)

Conclusion

I began this paper with the intent of looking for insights into the personal and social impacts of the study of technology education. The brief look into the history of industrial arts showed that both personal and social impacts were of concern to these early writers. The look at more modern writings in technology education show a similar concern though I had the feeling that the statements in the more modern writings were not as strong as those in the earlier documents viewed. I believe that may be true, at least in part because modern writers are using the term "technological literacy" in include a wide range of skills, concepts and impacts of the study of technology.

I return to the theme of this session and ask, What is the impact of technology education? I also return to my earlier statement and suggest that we must begin an answer with some suggestions of what impacts <u>can</u> there be from the study of technology and, possibly more important, what impacts <u>should</u> there be from the study of technology.

The beginnings of an answer to these questions can be made by listing some of the insights gained from my brief review of writings in our field.

- The problems of life related to the changes made by man in the forms of materials to increase their values. (Bonser & Mossman, 1923)

- "The social purpose in the study of the industrial workers and their work is realized in the measure that this study helps us to be intelligent and sympathetic in the regulation of the conditions of production so that employers, employees, and consumers shall all receive complete fairness and justice in the production or use of products."(Bonser & Mossman, 1923, p. 12)
- "…desirable social relationships, such as cooperation, tolerance, leadership and followership, and tact." (Wilber, 1954, p. 43)
- "…a feeling of belonging to and being accepted by a group and the need for a feeling of success." (Wilber, 1954, p. 25)
- "Discovery, development of self, with its release and realization through experience, expression, and achievement with materials, tools, machines, and ideas within an environment which is both technological and social." (Olson, 1973)
- "If society influences technology, then people should be able to influence or control the course and direction of innovation." (Johnson, 1993, p. 10)
- "Technology can serve as a great multiplier of social change, sometimes in new or unexpected ways." (Johnson, 1993, p. 11)
- "One significant aspect of a high-technology world is that the great benefits brought about by modern sociotechnical systems also carry risks." (Johnson, 1993, p. 11)
- "One of the goals of Technology Education is technological literacy of a broad and encompassing nature. Technological literacy in the context of this presentation is that understanding of technology – its evolution, its utilization and its significance – which would enable the individual to function effectively as a citizen as well as in those specialized roles that one plays in a given society." (ITEA, 1988, p.13)

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“No One Forgets a Good Teacher!” - What Do ‘Good’ Technology Teachers Know and How Does What They Know Impact on Pupil Learning?

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Abstract

How significant is content or subject knowledge for creative and effective teaching? What links can be made between a teacher’s knowledge and the associated pedagogic strategies and practices to ensure successful learning? Does the phrase ‘the best way to learn is to teach’ really underpin the teaching role?

These questions illustrate a theme in teacher education that is increasingly catching the attention of policy makers. In England and Wales, for example, secondary teachers are required to have at least two years of their first degree in the subject they wish to teach. Yet Technology is well known for the breadth of subject knowledge it encompasses and the limited way in which degree courses provide for the scope needed for school technology. Is subject knowledge, often the driver of both pre-service and in-service course design for technology teachers, really so crucial?

This paper reports on an empirical study conducted with technology initial teacher education students from the Open University and Brunel University in the United Kingdom. The teacher knowledge possessed by these students in terms of subject knowledge, pedagogical knowledge and ‘school’ knowledge (see Banks 1997a, PATT-8) is classified and the relative impact of such knowledge on pupil learning is discussed.

Introduction

“It’s quite a challenge making fractional distillation more interesting than sex” and “No one forgets a good teacher” are two examples of advertising slogans which have appeared in the press since 1993 trying to persuade people to enter the teaching profession, especially those with qualifications and experience in Technology. In early December 1998 the UK Minister of Education, David Blunkett, announced that he was introducing a new deal for teachers:

> “I’m going to teach them my three R’s. [...] To recruit, to retain and to reward high performance” [...] At the heart of the proposals is the introduction of a Civil Service style fast track for top graduates, guaranteeing them a rapid route to promotion and higher rates of classroom pay. (Bright and Wintour, 1998)

The link between a ‘good degree’ and being a ‘good teacher’ is taken by the minister as axiomatic. Degrees from Universities in the UK are usually classified into six levels the top two being ‘good’. The Teacher Training Agency (TTA) in England has established the criterion of the number of students on a post-graduate initial teacher training course who hold such a ‘good’ class of degree as worthy of being published in tables of success. But how significant is content or subject knowledge for creative and effective teaching? What links can be made between a teacher’s knowledge and the associated pedagogic strategies and practices to ensure successful learning? There are, after all, very few degree subjects that match neatly the subject knowledge and skills base needed for school technology. How can we help new teachers to conceptualise these relationships and reflect on how different sorts of ‘teacher knowledge’ impact on their teaching?

> 'The 1991 national survey of all 317 initial teacher education courses in England and Wales […] revealed that over 70 per cent of those courses that claimed to be under-pinned by a particular philosophy described that as being based on the principles of the reflective practitioner. […] Five years on, the term has achieved even wider currency, and the notion of reflectivity has become incorporated into many teachers' own view of what it means to be a professional' (Furlong and Maynard, 1995 p37)

There is little agreement, however, about what is meant by 'reflective practice' and Calderhead (1989) has described the notion as a slogan rather than a principle. We would agree with McIntyre (1993) that often a systematic approach to reflection is of limited value in the earliest stages of professional development where students have neither the time nor the breadth of experience to do more than experiment with the approach. However, we would strongly argue that such experimentation with reflection on practice would be more successful if the student is provided with a usable framework that will help them consider aspects of their professional knowledge in the widest sense.

It was with a view to discover the impact of an enhanced awareness of teacher professional knowledge on school technology teaching and learning that a joint project was established between the Open University and Brunel University. Both universities offer initial teacher education courses enabling the student teachers to teach school pupils aged 11 to 18 years. These student teachers were provided with a framework for analysis of their teacher professional knowledge. We report here how these technology student teachers used the framework and came to think through the implications of their understanding of the teacher role.

A Framework for conceptualising teacher professional knowledge

In this study of the self-awareness of teacher knowledge in pre-service technology student-teachers, we drew on the work of our colleagues in the Centre for Research and Development in Teacher Education (CReTE) at the Open University (see Leach and Banks, 1996; Moon and Banks, 1996; Banks, 1997a; Banks, Leach and Moon, 1999). By linking together four clusters of ideas they have produced a graphical framework which is helpful in visualising the different aspects of teacher knowledge. The ideas were: the curriculum oriented work of Shulman (1986); the cognitive approach of Gardner (1983, 1991) and the interrelated tradition of didactics and pedagogy in continental Europe (Verret, 1975, Chevellard, 1991). They also considered how the community of practice of schools influences a teacher's professional development and draw on ideas of situated learning developed by Lave (1988, 1991). The outcome of this work was a pictorial model of teacher professional knowledge (fig 1).

One might initially see 'school knowledge' as being intermediary between subject knowledge (knowledge of technology as practised by different types of technologists for example) and pedagogical knowledge as used by teachers ('the most powerful analogies, illustrations, examples, explanations and demonstrations '). This would be to underplay the dynamic relationship between the categories of knowledge implied by the diagram. For example, a teacher's subject knowledge is enhanced by his or her own pedagogy in practice and by the resources which form part of their school knowledge. Which teacher has not confessed to only really understanding a topic when they were required to teach it to others! It is the active intersection of subject knowledge, school knowledge and pedagogical knowledge that brings teacher professional knowledge into being.

Lying at the heart of this dynamic process are the ‘personal constructs’ of teacher and pupils, a complex amalgam of past knowledge, experiences of learning, a personal view of what constitutes ‘good’ teaching and belief in the purposes of the subject. This all underpins a teacher’s professional knowledge. This is as true for any teacher. A student teacher has to question his or her personal beliefs about their subject as they work out a rationale for their classroom behaviours.

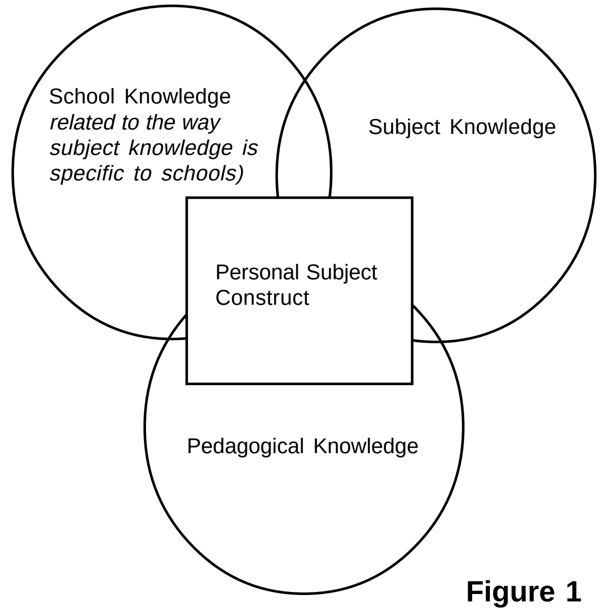

Figure 1

The diagram has some similarities with the developmental model of ‘pedagogical content knowing’ proposed by Cochran, DeRutter and King (1993), but is simpler in form. Since the mid 1980s there has been a growing body of research into the complex relationship between subject knowledge and pedagogy (Shulman and Sykes 1986; Shulman 1986, 1987; MacNamara 1991). Shulman’s original work in this field has been an obvious starting point:

> “how does the successful college student transform his or her expertise into the subject matter form that high school students can comprehend?” (Shulman 1986)

Like Cochran, DeRutter and King (1993), but from our perspective of technology teaching, we are critical of Shulman’s apparent emphasis on professional knowledge as a static body of content, lodged in the mind of the teacher. Pedagogical content knowledge thus defines the subject specialists’ task as that of discovering:

> “the most useful forms of analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject” in order to make it “comprehensible to others.” (Shulman, 1986, p.6).

As such Shulman’s work tends to devalue skills and processes, leaning towards a view of cognition that sees knowledge as an external body of information, assuming an essentially teacher centred pedagogy:

> “The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he/she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students” (Shulman, 1987, p.15)

Paramount amongst school subjects, technology is characterised by a pedagogy where there is no ‘right answer’ but rather different responses to the same problem are valued - some judged better than others. Compared with other subjects such as science and mathematics, perhaps a teacher of technology is less in a position of being a ‘fount of all wisdom’ but rather a guide to help a pupil to (as Barlex would put it) ‘Design what they Make and Make what they have Designed’. This is not to deny the important role for subject knowledge in Technology, nor to suggest that the teacher is not an important source of information, but the teacher’s knowledge and expertise need not be a brake on the speed or direction of the pupils’ development or creativity. For example, in electronics a pupil can treat an amplifier as a ‘system element’ without knowing or needing to know the details of the physics of its operation. Similarly a pupil can make artefacts using a polymer without needing to know much more than the underlying concept of giant molecules and the interaction between the chains. However, that pupil may indeed need to know more sophisticated ideas about amplification or plastics as their interest in their design problems develop. A teacher who is able to engage them in a conversation at an appropriate level will be better able to match the curriculum to the pupil.

In contrast to Shulman, Gardner's (1983) work is rooted in a fundamental reconceptualisation of knowledge and intelligence. His theory of multiple intelligences allows us to view pedagogy from a perspective on student understanding. In common with the ethos of School Technology, the focus shifts from teacher to learner, from technique to purpose. The five "entry points" which Gardner proposes for approaching any key concept - narrational, logical-quantitative, foundational, experiential and aesthetic - do not simply represent a rich and varied way of mediating a subject. Rather they emphasise the *process* of pedagogy and a practice which seeks to promote the "highest level of understanding possible" (Gardner 1991).

Gardner's work is central in shaking cognitive development free of a static, innate view of intelligence, and this is central to an endeavour to challenge widely held notions of ability as a fixed, unchanging concept.

School technology is different to technology as conducted in universities or in industry. The concept of "didactic transposition", a process by which "subject knowledge" is transformed into "school knowledge", enables us to consider the way that schools as institutions construct their own sort of knowledge. Ideas here have been informed by the work of Verret (1975) and Chevellard (1991).

Finally, Lave's (1988; 1991) research with adult learners engaged in new learning situations focuses on the social situation or "participation" framework in which such learning takes place, a process of involvement in 'communities of practice'. To become a full member of a "community of practice" requires access to a wide range of ongoing activity, old-timers, and other members of the community; and to information, resources and opportunities for participation in communities of practice. (Lave and Wenger 1991 p.101)

Lave's work is of particular significance for school technology because the community of technology teachers is having to cope with major changes in the subject that it is teaching. The difficulties experienced by teachers can to some extent be gauged by looking at the range of publications produced between 1989 and 1995 aimed at clarifying the situation for the teacher. These included a complete revision of the National Curriculum Orders for Design and Technology (D&T) (See Barlex 1998). One of the aims of the D&T curriculum in England and Wales is to provide a broad and balanced experience of designing and making using a range of materials and technical components.

> Pupils should be given opportunities to develop their design & technology capability through:
>
> a) Assignments in which they design and make products, focussing on different contexts and materials and making use of:
> - Resistant materials;
> - Compliant materials and/or food.
>
> Taken together, these assignments should include work with control systems, eg electrical, electronic, mechanical, pneumatic, and structures;
>
> b) focused practical tasks in which they develop and practise particular skills and knowledge;

c) activities in which they investigate, disassemble and evaluate familiar products and applications. (DFE/WO,1995, p6)

However, there is more to this breadth and balance than merely the materials and components used (See Barlex, 1995). Within the designing and making process there are features which will appeal to different degrees to a teacher according to the specialism and professional history of that teacher. Teachers will have greater familiarity with and preference for particular areas. The list below identifies such features and the often-articulated rationale for its significance. The difficulty in achieving breadth and balance arises when that significance becomes instead dominance:

· Aesthetics	The appearance is crucial. It says everything about the product.
· Communicating skills	Unless they communicate their ideas nothing will be accomplished.
· Design procedures	Without the procedural competence of design nothing can be achieved.
· Making skills	But if they can't make it it's a complete waste of time.
· Technical understanding	If it's not technically sound it just won't work.
· Values	Without an appreciation of the values implicit in the endeavour the whole exercise lacks worth

See Fig 2 'Developing a balanced approach'

Ideally a balanced designing and making assignment will call on each of these features if not in equal measure then certainly to a significant extent. But, if a teacher is strong in just one or two aspects, or believes that one is more significant than any of the others, the breadth and balance within the designing and making experience is lost. Many technology teachers were trained initially as craft teachers and their work has been generally criticised by the Office for Standards in Education (OFSTED).

> ". . . .in general pupils' attainment in designing lags behind that in making. This is because pupils are either not introduced to a sufficiently wide range of designing strategies [...] or are not taught to use them effectively. Pupils are generally confident where work is closely directed by the teacher, but less so when working independently to their own plans, with little awareness of how their work will develop in the later stages of their projects." (OFSTED, 1998)

Clearly there is the possibility, if not probability, that student teachers in school based training will be introduced to practice that is skewed because of the previous history of the supporting teachers in that school. So the school knowledge (see fig 1) developed by participation in the community of practice of the school may be at variance with what is considered to be best practice by the college. Important here is not merely the obvious point that school experience is vital for student-teachers but that learning is hampered if the meaning of the activities of teachers (in this case) is not made 'transparent'.

This study was conducted as an attempt to evaluate how transparent different aspects of teacher professional knowledge was to student technology teachers and to see how useful the framework was as a tool to help them reflect.

Methodology

Thirteen technology student teachers in the final year of their course from the Brunel University and the Open University were interviewed and shown a blank outline of the CReTE framework (Fig 1). The different elements of the framework were explained to them and, in relation to the work on teaching placement, they were asked the following:

- What subject knowledge (about D&T) do I have/need to get for the teaching?
- What pedagogic knowledge (about teaching methods) do I have/need to get for the teaching?
- What school knowledge (about ethos, procedures, significance of some activities) do I have/need to get for the teaching?

The students were also asked to consider their 'personal subject construct' as outlined above.

The Open University student teachers gave their views verbally and their points were noted onto the blank diagrams. The students from Brunel University were asked to produce a short piece of writing 'in which you reflect on some teaching that you did in your last practice in which you can comment on each of the three features'.

Results

As might be expected, the students used the framework with a range of levels of sophistication. For all students it provided a useful focus for debate, and in particular the nature and extent of school knowledge was discussed by the Brunel students using figure 2. The views of seven students who either contributed a piece of writing or made significant comments are included here.

School knowledge

First, some ideas about 'school knowledge':

James: It is important that I discover the expectations within the department [...] This may be as pedantic as the layout of work, something I perhaps may not entirely agree with, but [...] something they gain marks for after I have left, then they will be required to be familiar with it. My own teaching can then work around this.

Frank: After a few weeks within the department I noticed that the department ethos, or approach to teaching was the same across the board. [...] The projects from year 7 upward were very closed in nature and pupils were led by the hand through each assignment. This resulted in the pupils producing an end product identical to everyone else. I must admit it was to a high standard and I learned a lot about subject knowledge, especially in the area of woodwork practices and processes. It seemed to me that the department was setting Design and Make assignments that were in fact Focused Practical Tasks.

Karen: After working in [...] it is very easy to figure out what the subject teachers are like and the commitment to the school and pupils. The following points are things to look out for in the next school.

Karen goes on to list 23 bullet points. All but two we would classify as 'school knowledge'. She 'looks out' for wall displays, exam results, attitudes of the pupils and teachers, schemes of work and a range of school polices such as SEN, homework and detention.

Christopher: In school you have to work in a particular way. For example the control software package configures the way I have to work and the pupils have to think because that is recommended by the exam board.

Vincent: In this school the department is driven by the exam. That is all that is important. So I think technology here is too individualistic where industry is social.

Subject knowledge

All the students could identify subject knowledge gaps that they had. Indeed the rectification of technology subject gaps is a pre-occupation on many teacher preparation courses at all levels (see Banks 1997b) The Open University students in the sample were working as school technicians and felt relatively confident:

Colin: There is no 'big hole' in my knowledge due to being a technician but sometimes I forget the 'easy stuff'!

Competence in 'Graphics' was a declared problem for three of the students. Two of them said that they lacked sufficient knowledge of electronics for more than basic work.

Frank: I knew I was lacking in some of the graphics subject knowledge, so I spent a great deal of time and effort getting up to scratch on them.

Pedagogical knowledge

Vincent and Christopher had a clear view of how the pupils' enthusiasm for technology and the quality of their work was intimately bound up with the teaching strategies deployed.

Vincent: Pupils take their cue from the teacher. There is a lot of 'street cred' for the subject in this school – more so than Art – but it is just as creative. However, there is very little group discussion used.

Frank: During my last school practice I worked with a Year 10 Graphics group. I found this group to be very passive and generally switched off to the subject. [...]. There was a lack of imagination being demonstrated in their work, which I felt, was coming from the way the subject was being presented to them. [...] I introduced group-work, which they had not experienced in D&T and let them give their opinions. We explored ways we could use these skills in presenting what we wanted to say in graphics. [...] The pupils responded very well and produced many varied and imaginative results. In addition [...], I set a competition to produce a graphic image. This was very open, with the only criteria being that it was interesting to the eye or not as the case may be. This really was difficult for the pupils to take on board initially, as they wanted to know what I wanted as a result. In the end they produced a very good series of images, some 3D, some computerised, some with alternative backgrounds. The approach to teaching in a different way from chalk and talk seemed to awaken this group of pupils.

Khan: I felt that the pupils required a change of task setting and a more 3D approach to graphics. [...] I allocated time for the pupils to create prototypes or models from cardboard of the designs they had generated and present their museum designs, through their graphics based work and models to a board of directors (the rest of the class) therefore relating the project to real life contexts of designing in society. I left the presentation styles up to the individual pupils but did incorporate some input [...] on presentation techniques using computer graphics and boards. It was expected that the pupils would give a 2-3 min presentation. The end result was a positive change of all the attitudes of the pupils. They exhibited a general willingness to learn and an interest not only in their own work but others, especially the presentation where the pupils generated constructive criticism and reacted well to others discussing their work.

Personal subject construct

The nature and quality of the answers showed the range of personal subject constructs held by the student teachers and they often mentioned how it conflicted with construct held by their school mentor or other people in the school technology department. Vincent, like Kahn in the quote above, saw technology as being closely linked to ‘real-life’ and vocational preparation. Christopher, in contrast, saw technology as empowering for the pupils. They should understand ‘how to wire a plug and not be scared to do things’. He wanted pupils to ‘have a go’.

Conclusion

Although the extent of this study is limited in the number of students who took part, it is significant in that the students across two quite separate institutions, with students from very different parts of the UK, could identify with the concepts outlined in the CReTE framework. It is clear from the above extracts and examples that they could use the categories as a means to reflect on their practice. The investigators could, in turn, use the diagram as a way to group aspects of teacher knowledge when the students described both their own practice and that of their colleagues in school. The framework has been used at a number of in-service events throughout the UK and in other countries and many teachers have also been sympathetic to the model and how it matches on to aspects of their real-life practice.

Moreover, the sophistication of response shown by some seems to match well to those who are developing into effective teachers. Frank showed a deep insight into a number of aspects of teacher knowledge and was able to bring such awareness into developing his teaching. Karen, interestingly, was also thought to be an effective teacher and was given employment by her placement school. Her awareness was almost exclusively in the area of ‘school knowledge’. So is a ‘good’ teacher one who is seen to be good at what schools find important? In the case of both Karen and James, they were able to be self-aware of the community of practice of technology teachers that created the local ‘school knowledge’ that surrounded them and, to some extent, subvert it. As James put it, ‘My own teaching can then work around this’.

The positive impact on pupil learning in technology due to student teachers that are better able to reflect on their practice seems clear from the extracts presented here. As McIntyre (1993) suggests, reflection by novice teachers is very difficult. However, we believe that this study has shown the framework is a simple yet effective ‘way in’ to begin the discussion of the different aspects of teacher knowledge. Indeed, the discussion of the model will itself promote an insight into the various aspects that contribute to the professional role of an effective technology teacher.

Developing a balanced approach

Some teachers are committed to a particular feature of capability as the most important in developing designer maker capability in their pupils. Here is a typical set of opinions

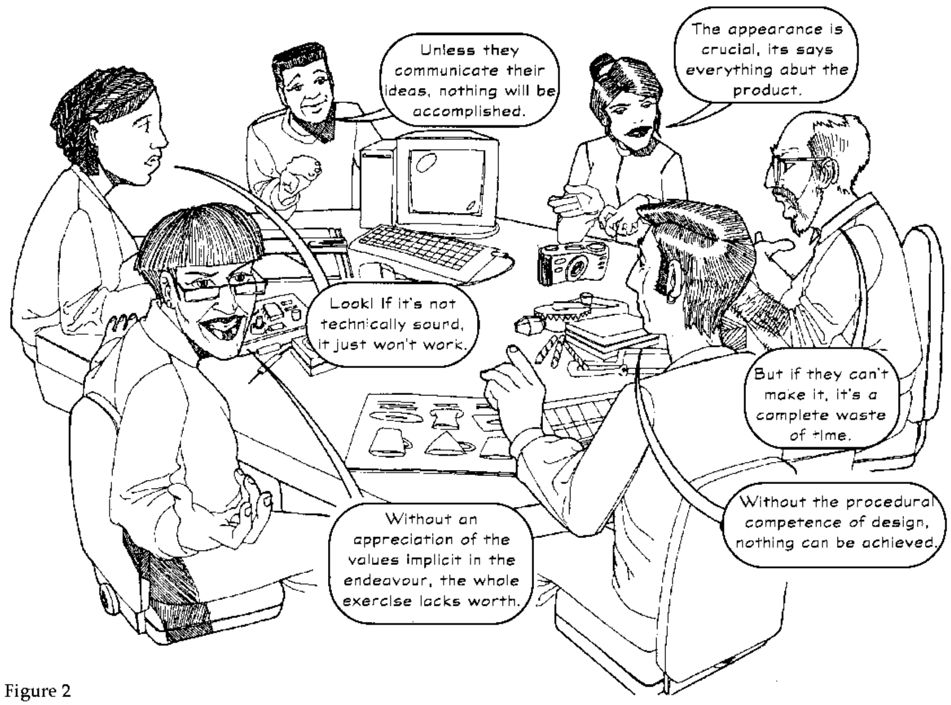

Figure 2

In reality of course, if any of these features is missing or minimised in the teaching, then the pupil is unlikely to develop the knowledge, understanding, skills and attitudes necessary for designer maker capability. Try to predict the consequences of minimising or missing out one or two features.

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Technology Education: The Empirical Evidence

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It is with considerable pleasure that I was able to accept the PATT Foundation's invitation to deliver this opening address to the 1999 conference. I have many pleasant memories associated with PATT. My first international experience was a trip to the 1991 PATT conference in Eindhoven, the Netherlands. At that conference, I was privileged to meet Jan Raat, Marc de Vries, Ilja Mottier, and many other technology education colleagues from around the world. This experience has had a significant impact on my career. Through the experiences of that initial conference as well as subsequent international meetings and experiences, I have developed a profound appreciation of how important it is that professional colleagues from around the world be in dialogue with one another. We have much in common. Many of the issues that we face in the U.S. with technology education are the same as those being addressed around the world. Of course, there are important differences around the world as well. Colleagues in different locations approach the study of technology in unique and intriguing ways. It is vitally important that we continue to engage one another, because we all have much to learn. The PATT foundation has played an important role in facilitating this communication and collaboration on an international scale over the years through a regular series of conferences. The profession owes its leadership a profound debt of gratitude.

Converging Factors

As we move into the 21st century, several factors are converging that are having a important influence on how we think about society, technology and their interaction with one another. Collectively, these influences converge to form an ideology (a context) within which education about technology must be cast if it is to be effective and meet the needs of society. I will present and discuss four of these.

Unprecedented growth of technology

The first of these factors is the unprecedented growth of technology. Technological innovation over the past century has far exceeded what occurred virtually since the dawn of time. In the span of a single lifetime, many of our grandparents went from horses to space exploration. This past century has included the development of mass production, routine automobile and air travel, enormous advances in the diagnosis and treatment of disease, rural electrification, global telecommunications, and explosive growth of the computer industry.

Several observations can be made about these changes. First, technology has become ubiquitous. It is an integral part of transportation, entertainment, and communication systems. Entertainment, communications, building, and sanitation technologies have fundamentally changed the nature of homes around the world. It is woven into hospitals and farms, schools and businesses. On a macro scale, computer technologies have triggered an unprecedented flow of information around the world. On a micro scale, the entire human genome will be mapped by 2002 and microelectronic circuits continue to shrink in size.

A second factor has to do with the rapid *pace* of technological expansion. When the technologies that were developed at the turn of the last century are compared with those that have occurred in the past 20 years, the difference is dramatic. For example, whereas automotive technology moved through a series of refinements during much of the first half of the century, most of the change was largely incremental. By contrast, nothing in the history of technology can compare with the explosive growth of the computer industry that has occurred during the past 20 years or the internet, which emerged from relative obscurity five years ago to an important and increasingly mature technology today. Given the escalating pace of technological change, it is virtually impossible to anticipate the forms technology will take, even as little as ten years into the future.

It is clear. Technology is increasingly becoming one of the most important factors affecting societies and individuals around the world, and this trend will almost certainly continue. It is becoming increasingly important that we as technology educators provide students with the tools they need to use these technologies. Just as important, citizens need to be sensitized to how technology is affecting their society and culture, both positively and negatively.

Linking of Idea of Progress with Science and Technology

A second factor affecting our worldview has to do with ideology, specifically, with the idea of progress. In the U.S., the idea of progress has evolved in some interesting ways throughout our relatively short history, reflecting a blend of political ideals and technological growth (Nisbet, 1980). Many assume that the concept of progress in America (and much of the West) is grounded in Marx's technocratic notions, having to do with the inevitable expansion and growth of industrialization. Or, that it grew out of boundless enthusiasm and optimism for exciting new knowledge and "contraptions" that flowed out scientist's labs and technologists' invention shops, particularly at the turn of the 20th century.

In reality, the historical record indicates that something very different actually occurred. The ideology of progress in the West had a very different grounding and origin. There was indeed optimism. But the focus of this "new world" optimism had very little, if anything, to do with science, technology, or machines. Rather, the emphasis was on virtue, quality of life and the betterment of the human condition. In America, the ideology of progress took form as the Jeffersonian Ideal – A New Republic. The driving forces were political liberation and personal and social virtue. There was tremendous hope that the growth in human knowledge would improve the common social good. As Studenmaier (1989) notes, "Jefferson actively resisted the early industrialization of the colonies, asserting that factories, industry, smokestacks and all would be better left in the Old World and then shipped to the New."

During the early years of the new republic, it is very clear that the ideology of progress had little to do with science and technology. Rather, it was about human betterment, wisdom, quality of life, and personal and social liberation. During the ensuing 200 years, however, the emphasis on progress has shifted dramatically, with the growth of scientific knowledge and the expansion of industrial capitalism. By the turn of the 20th century, with the flurry of technological invention that generated the automobile, the moving assembly line, interchangeable parts, the railroads, and airplanes, the concept of progress had been almost totally recast. The ideology of progress shifted away from wisdom and social progress and became firmly linked to science and technology. During this century in America, the idea has been tempered by two world wars, conflicts in Korea, Vietnam, technology-induced problems with environmental pollution, and political strife including Watergate, the civil rights movement, and the impeachment of a president. While these factors have served to mature and refine the ideology of progress, a solid thread of confidence in the future persists. Now, at the threshold of a new century, it is clear that science, technology and the ideology of progress remain very closely linked to one another.

Enormous communication gap about meaning of term "Technology"

Another factor that is particularly problematic for technology educators has to do with how technology is defined. Ask the average person on the streets of any city or town in America, or I suspect Amsterdam, Frankfurt, Paris, Capetown, or Bejing "What is technology?" and the response will be predictable. Most people will respond, "computers!" This perception persists in the popular press. When the media reports activity for technology stocks, it is not thinking about new ways of performing surgery, or new landing gear technology for airplanes, or new composite materials for bicycles. The meaning of technology is usually something closely related to computers.

When we as technology educators use the term technology, the unfortunate fact is that most of the world thinks we are talking about something else. Too often the response by well intentioned school officials to the assertion that "technology must be included in the curriculum" is "I couldn't agree more. Everyone should know how to use computers!" This misunderstanding of terms is posing serious problems as technology educators attempt to generate support for including the study of technology as a vital component of school curricula.

Low Technological Literacy

We are living in a time when sophisticated, smart technologies have been placed into the hands of people who understand very little about how they work. Most people know very little about the technology they depend on heavily. The average citizen has very little idea how an automobile, the phone system, a microwave oven, their home's electrical system, or water treatment utilities work. This situation is further exacerbated by the fact that so many of the technologies that used to be mechanical are now chemical and electronic. With mechanical devices, direct cause and effect can be observed. Such is not the case with chemical and electronic devices. The net effect is that many of the technologies have become invisible to the naked eye and therefore extend beyond the logical capacities of the general public.

The growing complexity of technological devices has created a situation where technological knowledge increasingly is becoming vested in a relatively small group of experts (an elite), comprised of brilliant engineers and scientists who develop machines designed to be so smart that the “workings” can go on in the background…without a need to know how the technology works. Just turn the key, hit the switch, push a lever, or turn the knob, and it works, reliably and without fail!

There are, of course, serious problems with having specialized knowledge vested in a small fraction of the citizenry. For example, I am Chair of a Department that uses many diverse kinds of technologies (CNC, CAD systems, robots, PLCs, electronics, sophisticated printing equipment, and more). The department also has its own computer network with a full time network manager. So we spend significant amounts of money on a variety of technologies. In my position, I must regularly make decisions about what to fund and what not to fund. I frequently find myself in a position where I lack the in-depth knowledge needed to make fully informed decisions. As a result, I must depend on others who have specific technical expertise. There are two such individuals on my faculty who do have this expertise, particularly in the computing area. Because of the knowledge these two people possess, they wield tremendous power in the Department and are in a position to have a major influence on important financial decisions. These two people have more influence than the rest of the faculty, a situation that they do not abuse. But it is very important that their influence and guidance be balanced against the need to maintain open communication across the faculty and involve as many of the faculty as possible in decision-making.

On a much grander scale, this same dynamic is occurring around the world. The “intelligence” is moving into the machine and is vested in an elite group of individuals. This has serious implications for democracy, because increasingly decisions that affect entire communities and even countries are being made by a handful of individuals with high levels of technical expertise. Even if all of these individuals were judged to be well meaning and invested in doing what is best for the public good, the implications are still serious. A fundamental precept of democracy is that citizens are knowledgeable and informed participants in the decision making process. Given this fundamental value, there is something about a large-scale ignorance about how technology works on the part of the average citizen that should concern and maybe even frighten us all. Decisions about the development and use of technology should extend far beyond the value systems of sub-sectors of a society (e.g., scientists, engineers, technicians, etc.). It is very important that the perspectives and values of the full spectrum of the global community be represented and included.

So, we as technology educators find ourselves at the center of this convergence of factors: an unprecedented growth of technology, a close association of progress with science and technology, serious confusion about the meaning of the term technology, and alarmingly low technological literacy among the world’s citizens. This mixture of factors raises some important questions. How much does the average citizen need to know about technology? What will happen to the foundations of civilization if high percentages of a population are ignorant about technology? How much of what needs to be known can and should be taught in schools? Who should be responsible for providing this education; technology educators, scientists, social scientists, others? What should the content base for such a curriculum include and how should it be delivered?

Technology Education: The Evidence

The question that I was asked to address in preparation for this conference had to do with empirical evidence. Specifically, the request was to present and describe the empirical evidence indicating that technology education either is, or is not making a difference. What evidence is there to suggest that technology education, as it is being delivered in its various forms around the world, is yielding something of positive value for students and, if so, what is that “value added”?

Those of us who teach technology know intuitively that certain students seem to learn better when they are actively engaged in doing something with their hands. Learning style and cognitive science research indicates that many students remember information better when it is reinforced by authentic applications and experiences rather than by simply manipulating ideas in the abstract. On a more intuitive level, we know that experiences with technology enable many students to be able to transfer and integrate learning between subjects. We know these kinds of things at an intuitive level…but I suspect (and would be pleasantly surprised if I were proved wrong) that we would be hard pressed if we had to present hard, empirical evidence, that technology education makes a difference.

So, what is the value of technology education? Several years ago, I worked for a year as a Program Officer at the National Science Foundation in Washington, DC. This experience provided an opportunity for exposure to the views of top scientists and engineers as well as to the larger federal policy-making community. What I discovered was that there is tremendous interest in technology education, particularly related to its potential for assisting the mathematics and science communities in delivering inquiry-based curricula. There is also great interest in the perceived value of technology education as a tool to integrate learning across academic disciplines. I also discovered that the policy-making community, in various ways, is asking for empirical evidence that federal dollars that are being directed toward educational improvement are making a difference.

Technology educators need to move beyond rhetoric to research. It is vitally important that technology educators be prepared to provide research-based evidence of the value of technology education if we are to have a future in the schools around the world. Rhetoric will only go so far. Technology educators are competing for valuable resources, time, and prestige with other school subjects that have a long history in the schools. Most educators know and understand (at least they think they do) mathematics, science, language arts, political science, psychology and other subjects. But many do not understand – or value – the study of technology. The need for solid, compelling evidence is critical.

Funded Projects

In spite of the minimal amount of empirical evidence supporting the value of technology education, there are some very positive pockets of activity that are occurring here in the U.S. that merit comment. These are in the form of funded projects. I will briefly describe three of these.

CeMaST. The Center for Mathematics, Science, and Technology (CeMaST) at Illinois State University has, over most of the past decade and through funding by the National Science Foundation, developed integrated mathematics, science, and technology curricula for middle school education. The leadership of the Center has invested significant effort into developing mechanisms (including professional development for teachers) for integrating content across the three academic areas. The project has conducted preliminary research (using TIMSS -Third International Mathematics and Science Study) and found that U.S. students performed significantly better using CeMaST's integrated materials than U.S. students who had used traditional, subject- specific materials. To be clear, this research was not specifically designed to analyze the impact of technology education on student performance. Rather the study indicates that this particular integrated curriculum is generating significant differences in student performance in mathematics and science achievement.

Project UPDATE. A second example of a major funded project is *Project UPDATE*, an elementary level technology education curriculum development and teacher enhancement effort, led by Dr. Ronald Todd at the College of New Jersey. The primary purpose of the teacher enhancement component of the project is to help elementary level teachers learn how to use design and engineering activities and concepts to teach children about a variety of school subjects. Through the project, a series of summer workshops and subsequent graduate courses have been delivered to help teachers learn how to teach in new and innovative ways using *UPDATE* and other design and technology oriented curriculum materials. Elementary level teachers are learning how to draw, conduct experiments with electric motors, configure basic mechanical devices and much more. Furthermore, they are learning how to use these techniques to enhance the delivery of many subjects and topics across the curriculum.

One of the constraints increasingly being placed by NSF on funded projects (especially Teacher Enhancement projects) is to demonstrate impact on students. The *UPDATE* project is currently at the point of implementation where sufficient activity has occurred to merit student impact research. Preliminary, qualitative data indicate that the design and technology approach is working (i.e., student enthusiasm, absentee data, teacher competence and interest, etc.). Additional, more formal research is being planned.

Learning by Design - Georgia Tech. A third example is the middle school based *Learning by Design* project at Georgia Tech, under the direction of Janet Kolodner. This project is a standards-based curriculum development project using a design based approach to learning science and technology concepts. In the curriculum, students alternate between design, construction, testing, and inquiry and reflective activities to help them learn a variety of concepts.

According to the project's leadership, preliminary research indicates that students appear to be more inclined to "think things through before jumping into them and we think we're seeing development of communication and collaboration skills, but the evidence is neither completely gathered yet nor completely analyzed" (J. K. Kolodner, personal communication, March 1999). A related finding is particularly encouraging. "One thing we did find is that after our design activities, girls bring up their science understanding to be even with boys', when before the activities, their understanding was significantly lower (the boys' understanding goes up too)" (J. K. Kolodner, personal communication, March 1999).

Public Policy Activity

A second response to the question of the impact of technology education in the U.S. can be found in the area of public policy. While this issue is something distinctly different from what technology education is doing for students, it addresses directly the question of the effectiveness and visibility of the field in the political policy making arena at the national level. Some very important activity is occurring here in the U.S.

National Science Foundation. Technology education has captured the attention of the National Science Foundation, which is a major and prestigious funding agency in the U.S. The Foundation has historically funded both basic and educational research. Prior to this decade, the resources directed toward educational programs were primarily for mathematics, science, and engineering. During the 90s, largely due to the advocacy of Gerhard Salinger (NSF Program Officer), the value of technology education was recognized at the Foundation. This recognition took the form of funding of technology education projects and the hiring of a succession of program officers from the technology education field to work at the foundation. Technology education's presence continues and is contributing significantly to helping educators explore new and creative ways of teaching inquiry-based and integrated technology, science, and mathematics.

Technology Standards. One of the most important activities in the history of the technology education field is the *Technology for All Americans* standards project, administered by the International Technology Education Association and directed by Dr. William Dugger. Jointly funded by NSF and the National Aeronautics and Space Administration (NASA), the standards will parallel the *National Science Education Standards* (1995), the *Benchmarks for Science Literacy* (1993), and the *Curriculum and Evaluation Standards for School Mathematics* (1989). The technology education standards, scheduled for release in early 2000, will clarify the content for the field from K-12. This effort represents a major step in the transition from industrial arts to technology education. The *Standards* will also further solidify the importance of the study of technology as a key component of general education for all students. Parenthetically, it is significant to note that the *Benchmarks* and *Science Education Standards* both contain significant sections on the study of technology. This inclusion of technology content in science standards did not occur by accident. Rather, it represents yet one more positive outcome of top level collaboration among science, mathematics, and technology education leaders.

National Research Council. Technology education is involved in the work of the National Research Council (NRC). The NRC is a highly respected agency that conducts science, engineering, and mathematics research, much of which is for the U.S. Federal government. The NRC represents the "working wing" of the National Academy of Engineering, the National Academy of Sciences, and the National Institute of Medicine (all honorific societies). Examples of notable studies include a study of the effects of Agent Orange in Vietnam and the cause of the Challenger space shuttle accident. Each year, more than 500 committees involving 5,700 individuals seek solutions to problems embracing virtually every aspect of society. Technology educators are currently involved in several research projects on various topics at the NRC, representing a significant level of involvement, unprecedented in the history of the profession. Two of these projects are particularly important for the profession. One is a project to conduct a review of the draft Technology for All Americans Standards. A NRC committee, comprised of science, engineering, and technology educators, has been convened to conduct this review and make recommendations. At stake is the potential endorsement of the NRC, which if obtained, would serve to enhance the credibility and importance of technology education within the larger educational community. A second major project, being conducted through the National Academy of Engineering at the NRC also will have a significant impact on technology education. This project, entitled M*aking the Case for Technological Literacy*, is exploring the implications of wide spread ignorance about technology and will make recommendations for how to infuse the study of technology into the educational systems across America. Technology Education will benefit substantially from these two projects. More important, the fact that technology education is, in various ways, on the agenda of the NRC is a clear indication that technology education is perceived, by members of the country's top research community, to be making a difference in the schools.

Based on the preliminary research regarding the impact of technology education in the schools and technology education's significant level of involvement in the political policy making arena, we can be justified in stating that technology education is indeed making a difference. Furthermore, given the potential impact of the *Standards*, the growing visibility and influence of the profession in Washington, and the major changes that are occurring around the country at the grass roots level, it is very likely that this impact will be sustained well into the 21st century. Technology education is currently experiencing one of the most significant windows of opportunity in the history of the profession!

Challenges

Based on these perspectives and comments, I would like to close by making some concrete recommendations related to how the technology education profession can and should capitalize on the many positive events that are occurring at this juncture in time. Let me first say that it is important to carefully embed these recommendations in the context described at the beginning of this speech. Specifically, it is vitally important that, during a dramatic period of technological growth, we also find ourselves surrounded by an alarming ignorance about technology as well as confusion about the meaning of the term. Against this background and from my perspective as a technology teacher educator, I see the challenges to be as follows:

Standards-based Curriculum, and Professional Development

One of the most important outcomes of the *Standards* project will be a clarification of and vision for the content of the technology education profession, grades K-12. But this represents only a beginning. Subsequent to content clarification will come the challenges associated with developing standards-based curriculum materials and engaging teachers in professional development. Teaching methods will change, as will laboratories and equipment. Undoubtedly, this will assume a variety of different forms and will emphasize different parts of the curriculum. The critical point that needs to be made in this context is that in order to assess the impact of technology education on students, the education system, or society, it will first be necessary to crystallize and clarify precisely what it is that we should teach as well as how it should be taught. In order to assess impact, it will first be necessary to clarify what technology education is and how it is to be delivered.

Implementation of the Standards

The *Standards* must be disseminated and implemented. In order for this to occur successfully, a large scale and coordinated effort will be required. Additional funding will be necessary to develop curriculum materials and to provide in-service training for teachers. It will be important to engage teachers from other disciplines (particularly from science and mathematics) to coordinate effort and integrate content. We must work with corporate partners who are developing support materials, including equipment, furniture, and curricula to make certain that educationally sound, standards-based materials are being developed for the schools. The *Standards* must be used to guide, leverage, and communicate within and beyond the technology education profession.

Assessment Tools and Activities

A third challenge associated with assessing the impact of technology education has to do with assessment. This includes both program and student assessment. During the decade of the 90s, through the influence of cognitive scientists and assessment professionals, major strides have been made in the area of authentic and performance-based assessment. Important shifts in emphasis have occurred including recognizing the importance of embedding assessment in rich, authentic contexts, focusing on formative and summative measures, and learning how to use new tools (e.g., portfolios, rubrics, performance tasks, etc.). Incidentally, some of the more innovative and systematic work that I am aware in the technology education is occurring in England at Goldsmith's College under the leadership of Mr. Richard Kimball and Ms. Kay Stables.

The many challenges associated with assessment will be advanced with the release of the *Standards*, since a significant part of the assessment process is clarifying precisely what is to be measured. That said however, the complex and dynamic nature of technology education will continue to present significant challenges to those engaged in the assessment of the impact of technology education.

Increase Level and Quality of Research
Another major challenge confronting technology educators is to increase the level and focus of technology education-related research. In the U.S., shrinking numbers of technology education, teacher education programs are being delivered in major research universities. Also, there has been some significant reduction in the total number of technology education related faculty in all colleges and universities nation wide. Across the nation, we have a number of capable people, but insufficient research is being conducted.

In spite of these challenges, some positive activity is occurring. For the past five years, the Council on Technology Teacher Education (CTTE) has funded research projects in an attempt to stimulate additional activity in Technology Education. The results of these studies are currently finding their way into the professional literature. Several well established research journals actively solicit and publish technology education research (i.e., *Journal of Technology Education*, *Journal of Industrial Teacher Education*, *Journal of Technological Studies*, *Journal of Design and Technology Education*, etc.).

Among the significant challenges of the next decade will be to develop and enhance the research infrastructure within colleges and universities to yield “impact-oriented” information. Among the activities that must occur are (a) preparation of individuals with top quality research skills in doctoral programs around the country and world, (b) maintenance and enhancement of doctoral programs, (c) development of reward structures for faculty engaged in research activities, (d) engagement of the profession in dialogue regarding technology education’s research agenda, (e) preparation of technology education professionals to engage in funded research and development projects, and (f) maintaining the quality of the profession’s research journals.

Maintain involvement in policy arena
As indicated earlier, due to the sustained efforts of leadership of a number of individuals at the ITEA, NSF, NASA, NRC, standards development projects, etc., the technology education community has gained access to the policy development arena at unprecedented levels. While many of these efforts are not well known at the “grass roots” level, they are extremely important to the future of the technology education profession. It is critically important that this type of activity be continued and increased. In the U.S. and around the world, change occurs at a variety of levels. Much is happening in local schools around the country, as the profession continues the change to technology education. These changes are exciting and important. But they will be difficult to sustain in the absence of strong and well informed support at the top levels of educational and political policy making. Every effort must be made to ensure that current levels of support and activity be continued and enhanced.

Concluding Comment

Is Technology Education making a difference? Is its content base unique and important as a component of the general education of all students? Do Technology Education programs and activities successfully serve to integrate curricula from across a variety of academic disciplines? Preliminary indications at various locations around the world are that the answers to these questions are “yes!” But we must be prepared to submit our work to the rigors of scholarly inquiry, critical analysis, and professional dialogue on an international scale.

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Pupils' Perspective on the Most Influential Characteristics and Major Outcomes of a Rich Technological Learning Environment

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Israel

Abstract

For more than two decades, educational research has been dealing with the contribution of a rich learning environment to attaining educational goals, such as improvement in learning achievements and attitudes towards studies and school. The term "rich learning environment" not only includes physical devices, such as experiment kits or computers, but also the teaching technique, the type of activity pupils engage in, and the method of assessment. The present study focuses on the pupils' perspective on this issue. The subjects were two groups of 10th grade pupils who studied technology and created projects, using the Lego-Logo environment. At the end of the school year, semi-structured interviews were conducted with pupils and their parents, in order to examine their views regarding this learning experience. Content analysis of the interviewees' responses revealed a number of aspects that appeared frequently, concerning learning method (the inputs of the program) and the effects of the program on the cognitive and affective domains (outputs). A closed questionnaire was constructed on the basis of these aspects and applied to the same group of interviewees, and to an additional group the following year. Results of the questionnaire showed that pupils perceive the following six features of the learning environment to be the most important: construction activities, freedom to select subjects, team projects, programming computers, thinking activities, and independent study. In addition, pupils indicated six major outcomes of the program studied: independent work, personal initiative, imagination, challenge, interests in the technology studies, and curiosity. These findings add a body of knowledge regarding the central components in technology education programs and project-based study, and their implications for learning and thinking.
Key Words: At-Risk Pupils, Technology Education, Major Learning, Creative Thinking, Learning Environment, LEGO/Logo, Pupils' perspective

Introduction

For more than two decades, educational research has been dealing with the contribution of a rich learning environment to attaining the educational goals, such as improvement in learning achievements and attitudes towards studies and school (Fraser & Tobin, 1991; Perkins, 1992; Fraser, Giddings, & McRobbie, 1995). The term "rich learning environment" not only includes physical devices, such as experiment kits or computers, but also the teaching technique, the type of activity pupils engage in, and the method of assessment.

Associating Science and Technology studies with a rich, flexible, computer-embedded learning-environment may enable advancement of pupils in attaining higher academic achievements and overcoming their cognitive and affective difficulties (Waks, 1994).

For that purpose, the Creative Thinking and Technology (CTT) program (Barak and Doppelt, 1998) was developed. The CTT program's main goal is to develop creative thinking via project based-learning approach. The program integrates creative thinking tools from Co.R.T 1 program (De Bono, 1986) within the technology curriculum (Barak and Doppelt, 1999a). The pupils created authentic technological projects and prepared portfolios that were used for assessing the learning process. In this paper we will concentrate on the pupils' perspective of the preferred learning environment.

Theoretical Background

One of the proclaimed goals of science and technology education is to enhance pupils' higher-order intellectual skills, such as mathematical-logical thinking and creativity (Sterenberg, 1998; Gardner, 1993; Perkins, Jay & Tishman, 1993). De Bono (1986) suggested a series of creative thinking tools that can be used as a general approach for the teaching of thinking. Perkins and Swartz (1992) suggested that the fostering of thinking should be part of learning specific context, such as science and technology.

Waks (1997) described the possibilities, which creative thinking tools can open for technology education. He points that lateral thinking activities can initiate the learning process while pupils seek for alternatives and examine different solutions. Vertical thinking is essential in the stage of choosing a solution and developing it. Vertical thinking and lateral thinking complement each other and both are the essential elements of creative thinking (De Bono, 1996).

Imparting creative thinking within science and technology education necessitates not only changing the teaching methods and learning environment, but also adopting new assessment methods, such as portfolio assessment, which is based on records of pupils' activities. The portfolio can consist of written material, computer files, audio and video items, sketches, drawings, models or pictures. The portfolio reflects what pupils have learned, how they question, analyze, synthesize, solve problems, and create new ideas or design and build useful products or systems. The portfolio shows also how pupils interact intellectually, emotionally and socially with others (Collins, 1991; Wolf, 1989).

Perkins (1992) identified several features of learning environments: Information Database, Symbol Platforms, Construction Systems, Phenomenarium (Microworlds) and Assignment Organizers. Learning environment should be flexible enough, allow different learning styles (Kolb, 1985), and develop different skills (Gardner, 1993, Sternberg, 1998). It should include portfolio assessment of pupils' original projects, rather than pen and paper examinations.

A rich, flexible learning environment is necessary for accelerating the learning of at-risk pupils (Levin, 1992). Advancing low-achieving pupils is an on-going challenge for educational systems. Routing low-achievers to low-learning tracks creates a vicious circle. The school system has low expectations from the pupils; the pupils accumulate a history of failure; and the teachers come out as having low self-esteem and professional image (Barak, Yehiav, & Mendelson, 1994).
The CTT program adopts the following lines: learning through completing authentic projects; integrating creative thinking activities into technology curriculum; allowing freedom to learn and encourage learning from mistakes. LEGO/Logo learning environment was selected to be the basis for the implementation of these guidelines.

LEGO/Logo is a learning environment that is widely used for technology education at elementary and secondary school. The benefits of LEGO/Logo for technology education are creating a community of learners; changing the teacher's role in class and using the pupils' authentic projects as the base for the learning process (Reznick & Ocko, 1991). In this paper we will describe the influence of the CTT program upon the affective and cognitive domains from pupils' point of view.

Intervention

The program entitled CTT - Creative Thinking and Technology (Barak & Doppelt, 1999a), encompasses two hours of study each week during an entire school year. During the first semester of the school year (about 15 weeks), the class learns thinking tools from the CoRT thinking program, developed by De Bono (1986). During this semester, thinking tools such as PMI (Plus, Minus, Interesting), CAF (Consider All Factors), and APC (Alternatives, Possibilities, Choices), are studied.

In the first few lessons, the examples are drawn from the pupils' daily lives. After that, learning focuses on the process of constructing mechanical systems, such as a car or a robot, by means of the LEGO/Logo system components. For example, all pupils construct identical cars according to a given LEGO design, compare their features and suggest improvements, while using the CAF and APC thinking tools. In the course of this process, the pupils also become familiar with the LEGO/Logo system, the computer interface and with writing simple programs in 'Multi-Techno-Logo'. This is a Hebrew version of LEGO/Logo that combines the advantages of Logo-Writer and LEGO/Logo using mother tongue for programming. This version was developed and described elsewhere (Armon and Doppelt, 1999).

During the second semester (about 15 weeks), the pupils choose and create original technological projects. As Barlex (1994) summarizes his paper: "It is difficult to capture the breath of spring that successful technology project work brings to a wintry curriculum. Perhaps it's the risk of failure and the uncertainty with no right answers, only possible solution". The pupils coped with complex problems and found solutions that depended on creative thinking in the sense of synthesizing lateral and vertical thinking.

The pupils created portfolios in which they collected their documentation of creative thinking and other outcomes of the learning process. Over a period of several years, each class developed criteria for assessing the portfolios. On the basis of these experiences a scale for assessing pupils' creative thinking through their portfolios was developed (Barak and Doppelt, 1999b).

This scale is comprised of four levels: (1) Awareness of thinking, (2) Observation of thinking, (3) Thinking strategy, and (4) Reflection upon thinking. The suggested scale is applied in two domains of the portfolio: (a) learning outcomes, such as research work or a technological product, and (b) processes of learning, thinking and teamwork in the class. Several examples of applying the scale to pupils' portfolios demonstrate how this methodological assessment can help educators to develop and evaluate learning assignments aimed at fostering creative thinking. Through the portfolio design, and systematic reflection on it, pupils can develop awareness of their internal thinking processes and learn to direct their own thinking.

Research Goals

The main goal of this research was to learn about pupils' perception of the influence of the learning environment on their outcomes. From theory we can assume that there are several characteristics of learning environments. In this paper we will concentrate on exploring the pupils' viewpoint about the contribution of these characteristics to their learning outcomes.

Method

Subjects

The subjects of this study were 10th grade pupils in a high school in northern Israel. These were low achieving pupils that had chosen the Machine Control Department in which to major. Some of the pupil's chose that route on their own, while school advisors directed others. School advisors' opinion is that this route is the only solution for low-achievers at school.

In Israel, at the end of junior high school, pupils have to choose one or more areas for a major, such as: Sciences, Humanities, Art or Technology. Technology curriculum for high school in Israel contains several major subjects that are related to physics and mathematics, such as: Computers and Electronics, Mechanics and Control Systems. It has been common in Israel during the last years to direct the "high-achievers" to the Computers and Electronics Department and "low-achievers" to the Machine Control Department. The issue of integrating low achievers into technology studies in Israel has been discussed in more detail elsewhere (Barak, Yehiav & Mendelson, 1994). We can say that the pupils under discussion can fit the definition of at-risk pupils (Levin, 1992).

The intervention program ran for five years (1994-1998). A total number of 56 pupils participated in this program (9-24 pupils each year). In this paper we would like to concentrate on examining the influence of the CTT program on two groups of pupils (1994, 1995 classes).

Data collection

This research combines qualitative and quantitative tools (Fraser & Tobin, 1991): observations of class activities, interviews with pupils and parents, and following the pupils' academic achievements. Content analysis of the interviews resulted in development of a questionnaire for assessing pupils' progress in an open learning environment, in terms of input-output relationship from the pupils' viewpoint. In this paper we will concentrate only on the findings from this questionnaire.

In quantitative research it is common to validate conclusions from the findings of one instrument by the findings of another instrument (Denzen & Lincoln, 1994). Educational research of learning environments seldom combines qualitative and quantitative instruments. Such a combination has been found to be effective and contribute to the understanding of the research field (Fraser & Tobin, 1991). In addition the research instruments that were developed to assess learning environment are not fit for science lab (Fraser, Giddings & McRobbie, 1995). Certainly, these tools are not appropriate for a technology curriculum that emphasizes hands-on activities, and the design and construction of team projects, beyond the use of computers.

The mapping sentence that is presented in figure 1 gives a flexible structure for researchers to use in classes (Waks, 1995). The words in each facet were taken from the interviews with the first group. This questionnaire is based on assessing the influence of the inputs of a learning environment on pupils' outcomes. Pupils from the two groups filled in this questionnaire by scoring each peer on a 1 to 5 scale (1 is most influencing and 5 is least influencing).

Figure 1: A mapping sentence for assessing the contribution of input 'A' to outcome 'B'

Pupil X assess that the influence of input A

INPUTS (15)

Learning styles
- Self learning
- Group discussions
- Team projects
- Individual progress rate

Pupils' activities
- Thinking
- Designing
- Programming
- Constructing

Class atmosphere
- Open mindedness
- Acceptance of mistakes
- Tolerance of different opinions
- Freedom to chose subjects
- Rich environment

Learning materials
- Instruction sheets
- Work sheets

Other

OUTCOMES (23)

on desirable pupil's outcome B

Social integration	Desire to learn
Department pride	Critical thinking skills
Technical skills	Success in the majors subjects
Mutual help	Interest in major subjects
Independence	Success in other subjects
Self-confidence	Interest in other subjects
Self enterprise	Desire to come to school gladly
Team work	Improvement in relationship with the teacher
Perseverance	Motivation to work at home
Self-responsibility	Increasing in other pupils' appreciation of the department
Curiosity	
Imagination	

is

Very much
To
Very little

For example: the pupils had to score the contribution of self-learning input to all the 23 outcomes.

A structuple can be: Pupil 1 assesses that the influence of [self-learning] upon [curiosity] is [little].

Findings

Examples of pupils' projects

Over period of several years of applying the CTT program 56 pupils built about 50 different team-projects. All the ideas were suggested by the pupils themselves. Two examples are presented:a.) in figure 2, A robot that moves forward or in circular motions and passes over obstacles; and b.) A crane that scans an area, collects objects that are randomly distributed, delivers them onto a train.

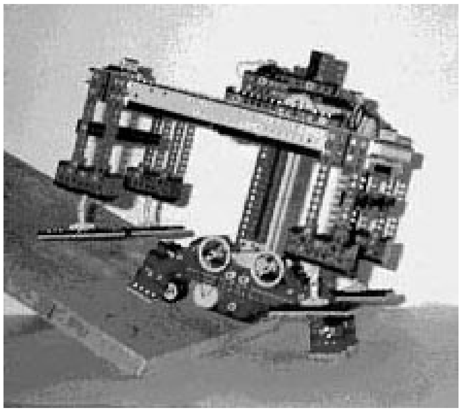


Figure 2: An obstacle climbing

Other examples are: an automatic conveyor belt, that receives, identifies and counts items loaded off a truck; and a 'chocolate drink machine' that fills powder into a glass, mixes it with milk and delivers the glass onto a conveyor. These examples demonstrate how the project based-learning approach enabled the pupils to create various authentic projects. These projects earned attention around the country from educational curriculum councils and other research groups.

Community of Learners

Observations in classes showed a variety of interactions between younger and elder members of the "Machine Control" department, between parents and their children and between pupils and their teacher. An external observer could see in the class that pupils were working individually or in pairs, and that the teacher was moving from one group to another. The laboratory became a second home for the pupils. They came during breaks and free hours and even after school to work on their projects. They could see and experience projects made by graduates (their 'elder brothers') who still come from time to time to visit their previous, but continuous, second home.

Pupils and Parents View Point

The quotes, below, from the interviews with pupils and their parents demonstrate the influences of the CTT program:

A pupil: "We do not build robots only for fun, we learn how to design prototypes. We learn automation, center of gravity, it demands thinking, develops us and we can apply what we learn. It is interesting and adds spice and motivation to learn more."

A mother of twins in the class: "There is a dramatic change in their self-confidence, they are alive and they have started to smile again, they were very sad in their past experiences in school."

The observations and the interview show the impact of the CTT program; furthermore, changing class-room atmosphere is very important for advancing at-risk pupils.

Questionnaire

We wanted to learn more about the influence of the learning environment from the pupils' viewpoint. For that purpose, a closed questionnaire was constructed based upon the interviews with the pupils. It includes 15 inputs of the learning environment such as: Freedom to Choose Subjects, Team Projects, Individual Progress, Construction Activities. These aspects are the input of the learning environment because they are concerned with the organization of the learning in the class, such as: various activities that have been introduced to the pupils, flexibility, and rank of freedom to choose activities. We identified

23 outcomes that pupils pointed to as being influenced by the CTT program, for example: Personal Initiative, Self-Confidence, Interest in Technology Studies, Challenge. In analysis of the findings an average score was calculated to every cell. This average score represents the influence of each input did upon every output. Table 1 shows some of the average scores among the inputs and the outputs of the 1994 class. Table 2 shows the same analysis for the 1995 class.

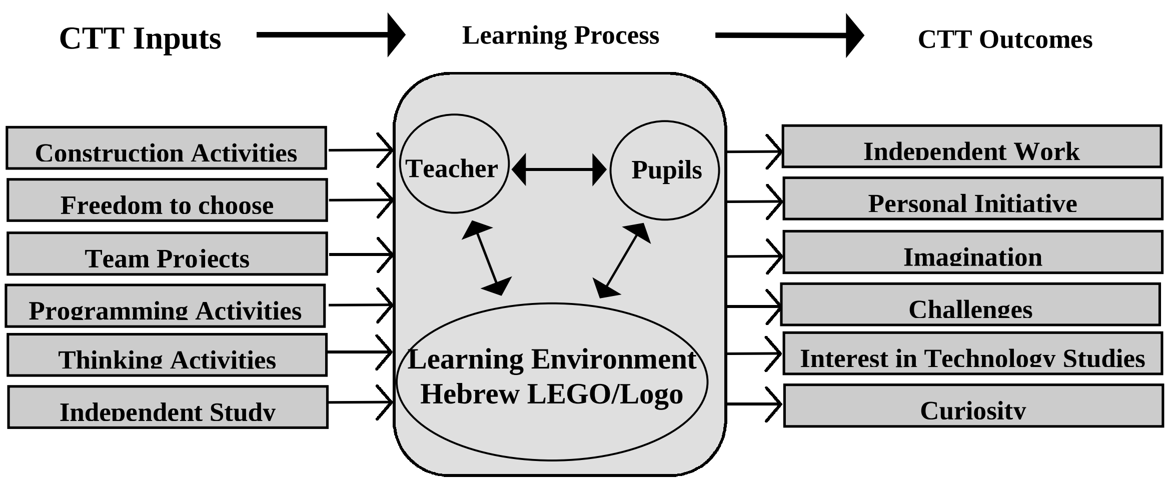
CTT Outputs / the 1994 class / CTT Inputs	Average Score	Independent Work	Personal Initiative	Interest in Technology Studies	Imagination	Team Work	Curiosity	Challenge	Desire to Learn	Pride in the Technology Studies	Other Pupils' Evaluation of the Technology Department	Coming with Joy to School	Success in other Professions
Average Score	2.03	**1.73**	**1.83**	**1.83**	**1.86**	**1.91**	**1.93**	**1.95**	**1.98**	2.11	2.31	2.33	2.54
Construction Activities	**1.51**	**1.0**	**1.6**	**1.3**	**1.1**	**1.4**	**1.0**	**1.2**	**1.4**	**1.8**	**1.8**	**1.8**	2.7
Team Projects	**1.70**	**1.9**	**1.5**	**1.8**	**1.6**	**1.1**	**2**	**1.5**	**1.7**	**1.0**	**1.8**	**1.9**	2.6
Freedom to Choose	**1.80**	**1.1**	**1.5**	**1.9**	**1.5**	**1.9**	**1.4**	**1.5**	**1.3**	2.6	**1.9**	2.2	2.8
Individual Progress	**1.90**	**1.4**	**1.4**	**1.5**	**1.8**	**2**	**1.9**	**1.7**	**1.7**	2.8	**2.0**	2.2	2.4
Thinking Activities	**2.01**	**1.7**	**1.5**	**1.6**	**1.4**	**2**	**1.9**	**1.8**	2.5	2.7	2.4	2.4	2.2
Openness for Ideas	**2.02**	2.3	**1.8**	**2**	**1.7**	**1.6**	**1.9**	**2**	**1.7**	**1.6**	2.6	2.4	2.6
Programming Activities	**2.05**	**1.3**	2.1	**1.6**	**1.8**	2.1	2.1	**1.8**	2.2	2.3	2.2	2.4	2.7
Independent Learning	**2.07**	**1.1**	**2**	**1.8**	2.1	2.4	**1.9**	**1.6**	2.6	2.6	2.2	2.4	2.1
Group Discusion	2.15	2.5	2.2	**1.8**	2.2	**1.9**	2.2	2.6	2.2	**1.1**	2.4	2.4	2.3
Openness for Mistakes	2.26	2.4	2.3	**1.9**	**2.0**	**1.7**	2.1	2.4	2.2	2.1	2.9	2.6	2.5
Rich Environment	2.36	**2.0**	2.1	2.7	2.2	2.4	2.1	2.5	**2.0**	2.3	2.6	2.5	2.9
Work-Sheet	2.48	**2.0**	**1.9**	2.1	2.9	2.4	2.6	2.8	2.3	2.4	2.9	2.8	2.7

Table 1: Examples of Meaningful Inputs & Outputs Assessed by pupils from 1994 class

CTT Outputs / the 1995 class / CTT Inputs	Average Score	Personal Initiative	Pride in the Technology Studies	Challenge	Imagination	Interest in Technology Studies	Curiosity	Independent Work	Team Work	Desire to Learn	Other Pupils' Evaluation of the Technology Department	Coming with Joy to School	Success in other Professions
Average Score	2.14	**1.70**	**1.78**	**1.79**	**1.83**	**1.93**	**1.94**	**1.99**	2.18	2.38	2.40	2.80	2.96
Freedom to Choose	**1.82**	**1.1**	**1.8**	**1.3**	**1.1**	**1.7**	**1.6**	**1.9**	2.3	**1.7**	**1.9**	2.6	**3.0**
Construction Activities	**1.96**	**1.7**	**1.7**	**1.4**	**1.9**	**1.9**	**2.0**	2.1	**1.3**	2.3	2.1	2.2	2.9
Programming Activities	**1.99**	**1.7**	**1.7**	**1.2**	**1.2**	**1.8**	**1.8**	**1.9**	**1.9**	2.3	2.8	2.8	2.9
Group Discusion	**2.08**	**1.3**	**1.6**	**1.6**	**1.7**	**1.8**	2.1	**1.4**	**3.0**	2.3	2.3	2.9	**3.0**
Independent Learning	**2.09**	**1.6**	**1.9**	**1.3**	**1.4**	**1.9**	**1.7**	**1.8**	2.2	2.8	2.4	**3.0**	**3.1**
Thinking Activities	**2.13**	**1.8**	**1.9**	**1.8**	**1.9**	**1.7**	2.2	**2.0**	**2.0**	2.6	2.1	**3.0**	2.7
Team Projects	**2.14**	**1.7**	**1.9**	**2.0**	2.1	**1.8**	**2.0**	**1.8**	2.6	2.1	2.3	2.4	**3.0**
Rich Environment	**2.15**	**1.7**	**1.7**	2.6	2.1	**1.8**	**1.6**	2.2	**1.9**	2.2	2.4	2.8	2.9
Design Activities	2.31	**1.7**	**1.9**	**1.8**	**1.6**	2.1	**1.9**	2.1	2.7	2.9	2.8	**3.1**	**3.2**
Work-Sheet	2.33	2.2	**1.7**	2.3	2.4	2.2	2.3	2.2	**2.0**	2.2	2.7	**3.0**	2.7
Individual Progress	2.53	2.3	**2.0**	2.3	2.7	2.7	2.2	2.4	2.1	2.8	2.6	**3.0**	**3.2**
Openness for Mistakes	2.97	**3.0**	2.4	**3.0**	**3.0**	**3.4**	**3.3**	2.6	2.8	2.9	2.9	**3.3**	**3.0**

Table 2: Examples of Meaningful Inputs & Outputs Assessed by pupils from 1995 class

Both tables were ranked and sorted by the averages of inputs and by the averages of the outputs. Finally, a similar structure in both groups' perception was found. This structure shows, from the pupils' point of view, the main inputs of the learning environment that influenced more their outcomes during the learning process through the CTT program. The structure can be presented as a model that emphasizes the pupils' point of view of how educators should design learning environments.



Discussion

This field research enabled a close and continuous view of pupils' learning processes through a rich and modern technology learning-environment. School records, observations of pupils' activities in class, interviews with pupils and their parents, talking with the school team and the findings from the questionnaire give us evidence of improvement in both cognitive and affective domains. The findings indicate improvements in pupils' self-esteem, self-confidence, interest and success in technology subjects. The pupils changed their attitude towards their every-day learning and future intentions to continue studying. They created authentic technology projects from their own imagination and documented rich portfolios. These projects are described and assessed elsewhere (Barak & Doppelt, 1999a, 1999b).

The findings from this research suggest that educators invest resources in developing learning-environments that emphasize technology and science subjects not only by computerized activities and simulations but with wide use of hands-on and heads-in activities. Educators can use LEGO/Logo to advance at-risk pupils' learning and thinking. LEGO/Logo is attractive to technology education as previous works have shown (Papert, 1991, Reznick & Ocko, 1991, Jarvela, 1995; Jarvinen, 1998; Kromholtz, 1998;). However, this research shows an application of LEGO/Logo by using pupils' authentic projects for learning technology as a major subject in high school.

Conclusions

The research addresses the issues of promoting low-achievers by providing them a rich, modern and flexible technological learning environment. In this way the technology laboratory turned into an instrument for creating a community of learners that seeks inventions and authentic prototypes. This community is united in achieving the collaborative goals of which teachers and parents are an integral part of this reality.

There are cases when such modern learning environments are kept only for the high-achievers and the low classes are located at the far end of school and pupils are not permitted to enter those laboratories. High-Tech, modern, flexible and rich learning-environment is important, especially for at-risk pupils.

The findings from the questionnaire focus our attention to several main conclusions, the Pupils:

Ask for: thinking activities, construction activities and programming activities.

Prefer: team projects, freedom to choose subjects and independent learning.

Give high score to outcomes such as: independent work, individual progress, imagination, challenge and curiosity.

These are outcomes that schools usually ignore because educational systems concentrate only on academic achievements.

Our final conclusion, based on the pupils' perspective on the most influential characteristics of learning environment, fits the theories that are applied with at-risk pupils in the accelerated school project as described in Levin (1992). It is the role of the school and the teacher to adjust the learning environment to pupils needs. We had better stop looking for pupils' learning disabilities – instead, let us develop their talents. As the words of the song: "always look at the bright side of life". We should not look at the glass as being half-empty but rather as being half-full.

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Home Security - Children’s Innovations in Action

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Abstract

This paper is about the experiment where primary school pupils carried out automation technology on the basis of their own needs. The need was raised by asking the children to think their homes to be vulnerable to robbery. Then they were given a broad problem solving framework in order to give them possibilities to pursue the task in a creative and innovative way. The study reported herein focuses on the children’s problem solving situations during the process. Despite of the open-ended nature of the work, the children were expected to carry out some essential contents of automation technology. Data gathering methods and analysis process were qualitative in nature and enabled the researchers to gain some detailed insights in to the children’s work.

Keywords: Automation, Constructivism, Control Engineering, Learning, Teaching, Technology Education.

Introduction

Learning has been defined as 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). In sociocultural interpretation, the learning is understood to take part in the social context and is seen to be as a process of enculturation, where the learner increasingly participates in an authentic and context dependent activity (McCormick et.al., 1996; Koulaidis & Tsatsaroni, 1996, p.73) and also in apprenticeship- like collaborative settings (Gallimore & Tharp, 1990; Honebein et.al., 1992). Moreover, in order to make learning more authentic and meaningful to the children, it is essential to give them both a sense of having an ownership over the problem (Savery & Duffy, 1995) and also allowing experience of intersubjectivity to take place in learning activity, epitomized by Biesta (1994, p.315): ”Contribution of the child is not pseudo-contribution that is totally dependent upon the intentions and activities of the teacher.”

However, in authoritative teaching methods (Wertsch, 1991), whereby the teacher controls classroom activities, the actions of many children are often in response to what they perceive to be the teacher’s expectations and traditional school evaluation practices (Edwards & Mercer, 1987; Vygotsky, 1997, p. 126). In this kind of school setting the pupils do not necessarily feel the teaching and its content to be personally important or useful and thus it is difficult for them to make meaningful connections with their everyday life, all this resulting as a motivation problems.

Since technology can be seen as a response to ”satisfy human needs and wants” in creating our habitats, food supply, communication, security etc. (Hacker & Barden, 1988, p.21; Savage & Sterry, 1990, p. 11; Black & Harrison, 1985, p.3) and regarded as an human innovation in action (see http://www.iteaorg/A1.html) teaching methods in technology lessons should be adjusted accordingly. Problem solving should relate to children’s real life environment (Schwarz, 1996; Lehto, 1998) allowing them to make appropriate and meaningful connections and moreover, the given problems should enable them, at least to some extent, to explore and pursue their own needs and wants. Importantly, the children should actually be supported to notice problems, even deficient features of their everyday environment and given changes to apply technological knowledge and skills they have acquired in subsequent problem solving (Adams, 1991; Lindh, 1997).

Automation in Technology Education

Automation can be seen to include both theoretical issues concerned on control and systems theory and practical solutions made to realize automatic operations. Automation is an essential part of modern technology education. It effects almost all aspects of life and it is so prevalent in everyday life that it's role in technology education is easily justified.

Automation is based on control and systems theory that is not limited only to technical systems but covers also other systems like economical, biological and sociological systems. When handling with automation one can not avoid to use computers as an implementation environment of control functions as well as a tool for human operations and supervisory of the controlled system. Automation is based on largely applied control and systems theory and utilizes modern computers so that it forms one of the most interesting and useful substance area in technology education. (see for example Norman et.al., 1995)

The Experiment

The experiment project took place in the central primary school in the township of Haapavesi, located in the Oulu Region, middle of Finland. Overall purpose of the experiment was to consider especially automation technology as a substance area in endeavors to develop Finnish primary curriculum from the viewpoint of technology education.

The Lego Dacta Control Lab system was selected for the experiment   with the costs underwritten by a national electrical power supply company, IVO Ltd. The materials and equipment were part of the Technic series of Lego product line and the "box of bricks" also includes sensors for light, touch, angle and temperature (Lego Dacta Control Lab, 9701); process interface connected to the computer serial port (Lego Dacta Multi-interface 8+8, 9751); and the Lego/logo- programming language software which allowed the pupils to write control programs (Lego Dacta Control Lab Software for PC Version 1.0). (see Lego Dacta, 1993) The programming language is based on a logo-language, which was developed by Seymour Papert for the purpose of enhancing learning in mathematics together with assumption to enable natural and spontaneous learning. (Papert, 1980; also Suomala, 1993, pp. 69-74). Only thing the children were given was a handout sheet that included some of the principles of programming and the main commands. Lego manuals were put aside and the children were allowed to freely explore the possibilities of the system.

In the first phase, the experiment consisted of three six hour periods (time blocks) taking place during the school year 1995-1996. All the fifth (A,B,C) and sixth (A,B,C) grade classes took part. Then, due to the continuing interest of the class teachers and the researchers, one more six hour period was decided to arrange a year after, in spring term 1997. This time previous year sixth grade had gone to the secondary school and did not took part, thus in the fourth period the were only three 'remaining' classes, now being in the sixth grade.

In the fourth period the children were given a short imaginary notice that there is some burglars going around in the town. Then children's personal concern was raised by asking them to think their own home to be robbed and they were given a problem; How could you protect your home against robbery by using automation technology? The children were expected to know best their home conditions and needs and in this way, they were expected to be emotionally engaged in problem solving (Lave, 1988). Moreover, the children were told that there is no wrong answers to the problem, but rather only appropriate solutions (Lampert, 1990) and they were encouraged to use their imagination and creativity without concern of being submitted to the traditional school evaluation practices.

The purpose and focus of this study

While sharing the overall purpose of the Haapavesi experiment, this particular study is based on the stance that the tasks given in technology lessons should both allow children to make authentic and context dependent connections to their own lives, needs and wants and also enable them to be constructors of their information structure on the basis of prior knowledge and experience. More specifically the objective of this study is to investigate the meaning and suitability of a teaching method that embodies these approaches in technology education. Consequently, the research problem is stated as follows:

How the children were able to deal with some essential aspects of modern automation technology while working on the basis of their own needs and wants?

This study concentrates on fourth project period and from all the three sixth grade classes, two classes were randomly selected for this particular study. These classes are sixth A grade class (12 girls, 8 boys) and sixth C grade class (13 girls, 10 boys) from the Haapavesi township central primary school. Despite of this procedure, there was no reason to believe that the selected classes differed from the other four. All six classes were also treated in the same way and were given similar instructions and arrangements and also followed a similar class schedule. The experiment was arranged to fit into normal school routines by means of workshop-like environment. The computer laboratory was reserved for the construction 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 to work.

Method

The sociocultural constructivist perspective relative to learning enabled a theoretical background that draws on both constructivism and interpretivism, thus aiming to understand the meanings constructed by children taking part in context dependent and socially situated activity through social interaction (Schwandt, 1994). Although the study was oriented by certain research interests and stated research problem, it employed an open search for categories, concepts and patterns emerging the data. Thus the study can be claimed to be qualitative in nature and was based on inductive analysis (Patton, 1990).

Data collection was done in the role of participant observer, enabling to be "inside" the study (Erickson, 1986). The main focus of the data collection was on the automation technology content of the social interaction and its understanding at the individual level. Primary data source consists of videotape recordings. In each class, one group's work was selected to be recorded as a whole, continuous process. The other groups were not video recorded during the process, but when at the end of the experiment all the groups had to present their outcomes to whole class, all the presentations and outcomes were documented. Video recordings were transcribed from the viewpoint of automation technology, i.e. situations in where the pupils spontaneously generated problems consisting contents of automation technology to solve were included in the transcription. All names in transcriptions are pseudonyms.

During the first viewing of the data, an idea of the emergent phenomena were formed in relation to the theme of the study. This included the emerging notion of the automation technology as a content in children's work. During further analysis more detailed classification were developed of the contents of automation technology (Miles & Hubermann, 1994). Data analysis was a continuous process in where the researchers discussed and shared thoughts in several occasions. Data examples presented in this article were analyzed by both of the researchers individually and also in the collaborative discussion in where the final interpretations were developed. (Ritchie & Hampson, 1996)

Results and Discussion

The inductive interpretative analysis process used in this study enabled the results to be framed as an empirical assertion, with data as evidentiary warrants (Erickson, 1986: p. 145) including classifications of automation technology contents. (Miles & Huberman, 1994, p. 248-250). Thus results are presented through empirical assertion including content classifications supported by evidentiary examples taken from primary and secondary data sources. Examples presented to support assertion and classifications were also ”microanalysed” (Interpretation) in order to clarify the interpretative analysis process, which consequently led both to empirical assertion and automation technology content classifications. Although information in the examples overlaps considerably throughout classifications, they have been chosen to present clearly at least the classification to which they refers to and the microanalysis is done correspondingly.

Empirical Assertion

The pupils were able to create problems based on their own needs, thus enabling them to have an ownership of the problem solving processes and, despite of this handled subsequently classified contents of automation technology mostly with procedural understanding.

The work and the actual outcomes of the pupils consisted at least of the following contents of automation technology:

- Using sensors and switches in the context of automation technology
- Open loop control systems
- Logical operations (Not supported by particular example, but rather interpreted to emerge throughout the process.)
- Block-based programming and system configuration especially in the context of automation technology
- Using sensors and switches in the context of automation technology:

Using different sensors appeared to be very common (and naturally done) by the pupils. Despite of the fact that the programming of the sensors caused many difficulties and even frustrations, most of the pupils can be claimed to have an clear understanding of the meaning of them in order to realize different automated actions and functions. The sensors usually played an essential role even from the beginning of the work and were taken in to account in the planning of control systems.

Following two examples illustrates situations in where the pupils proved to understand the meaning of the sensors in order to get out desired functions.

Example 1.

This example is from the very beginning of the process. The home security system is just planned and some initial ideas are generated.

01 Sara:	[explains to Joonas] We can put a lightsensor here and when someone goes by it..
02 Joonas:	[is still more interested about planning the mechanism of the device and seem to ignore Sara’s proposal]
03 Sara:	[Sara goes further with her lightsensor idea and attaches it to the interface. Then she investigates the value measured by the lightsensor by both sweeping her finger by it and also looking for the value changed in the Setup-page]

(6th A-class; transcription and description from the video recording)

Interpretation:
In this example the group's process is in initial stage of, but Sara has already got an idea to trigger out the system by using lightsensor (line 01), but did not get any notable response from Joonas (line 02). She undeniably understands the meaning of the light sensor in this particular context. When she explains the idea, she both reveals her priori process knowledge (someone has to go by lightsensor). When doing investigation concerning the altering light values when the lightsensor is obstructed, she shows understanding about the basic idea of lightsensor to trigger out functions (line 03).

Example 2.
The group is designing a home security system, where the door 'allows' the thief to enter the house, but the system alarms about the intrusion. Like in the previous example, the process is in quite initial stage.

01 Topias: I know...[takes touch sensor from the box]...when the door opens it presses this and then..

02 Aurora: Yes... and what might happen then...maybe lights?

03 Topias: ...and siren...

04 Aurora: Yes...lights and siren are switched on.
(6th C-class; transcription from the video recording)

Interpretation:
Topias's proposal is in accordance with the capabilities of touch sensor itself; when pressed its condition (from false to true) is changed (line 01). The question posed by Aurora (line 02) indicates her understanding about the idea of touch sensor to act as a kind of switch to trigger out ensuing appropriate functions. The rest of the conversation (lines 02 ->04) is more about the desired functions after touch sensor is pressed. Interestingly, conversation begins with the idea parallel to the logical operation IF-THEN, but quickly develops to the idea of conjunction in the output; IF(touch sensor)-THEN(lights)AND (siren). Most importantly, both Topias and Aurora understands that there is no proposed functions before the system receives an input signal, but, rather after it. Procedural (or device) knowledge in action (see Mc Cormick, 1998). Moreover, their 'brainstorming' seems to indicate that they are really engaged in the authentic problem.

<u>Open loop control systems:</u>

Open loop control systems appeared to be the most common form of control systems in the works of the children. The idea of open loop control systems were attained and accomplished in relatively simple works. They did not need complicated programming either, for adequate programming was done even by using only two or three basic commands. Actually, making open loop control systems developed to be as a routine tasks for most of the children.

Following example illustrates those numerous situations in where the children were involved in tasks planning and making open loop control systems and also understood the principles of them.

Example 3.
In this example the group has developed the home security system to the phase they want to test it. The test goes accordingly:

01 Sara: [Activates the system from the control panel] The thief thinks that it is just a piece of cake to go in to this house...and presses this [touchsensor] and then the thief is captured. [the door closes behind the thief]

02 Lydia: [playing the role of thief] Cripes!...I got caught...and now the siren began to blare.
(6th A-class; transcription from the video recording)

Interpretation:
Besides of her clear understanding about the application process and the meaning of sensors when automating this application process, Sara's explanations, with a priori process knowledge, (line 01) "reveals" the idea of open loop control system (Norman et.al., 1995). When the thief presses the touch sensor Input is given to the system, resulting as an desired Output and the thief is captured by closing door. Moreover, the Output consists of blaring siren, as indicated in the Lydia's comment (line 02), also belonging to the same open loop control system. Logical operations are evident in this example also; IF(touchsensor)-THEN(door)AND(siren). There were no requirements posed by the teacher or text-book to use open loop control systems in the work, and importantly, open loop control system is achieved in the process where the pupil's can be claimed to pursue their own problem. Taking the role of the thief, Lydia can be claimed to be emotionally engaged in the situation (Lave 1988). This, although short, piece of process indicates also strong context dependent authenticity and enculturation to have taken place in the process (McCormick et.al., 1996).

Example 4.
In this example the group's process has gone a bit further, and the children are discussing about the use of lightsensor.

01 Topias: Let's use lightsensor in this system...together with that door...I mean that with touch sensor it might not be quite so successful.

02 Aurora: But should we do it so that it [alarm system] operates by itself...I mean that when somebody comes..

03 Topias: That is just what I mean...You know
(6th C-class; transcription from the video recording)

Interpretation:
In here, Topias has noticed the capability of light sensor as being more appropriate and effective media to transmit an necessary Input to the alarm system (see and compare to example 2.) (line 01). Although Aurora seem to be less aware of the capability of light sensor, she has got a right idea of the system itself; when somebody comes, the system 'activates itself' (line 02). This idea is in accordance with the notion of open loop control system; when the system receives an input signal, it responds to it with expedient output (see for example Norman et.al., 1995) .In the last line Topias confirms Aurora's reasoning (line 03) and, actually they both can be interpreted to have parallel idea about the logic of alarm system.

<u>Block-based programming and system configuration especially in the context of automation technology:</u>

The importance of programming in the automation technology can be claimed to be understood by almost all the children. When the constructed devices had to be programmed or they for some reason or another did not functioned in the desired way, the pupils attention was immediately directed to the programming. In this way the children encountered the importance of programming in very concrete and realistic way, sometimes even to the extent of frustrating level. Independent programming skills were quite difficult to acquire, however, but in some cases the pupils progressed amazingly well and, in one group's case, even managed to make a loop to their procedures.

The following two examples illustrates the situations where the programming served as an tool to implement the automation technology; the aim of work was to make planned systems and accomplished devices to be functional in desired way.

Example 5.
Here the group of children is presenting their system to the whole class. The pupil responsible for programming is asked to explain the program written in the procedures-page.

```
To vahti [to ‘guard’]
     waituntil [light 5 > 45]
     talkto ”soundb
     talkto ”lampa
     talkto [soundb lampa] onfor 15
     talkto ”motorc setpower 8 onfor 20
     talkto [soundb lampa] onfor 100
     end
```

(6th A-class; program form the groups’ project pages)

01 Rosa: These [commands] are written in such an order, in which this [alarm system] has to function...in what power this conveyor is about to run and so forth..

02 Researcher: Could You tell us line by line what does all those commands mean...why are they for...beginning from the first line like for ‘whom’ is first command line addressed?

03 Tatu: [whispers while Rosa hesitates to answer]... for lightsensor.
04 Researcher: Yes that’s right.....and then...what does that ”talkto ”soundb mean”?

05 Rosa: It is for this sound in here. [in the interface output-port b]

06 Researcher: And then there is ”talkto ”lampa”.

07 Rosa: That lamp is here in the a. [in the interface output-port a]

08 Researcher: And then you have got both sound b and lamp a in the brackets...what does it mean?

09 Rosa: That’s because they [sound b and lamp a] are to be function simultaneously.

10 Researcher: What does that onfor 15 mean then?

11 Rosa: Because they [sound b and lamp a] are meant to be on for one and half seconds.

12 Researcher: And then there is that ”talkto ”motorc setpower 8 onfor 20”... is this now for this conveyor which throws all those ”tires” in order to ‘knock out’ the thief?

13 Rosa: Yes...in here that 8 stands for the power conveyor rotates and 20 means for two seconds..... and then lamp and siren are again on..now for ten seconds.
(6th A-class; transcription from the videotape)

Interpretation:
In this quite lengthy example Rosa proves to understand most of the programming she has been doing. Importantly, she says (line 01) that these command lines are written in the same order in which the alarm system is supposed to function, thus proving to understand the idea of logical relationship between the programming and the home security system built. In spite of this, the first line written to the light sensor seem to be the quite difficult and, because of her hesitation Tatu outside of the group gets an opportunity to help/answer in a right way (line 03). However, after the first line of commands she is more fluent in explaining the purposes of different commands. Actually, she seems to be completely aware of the relationship of written commands and different functions; when explaining the commands she refers to the corresponding output-ports in the interface (lines 05 and 07). Rest of the conversation is done without direct reference to the interface, but rather is about getting simultaneous functions out of output (lines 08 and 09) and further relates to the particular device, conveyor, in the home security system (lines 12 and 13), all this proving Rosa's understanding about the programming in the context of automation technology. Moreover, from the viewpoint of logical operations, there is quite complicated conjunction on output; IF(lightsensor)-THEN(sound &lamp)AND(motor)AND(sound&lamp).

Conclusion

One of the most remarkable outcomes of the experiment and the study reported herein was the motivation and task orientation of the children. When the work was based on the problems found acute in their own life, they seemed to have an ownership and emotional engagement over the task at hand (Savery & Duffy, 1995; Lave, 1988). However, at the same time their work consisted the classified contents of automation technology and interestingly, without any use of textbooks, worksheets, manuals or the like. Although the children mainly worked on the basis of procedural knowledge, or device knowledge, their knowledge can be interpreted to ”reflect as much of the context of the device (e.g. its operation) as any abstract knowledge taught in science” (see McCormick et.al. 1998, p.7). Moreover and importantly, they can be claimed to participate in the process of the technological development in order to meet our needs and wants (Hacker & Barden, 1998).

Interestingly, no one of the groups did closed loop control systems, and did not encounter the idea of feedback either. This can be claimed to be, at least to some extent, due to the task allocation; doing home security systems did not prompt the pupils to tackle those essential aspects of automation technology. However, in the third project period (”how the pet can survive alone at home while the family is on a vacation”) some of the groups managed to do closed loop control systems and thus made use of the idea of feedback. This phenomena raises quite a fundamental dilemma; if the pupils are designed to pursue their own needs and wants and own the task at hand, how to present the problems in such a manner that all the required aspects of the substance (for example posed by curriculum) are likely to be undertaken by the pupils?

One of the most important things in education is to adjust the teaching methods according 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). The action itself and generated procedural knowledge and understanding are most important, conceptual knowledge can be introduced by the teachers later on. Especially in technology education, pupils may be better at defining appropriate learning outcomes than are textbooks or teaching manuals. Actually, in technology lessons there should not be right answers to the posed questions, but rather appropriate solutions to emerging problems. In this way the pupils can be real contributors in the learning activity (Biesta, 1994).

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The Future of Values in Technology Education

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Introduction

As we prepare to enter the next century it is timely to consider the purposes and practices of the technology education we provide to the next generation through the school curriculum. With the dominance of communications technology and the increasing amount of income spent on technological consumer goods, pupils must be given some education in methods of learning about, and discerning between, the technological products that will be available to them. In addition, the traditional craft basis of design and technology education needs to be put in perspective. Is there, for example, currently the correct balance within the subject between time spent designing and making products and time devoted to evaluating design and technological activity in general. If there is, as there seems to be, a growing interest in pupils exploring products, how should pupils be given opportunities to value, for themselves, the results of their own and others' design and technological activity?

These issues are tackled by looking at three interconnected elements. Firstly to explore how values, and values issues, fit into definitions of technology education. Secondly to review the curriculum content, educational debate and classroom practice in the UK during the last decade (particularly the last 3 years). Thirdly the paper speculates on the possible future role of values in technology education and the impact that critical evaluation might have on our consumer cultures.

Values and technology

This paper starts from the position that technology is not value free. The technological products that we see around us reflect the values of our society, the values of the designers and manufacturers involved, and the perceived values of the end-users.

> *Technology does not spring, ab initio, from some disinterested fount of innovation. Rather it is born of the social, the economic, and the technical relations that are already in place.*
> p11, Bijker, W and Law, J (1992)

It is clear therefore that consideration of economic, social, moral, environmental and other issues should be an important part of design and technological activity. To view technology as objects, without considering the processes of design and manufacture, as well as the context and situation in which it is used, is to take a narrow view and to accept a limited, and it can be argued, impoverished interpretation of the term technology.

Such narrow deterministic views are seemingly in opposition with those that believe that technology is socially constructed. How have such di-poles of opinion, about the relationship we have with technology, come about?

To some extent, the existence of such views can be explained by considering the different meanings given to the term *technology*. Those holding a deterministic view of technology use a restricted meaning of technological practice whilst the social constructionists use a more generalised view of technology with technological development integrated into our culture.

One of the clearest explanations of the varying views about technology was presented by Arnold Pacey more than 10 years ago. Pacey (1983) developed a model of technological practice that mirrored medical practice. He proposed that there were three key aspects to a general view of technological practice: technical, organisational and cultural. He suggested that to consider technology as the purely technical is to use a restricted meaning of technological practice.

General meaning of technology	**Cultural Aspect** Goals, values and ethical codes, belief in progress, awareness and creativity		**Organisational Aspect** Economic and industrial activity, professional activity, users and consumers, trade unions
		Technology Practice	
	Restricted meaning of technology	**Technical Aspect** Knowledge, skill and technique; tools, machines, chemicals, liveware; resources, products and waste	

Values and technology education

Views of technology education have also been varied and conflicting. This has particularly been the case in the UK where technology education has been used as a political football with a variety of interest groups attempting to shape the subject towards their own ends Layton (1992). During the 10 year period 1988-1998 a wide range of views about the nature of design and technology education have be aired, reviewed, revised and often dismissed. All, however have kept two key elements explicit. Firstly that technological knowledge and skills are involved, Secondly that transferable process skills are also involved.

A third, and sometimes hidden or incoherent, element is that of developing attitudes and values and the opportunity for pupils to consider, or value, the work of other people (including those in different cultures).

If technology education is to align closely with the reality of technological practice in our societies, then a model of technology education practice similar to that used for technology practice should be useful. To this end a modified version of Pacey's diagram is given below. This helps to clarify the place and importance of values, attitudes and valuing processes in the domain of technology education practice.

General meaning of technology education	**Cultural Aspect** Attitudes and values, skills of valuing		**Organisational Aspect** Developing capability in the use of design strategies and processes
		Technology Education Practice	
	Restricted meaning of technology education	**Technical Aspect** Acquisition of technical knowledge, skill, and technique: tools, machines, etc.	

In reality all three elements are integrated. The curriculum of the day reflects the relative emphasis given to each of these elements. Focussing only on technical aspects in the education of young people is to remain blinkered educators and deprive pupils of the opportunity to develop a view of technology's place in society.

Curriculum development

The interest in, and awareness of, values issues in design and technology education has varied quite considerably during the last 10 years. This is reflected in the variation in emphasis given in curriculum documentation.

During the formation of the first National Curriculum in England and Wales various working groups were set up. The Interim Report of the Technology Working Group (1988) wrote a document that loosely formed the basis for the first Technology Curriculum in the UK. Those writing the report felt that values had a significant place in the curriculum:

> *By the end of the period of compulsory education pupils should have some understanding of the value options and decisions that have empowered the technological process in the past and which are doing so today.*
> p6, DES (1988)

It was no surprise therefore that in the 1990 Order there were references to values issues and the need to develop pupils awareness:

> *Pupils should be taught to:*
> *understand that artifacts, systems or environments reflect the circumstances and values of particular cultures and communities.*
> p17, DES (1990)

The 1990 National Curriculum Order presented great opportunities for the exploration of values issues. However, a lack of coherence and progression, combined with insufficient guidance for teachers, meant that the Order was easily undermined. From 1990 to 1995 it's content and structure was fought over with new proposals from government agencies every year. During this period it was (mistakenly) felt important to define design and technology in narrow terms.

> *Design and technology involves pupils applying knowledge and skills when designing and making good quality products fit for their intended purpose.*
> p13, DFE (1992)

Definitions such as this, focusing on making products, did much to minimise any possible valuing activities that might take place in the classroom. Ironically, it was during this time that some of the most significant contributions, to understanding values in design and technology, were made.

Discussion

One of the most significant contributions to the debate about values issues in design and technology education came from David Layton's keynote address to the IDATER conference in 1992. This occurred at the same time as the publication of a chapter he wrote in the book Make the Future Work (Budgett-Meakin 1992). The explanation was clear and precise and made more significant by the fact that Layton had been a member of the Working Group on Technology.

Values and value judgements are the engine of design and technology. Judgements about what is possible and worthwhile initiate activity; judgements about how intentions are to be realised shape the activity; and judgements about the efficacy and effects of the product influence the next steps to take. Value judgements, reflecting people's beliefs, concerns and preferences are ubiquitous in design and technology activity.
p36, Layton in Budgett-Meakin (1992)

In addition to a number of academic papers alongside that of Layton, a Values Special Interest Group was launched at Loughborough University's IDATER conference. This has subsequently become VALIDATE[1] - an independent group of educators interested in promoting the discussion of values and value judgements by pupils and teachers.

In the following years there were two events that helped develop the understanding of values in technology education in the UK. The first event was the *Values in Technology: Approaches to Learning* conference held in Birmingham in March 1993. One of the outcomes of this conference was an edition of the journal *Design and Technology Teaching* devoted entirely to values.

The second event of note was the conference *Looking at Values through Products and Applications* held in February 1995. This provided an opportunity for teachers to evaluate products alongside of representatives from the companies who made them.

1995 revised Order

Despite the debate and significant interest in values, as outlined above, the 1995 Order for Design and Technology in England and Wales made little explicit reference to values issues. However the requirement for pupils to be given opportunities to investigate, disassemble and evaluate products presented some opportunities.

Pupils should be taught:
to consider the effectiveness of a product, including the extent to which it meets a clear need, is fit for purpose, and uses resources appropriately;
p5, DFE (1995)

Such a statement in the entitlement curriculum for pupils puts considerable demands on both the pupils and their teachers. How are pupils to judge whether products meet a clear need? What knowledge do they need in order to be able to judge whether a product is an appropriate use of resources?

Classroom practice

In order to find out the level of interest and actual classroom practice involving values issues a questionnaire was sent in 1997 to more than 200 schools. From some 50 returns it would seem that there was little explicit teaching about values issues although many expressed great interest. What became clear was that teachers understood the issues but needed some guidance on ways of introducing values into their work with pupils. Examples of successful strategies are given below.

1 More information on VALIDATE is available at www.gold.ac.uk/~dts01mm

Starting with an issue

The choice of starting point for design and technological activity can play a significant role in opening up opportunities for pupils to engage in valuing and discuss a range of issues. Starting with an issue, rather than a fixed brief, provides opportunities for valuing to take place. For example consider a design and make activity on the theme of C*arrying* where the teacher intends pupils to develop a carrier from textile materials. How is the task presented to pupils? Let us consider two possibilities.

1. Design and make a carrying device to hold a range of foodstuffs.
2. Address the issue of an elderly shopper who needs the means of carrying his/her shopping back home from the precinct.

Both design activities may result in exactly the same solution but the second activity presents a much richer situation for pupils to explore and discuss a range of issues.

Product evaluation

The evaluation of products is an increasingly important area of the curriculum in the UK. Pupils are encouraged to investigate disassemble and evaluate a range of familiar products. There has been, until recently, little guidance on how this should be undertaken with pupils in the classroom and also little research to identify appropriate teaching and learning strategies.

Research undertaken since 1996 at University College Chester, and now Goldsmiths, has tended to focus on product evaluation. In particular, enabling pupils to make comparisons between products that meet the same need has proven useful in exposing attitudes towards products (and technology in general). Below are examples of the type of comment made by pupils (Yr7 and Yr8) evaluating products:

> *Handmade (products) could be like more ungraceful but machine made can be like a bit tacky.*
>
> Researcher: *So do you think that's worth more then?*
> Pupil: *I don't think it would cos if it's made in one of the Far East countries the workers don't get paid very much.*
>
> Researcher: *Do you think it is important that we have things that last a long time?*
> Pupil: *Yes. It's best to spend more money on something if you want it for a long time. But if you want to use something once then you can buy it cheap.*

These quotes illustrate the strongly held views that pupils have about technology. In developing a more socially responsible curriculum there needs to be time for pupils to engage in discussion about their views.

The future of values in technology education?

How should technology education develop to enable teachers to work with the kinds of issues raised by pupils' comments above and discuss the social, environmental consequences of technology? Let us first consider the future role of technology education as part of general education. A possible scenario for the future might be:

- Few pupils will be actively engaged in design and make activities on a day-to-day basis.
- Some pupils will be able to make use of transferable design process skills.
- All pupils will be expected to participate in a highly technological world and be able to make informed decisions about the use and applications of technology.

Given these statements, why is it that technological knowledge has been given a high status in the technology curriculum and values and attitudes a low status? Indeed there is very little written about the types of attitudes about technology that could or should be engendered in pupils.

Curriculum content

Pupils should be given opportunities to critically evaluate technological products and should be encouraged to consider alternative ways of addressing needs and opportunities other than making products. It is important that this is linked in with pupils' own designing and making so that pupils' thinking informs their own creative activities, and vice-versa.

There are also a number of issues, conspicuously absent, that need to be emphasised in the curriculum. These include: reducing consumption; re-using products; wear, tear and maintenance; re-conditioning; design for disassembly; recycling.

How realistic is the possibility of the Design and Technology curriculum taking on board values issues to become more socially responsible? With the arrival of a further revised curriculum in 2000 there are already signs of which direction it will be taking. There are encouraging signs that values are being taken seriously.

> *It (design and technology) should enable pupils to become discriminating citizens and consumers, and be able to contribute to their home, the community and industry; by having a better understanding of products and the associated values; by developing specific technological understanding; and by fostering the design and manufacturing skills needed to produce quality practical solutions to real problems.*
> p5, DATA (1999)

Given such comments made by those with key roles in the shaping of the curriculum it is clear that value issues really will have a higher profile in the future. Inclusion in the curriculum, however, is one thing. If values are to be tackled in classrooms of the future there are a number of issues that need to be addressed.

Educational issues

There are a considerable range of issues arising from the arguments put forward above. These are compounded by some confusion over what is meant by values in technology education

One of the most significant and fundamental issues is whether controversial issues should be discussed in technology education, and in school as a whole. Whilst this view is accepted, where else in pupils' education will they have the opportunity to learn, consider and reflect upon the technology that surrounds them and makes such an impact upon their lives and the community as a whole?

Progression

One issue that has received little attention from commentators and curriculum organisations is that of progression. Conway and Riggs quite rightly say:

As pupils move through the key stages there should be a growing ability to justify the choices they are making with reference to values and beliefs and a growing acceptance of responsibility for the consequences of technological activity.
p236, Conway & Riggs (1994)

What does this progression look like? Should there be different approaches in Primary and Secondary necessary? Are pupils' attitudes, and interests, different at different ages? Focussing on product evaluation in particular some suggested lines of progression are given below:

>>> Progression >>>	
Familiar products	Unfamiliar products
Simple products (one piece)	Complex products (many parts)
Comparison with similar products	Comparison with different products
Using given evaluation criteria	Developing and using own criteria
Evaluate for use by self	Evaluate for use by others

The above lines of progression are questionable and there is a need for research to be undertaken in this area. In the meantime, however, such activities appear in the statutory curriculum and teachers will be expected to tackle issues of progression themselves to the satisfaction of school inspectors. The lack of guidance from the Qualifications and Curriculum Authority and its predecessors gives cause for concern.

Assessing capability

How can we assess pupils' capability in handling values issues in Design and Technology? What do we look for in assessing pupils' ability to evaluate products?

If pupils capability cannot be assessed then how can the effectiveness of teaching strategies be measured? To address this issue for product evaluation, the following criteria are suggested:

- **Dialogue and reasoning** (from subjective reaction to objective argument)
- **Number and type of evaluation criteria used** (inclusion of own criteria)
- **Consideration of wider issues** (from purely functional to environmental, moral)
- **Supporting information** (evaluation backed up by other sources)

From the experience of those working in Development Education it is clear that assessing attitudes and attitudinal change is extremely difficult. Given the current importance of assessment and accountability in our curriculum this is an issue that needs to be carefully researched.

Exposing personal beliefs/constructs

Asking pupils to value technology and express an opinion inevitably exposes their beliefs and interests. If the causes of particular viewpoints are sought, this may expose deeper beliefs or constructs. There is a danger that this process may go too far and may expose deeply held beliefs of pupils - ready for ridicule by other pupils.

Of course, strongly held, conflicting values will sometimes be identified and an open, dialogic approach is required of the teacher. An educational climate of tolerance and mutual respect must be developed. This also has implications for the degree of 'laddering', or depth of elicitation undertaken in classrooms and workshops.
p200, Siraj-Blatchford (1995)

Overall, there are a number of issues that need to be addressed and research is required to explore how teachers can be supported in their work with pupils.

Conclusion

As fewer people are involved in designing and making there needs to be greater emphasis on technological literacy that develops valuing abilities. Consequently in 2000, and beyond, there will need to be an equal balance between technology acquisition, process skills and valuing abilities in the curriculum.

Young people need to be developing as both responsible designers and responsible users and consumers. We should be providing pupils with the skills to look critically at technology and the products they are consuming every day. It is important that pupils are given opportunities to develop and overview and not be totally submerged in design and making.

> *Do we have a curriculum which, as Professor David Hargreaves put it, leaves pupils 'so busy doing that they have no time for seeing', thus depriving them of the opportunity to make crucial design judgements about the objects they encounter in their lives? One thinks here of the purchases we all make daily, whether these are of clothes, cars, crockery, food or stationery, and of the practical, aesthetic and ethical judgements these inevitably entail*.
> p8, Tate (1996)

The implications of this for educators are considerable as all teachers of design and technology will need to be able to handle potentially controversial issues in the classroom. With guidance and support from government agencies, and independent organisations like VALIDATE this can be achieved. With all pupils able to reflect critically about technology, we will have a generation able to make informed choices rather than become victims of our technological overconsumption.

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A Fundamental Study on Fostering Creativity in Technology Education Fostering Creativity in Productive Practices Using Two Teaching Subjects

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Abstract

Linked with a study on fostering creativity in Technology Education at a junior high school, this study has chosen the learning using two teaching subjects in “Metalworking” area and implemented the creativity diagnosis test and examined the findings.

From results of the test, it was found that three structures of Creativity, Creative Thinking, Creative Skills, and Creative Attitude, were fostered by the learning through productive practices using two teaching subjects in “Metalworking” area, and especially Creative Skills were enhanced by a series of leaning using the first and the second teaching subject. Also, the ultimate scores of components of Creativity were found high with “Cognition of Problems,” “Memory,” “Self-Evaluation,” “Observation,” and “Openness”. Further, the components could be grouped into three types according to the pattern of their development by each teaching subject: (1) the components which are fostered by the first and the second teaching subject continuously; (2) the components which are enhanced more by the first teaching subject though both the first and the second teaching subject are effective on them; (3) the components which are developed by the first teaching subject but not so much by the second one.

Key words: Creativity, Technology Education, Teaching Subject, Productive Practice
“Metalworking” Area, Creativity Diagnosis Test

1. Introduction

Instruction process in each area of Technology and Homemaking Education is broadly composed of the learning through lecture in which the whole class learn the same thing all together, and the leaning mainly through productive practices. The latter is considered to be an especially important instruction process to achieve teaching objectives of the subject and to carry out teaching contents. Also, the number of teaching subjects set for the use depends on teaching objectives as some teaching objectives are tried to be achieved by one teaching subject and others are by multiple teaching subjects.

In the previous report[1)], one instruction process in “Woodworking” area was chosen and the creativity diagnosis test and the creativity fostering process test were implemented, then the results of the tests were examined. The report shows some fundamental knowledge earned about the learning in “Woodworking” area such as that productive practices are more effective for fostering Creativity than the learning through lecture and that Creative Thinking and Creative Attitude, which are among three structures composing Creativity, are fostered greater by productive practices than by the learning through lecture. This previous report has been already published as a refereed paper in Journal of Japan Academic Society for Industrial Education Vol.1 (1996).

This study, as a continuous report of the previous one, selects productive practices in “Metalworking” to clarify the relationship between productive practices using two teaching subjects and fostering creativity.

2. Study Method

In this study, to grasp the conditions of fostering creativity, the creativity diagnosis test, which was developed based on three structures and fourteen components for fostering creativity in Technology Education, were used[2]. The brief explanation about establishing the components and developing the creativity diagnosis test is as follows. First, regarding the structures and their components for fostering creativity in Technology Education, the literature on creativity based on general educational concept was studied[3)-7)]. Then, objectives and contents for Technology and Homemaking Education defined by Course of Study for Junior High Schools were examined from the point of view of fostering creativity. Further, the results of the studies above were integrated for establishing the structures and their components for fostering creativity in Technology Education. In addition to that, the creativity diagnosis test was developed based on the structures and the components. For reference, Appendix 1 shows the components on fostering creativity in Technology Education and Appendix 2 indicates the definitions of these components. In addition, Appendix 3 shows the creativity diagnosis test.

The subjects of this study are 62 male students at four classes in M Junior High School in Shimane Prefecture and the creativity diagnosis test was implemented at productive practices in “Metalworking” area. Table 1 shows the whole teaching plan (30 hours in total). As shown by Table 1, the first to the third class hours are sedentary learning, the forth to the 15th class hours are productive practices with a teaching subject of “design and production of a steam-powered boat” (hereafter the first teaching subject), the 16th to the 29th class hours are productive practices with a teaching subject of “design and production of a tape cutter”(hereafter the second teaching subject), and finally the 30th class hour is sedentary learning again. The creativity diagnosis test was implemented three times; before the productive practices using the first teaching subject (immediately before the beginning of the forth class hour); after them (immediately after the 15th class hour), which is before the productive practices using the second teaching subject (immediately before the 16th class hour); after the productive practices using the second teaching subject. (Hereafter they are called “before the first teaching subject,” “after the first teaching subject,” and “after the second teaching subject” respectively.)

The objectives of the instruction using the first teaching subject are to motivate students toward productive practices and to make them understand the basic nature of metal materials and the relationship between their characteristics and working methods. On the other hand, those of instruction using the second teaching subject are to make students conduct productive practices actively as planned, learn skills on the productive practices, and devise in design and production.

3. Study Results and Considerations

In the results of the creative diagnosis test, the points earned by simply averaging the total scores of all subjects are regarded as average scores, which are to be compared before the first teaching subject, after the first teaching subject, and after the second teaching subject. In comparing two of them, T-Test (both-side test) was carried out to see if there was significant difference between the average scores at the significance level of 5%. Since the extent of variance could not be considered homogeneous, T-Test in accordance with Welch Method was also conducted. In figures indicating the results, instruction processes and average scores are shown on the axis of abscissas and ordinates respectively.

3.1 Average Scores of the Whole Creativity and Its Three Structures

Figure 1 shows the results of average scores of the whole Creativity and its three structures in productive practices using the first and the second teaching subject. The score of the whole Creativity is 2.52 points before the first teaching subject, which is about the mean value, and it increases to 2.76

points after the first teaching subject. Then, it keeps about the same score which is 2.77 points after the second teaching subject. This result indicates that the scores of Creativity in productive practices of “Metalworking” area increase as the instruction process proceeds. From these results, it is found that Creativity is developed by the first teaching subject and is maintained through the second teaching subject.

Also, as the result of the T-Test conducted before and after each teaching subject, there was significant difference between the average scores of Creativity before and after the first teaching subject ($t(121)=3.378$, $p<.05$) and between those before the first teaching subject and after the second one ($t(120)=3.191$, $p<.05$), while there was no significant difference between those after the first and the second teaching subject.

Next, as for average scores of three structures of Creative thinking, Creative Skills, and Creative Attitude, those before the first teaching subject are 2.52, 2.45, and 2.56 points respectively, those after the first teaching subject are 2.81, 2.68, and 2.77 points respectively, and those after the second teaching subject are 2.78, 2.76, and 2.76 points respectively. The score of Creative Thinking is about the same as the mean value before the first teaching subject, then it increases to 2.81 points after the first teaching subject. However, it decreases slightly to 2.78 points after the second teaching subject, which is still higher than the score before the first teaching subject. The score of Creative Skills is 2.45 points before the first teaching subject, which is lower than the mean value. Then, it increases to 2.68 points after the first teaching subject and keeps increasing to 2.76 points after the second teaching subject, which is about the same score as that of Creative Thinking ultimately. The score of Creative Attitude is 2.56 points before the first teaching subject, which is higher than the mean value. Then it increases to 2.77 points after the first teaching subject, and it maintains the score and is 2.76 points after the second teaching subject.

In brief, the three structures of Creative Thinking, Creative Skills, and Creative Attitude can be considered to be fostered through the instruction process that uses two teaching subjects. It is found that Creative Thinking and Creative Attitude are fostered greatly by the first teaching subject, and they are maintained at the same level after the second teaching subject, while Creative Skills is fostered by the series of instruction through the first to the second teaching subject.

The result of the T-Test conducted on average scores before and after each teaching subject indicates that there was significant difference between the average scores of Creative Thinking, Creative Skills, and Creative Attitude before the first teaching subject and those after the first teaching subject. (Creative Thinking: $t(121)=3.858$, $p<.05$, Creative Skills: $t(121)=3.207$, $p<.05$, and Creative Attitude: $t(120)=2.627$, $p <.05$) As for the average scores of all three structures, there was no significant difference between those after the first teaching subject and those after the second one. Concerning the average scores of Creative Thinking, Creative Skills, and Creative Attitude before the first teaching subject and those after the second teaching subject, there was significant difference. (Creative Thinking: $t(122)=3.351$, $p<.05$, Creative Skills: $t(119) =3.929$, $p<.05$, and Creative Attitude: $t(119)=2.198$, $p<.05$)

3.2 Average Scores of Components

Average scores of components for the three structures of Creative Thinking, Creative Skills, and Creative Attitude which are mentioned above are concretely examined.
At first, as shown in Figure 2, average scores of “Cognition of Problems,” “Memory,” “Divergent Thinking,” “Convergent Thinking,” and “Self-Evaluation”, which are components of Creative Thinking, are 2.60, 2.59, 2.60, 2.31, and 2.51 points respectively before the first teaching subject, while they are 2.98, 2.90, 2.78, 2.51, and 2.87 points respectively after the first teaching subject, and 2.90, 2.87, 2.72,

2.52, and 2.90 points respectively after the second teaching subject. The average scores of "Cognition of Problems" and "Divergent Thinking" are both 2.59 points, which are higher than the mean values, and they increase to 2.98 and 2.78 points respectively after the first teaching subject, then both slightly decrease to 2.90 and 2.72 points respectively after the second teaching subject though they are still higher than the scores before the first teaching subject. The average scores of "Memory" and "Self-Evaluation" are 2.59 and 2.51 points respectively before the first teaching subject, which are higher than the mean values, and they increase to 2.90 and 2.87 points respectively after the first teaching subject, then they are 2.87 and 2.90 points respectively after the second teaching subject, which means that the scores after the first teaching subject are almost maintained and they are about the same scores as that of "Cognition of Problems." The average score of "Convergent Thinking" is 2.31 points, which is lower than the mean value, and it increases to 2.51 points, which is close to the mean value, and then it indicates 2.52 points after the second teaching subject, which is about the same score as that after the first teaching subject.

From these results, it is found that all five components of Creative Thinking have a tendency of being fostered by this instruction process. Among the components, the scores of "Cognition of Problems" and "Divergent Thinking" are found to be developed greatly by the first teaching subject, but they are decreased by the second teaching subject. The scores of "Memory," "Convergent Thinking," and "Self-Evaluation" are also found to be highly enhanced by the first teaching subject and to be maintained by the second teaching subject. Though the scores of "Divergent Thinking" and "Convergent Thinking" show lower points compared with other three components after the first and the second teaching subject, both components should be preferably closer to the level of other three components and especially it seems necessary to devise the teaching method of the second teaching subject.

As the result of the T-Test conducted on average scores of the components before and after each teaching subject, there was significant difference between the average scores of "Cognition of Problems," "Memory," and "Self-Evaluation" before the first teaching subject and those after it. ("Cognition of Problems" $t(121)=4.107$, $p<.05$, "Memory" $t(117)=2.948$, p.<.05, "Self-Evaluation" $t(121)=3.621$, $p<.05$), while there was no significant difference between the average scores of other two components, "Divergent Thinking" and "Convergent Thinking". Concerning the average scores of all five components after the first teaching subject and after the second one, there was no significant difference. However, there was significant difference between the average scores of "Cognition of Problems," "Memory," and "Self-Evaluation" before the first teaching subject and those after the second teaching subject ("Cognition of Problems" $t(122)=3.406$, $p<.05$, "Memory" $t(120)=2.575$, $p<.05$, "Self-Evaluation" $t(121)=3.777$, $p<.05$). Regarding other two components, "Divergent Thinking" and "Convergent Thinking", there was no significant difference.

Next, as shown in Figure 3, the average scores of "Expression," "Planning," "Information Collection," and "Observation," which are components of Creative Skills, are 2.46, 2.37, 2.35, and 2.68 points respectively before the first teaching subject, while they are 2.69, 2.59, 2.55, and 2.89 points respectively after the first teaching subject, and 2.74, 2.77, 2.72, and 2.84 points respectively after the second teaching subject. The average score of "Observation" before the first teaching subject is 2.68 points, which is higher than the mean value. Then, it increases to 2.89 points after the first teaching subject, but it decreases slightly to 2.84 points after the second teaching subject, which is still higher than that before the first teaching subject. The average score of "Expression" is 2.46 points before the first teaching subject, which is slightly lower than the mean value. Then, it increases to 2.69 points after the first teaching subject, and it increases more to 2.74 points after the second teaching subject, which is ultimately higher than the mean value. The average scores of "Planning" and "Information Collection" are 2.37 and 2.35 points respectively before the first teaching subject, which are lower than the mean values. Then, they increase to 2.59 and 2.55 points respectively after the first teaching subject, which are higher than the mean values, and they increase more to 2.77 and 2.72 points respectively after the second teaching subject, which are ultimately about the same score as that of "Expression".

In brief, all four components of Creative Skills show a tendency to be fostered by this instruction process. Among them, the average score of "Observation" is high both with the first and the second teaching subject, though it decreases slightly with the second teaching subject. That of "Expression" is developed greatly by the first teaching subject and slightly by the second teaching subject. That of "Planning" and "Information Collection" are enhanced greatly by the series of the instruction with the first and the second teaching subject. Ultimately, the all four components are close at the high score. Therefore , this instruction process is considered especially effective to foster the four components of Creative Skills.

Also, the result of the T-test conducted on the average scores before and after each teaching subject indicates that there was significant difference between the average scores of "Expression," "Planning," and "Observation" before and after the first teaching subject ("Expression" $t(122)=2.764$, $p<.05$, "Planning" $t(120)=2.635$, $p<.05$, "Observation" $t(120)=2.222$, $p<.05$). However, there was no significant difference between the average score of "Information Collection" before and after the first teaching subject. Concerning the average scores after the first teaching subject and after the second one, there was significant difference on "Planning" ("Planning" $t(117)= 2.046$, $p<.05$), though there was no significant difference on other three components, "Expression." "Information Collection," and "Observation." Regarding the average scores before the first teaching subject and after the second one, there was significant difference on "Expression," "Planning," and "Information Collection" ("Expression" $t(120)=3.186$, $p<.05$, "Planning" $t(121)=4.344$, $p<.05$, "Information Collection" $t(119)=3.380$, $p<.05$), while there was no significant difference on "Observation."

Next, as shown in Figure 4, the average scores of the components of Creative Attitude, which are "Independence," "Curiosity," "Persistence," "Openness," and "Impulsiveness," are 2.53, 2.30, 2.49, 2.85, and 2.62 points respectively before the first teaching subject, while they are 2.62, 2.66, 2.81, 2.98, and 2.79 points respectively after the first teaching subject and 2.74, 2.55, 2.76, 2.95, and 2.80 points respectively after the second teaching subject. The average scores of "Openness" and "Impulsiveness" are 2.85 and 2.62 points respectively before the first teaching subject, which are higher than the mean values. Then, they increase to 2.98 and 2.79 points respectively after the first teaching subject, and they are 2.95 and 2.80 points respectively after the second teaching subject, which almost maintain the scores after the first teaching subject. The average score of "Independence" indicates 2.53 points before the first teaching subject, which is about the same score as the mean value. Then, it increases to 2.62 points after the first teaching subject, and increases more to 2.74 points after the second teaching subject. Therefore, ultimately it is about the same score as that of "Impulsiveness." The average score of "Persistence" indicates 2.49 points before the first teaching subject, which is about the same score as the mean value. Then, it greatly increases to 2.81 points after the first teaching subject, but it slightly decreases to 2.76 points after the second teaching subject. Therefore, ultimately it is about the same score as that of "Independence" and "Impulsiveness." The average score of "Curiosity" indicates 2.30 points before the first teaching subject, which is much lower than the mean value, but it greatly increases to 2.66 points after the first teaching subject, which is higher than the mean value. Then, it decreases to as low as 2.55 points, which is still higher than the mean value.

In brief, all five components of Creative Attitude are found to be fostered by this instruction process. In detail, the followings are found; "Openness" is high through the first to the second teaching subject; "Impulsiveness" is greatly developed by the first teaching subject and the high "Impulsiveness" is almost maintained by the second teaching subject; "Curiosity" and "Persistence" are enhanced greatly by the first teaching subject and lessened slightly by the second teaching subject; "Independence" is fostered by the series of instruction with the first and the second teaching subject. Ultimately, the average score of “Curiosity” shows lower score compared with other four components. However, this component is important for creative productive practices, therefore it is considered necessary to devise teaching contents of the second teaching subject for increasing the score.

Also, the result of the T-test conducted on average scores before and after each teaching subject indicates that there was significant difference between the average scores of “Curiosity” and “Persistence” before and after the first teaching subject (“Curiosity” $t(121)=3.375$, $p<.05$, “Persistence” $t(121)=3.272$, $p<.05$), while there was no significant difference on “Independence” and “Openness”. Concerning the average scores of all five components after the first and the second teaching material, there was no significant difference. However, regarding the average scores before the first teaching subject and after the second one, there was significant difference on “Curiosity” and “Persistence” (“Curiosity” $t(121)=2.231$, $p<.05$, “Persistency” $t(117)=2.537$, $p<.05$), while there was no significant difference on other three components, “Independence,” “Openness,” and “Impulsiveness.”

4. Conclusion

Conducting the creativity diagnosis test in productive practices of “Metalworking” area using two teaching subjects has clarified the followings on the relationship between fostering creativity and productive practices.

(1) Three structures of Creativity, Creative Thinking, Creative skills, and Creative Attitude are found to be fostered by productive practices using two teaching subjects. Especially, Creative Skills tends to be developed by the series of instruction using the first and the second teaching subject.

(2) The scores of components related to fostering creativity indicate tendency that they are enhanced by the instruction process using two teaching subjects. These components can be divided into three groups according to their ultimate average scores as follows. 1) The components which have high average scores are “Cognition of Problems,” “Memory,” “Self-Evaluation,” “Observation,” and “Openness.” 2) The components which have comparatively high average scores are “Divergent Thinking,” “Expression,” “Information Collection,” “Independence,” “Persistence,” and “Impulsiveness.” 3) The components which have comparatively low average scores are “Convergent Thinking” and “Curiosity.”

(3) The components can be also classified into three types as follows according to the effectiveness of each teaching subject. A) The components whose average scores are developed by the series of instruction with the first and the second teaching subject are “Expression,” “Information Collection,” and “Independence”. B) The components whose average scores are greatly enhanced by the first teaching subject and maintained by the second teaching subject are “Memory,” “Convergent Thinking,” “Self-Evaluation,” “Openness,” and “Impulsiveness.” C) The components whose average scores are highly increased by the first teaching subject but are slightly lessened by the second teaching subject are “Cognition of Problems,” “Divergent Thinking,” “Observation,” “Curiosity,” and “Persistence.” In other words, from the point of view of fostering creativity, the components in type (A) are fostered by the first and the second teaching subject continuously; the components in type (B) are fostered by both the first and the second teaching subject and the first teaching subject is more effective than the second one; the components in type (C) are fostered by the first teaching subject but not so much by the second teaching subject as the first one.

As described above, the fundamental knowledge on fostering creativity in productive practices using two teaching subjects is earned by this study. Based on the findings, we are going to continue to study further about fostering creativity in Technology Education.

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Environment and Solid Urban Waste-Material as Experience for the Pupils

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In the last 10 years technological progress has reached very advanced levels, but it often has not been followed by an adequate behaviour to protect the environment.

That is, it has caused serious damages of pollution of the air, of the water and of the ground.

"We have only one Earth. It is the only place where life is possible, and we do not have another one to replace it".

In this "solemn" declaration, undersigned by 131 countries in 1972 in Stockholm, was concentrated all that which in humanity's hopes, should have become the new conception of survival, and harmonious cohabitation between peoples.

A cohabitation on a planet in step with Science and Technology, but clean and exploited intelligently within the acceptable limits. Above all freed from the plague of Pollution. Actually, man's intervention on natural environment is still today, after many years since the declaration of Stockholm, disordered and unprogrammed.

The consequence is the disaster that lies on our planet.

The present development of the population, that should duplicate during the first years of the coming millennium, will lead to a considerable exploitation of natural ressources, in the aim of meeting the increasing requirements.

Thus technology will be forced further towards the future, to be able to satisfy the new and more sophisticated requirements of production.

Consequently we shall have a greater promotion of the industrial activities, together with an increase of industrial and urban waste material.

From this derives the major incidence of pollution, that is the daily introduction in the surroundings, of increasing volumes of injurious substances: solid-liquid-gaseous.

Substances harmful to vegetation, to fauna and to the human organism.

To be able to solve and prevent the degrading environment problems, it is necessary to be acquainted with the different factors of pollution deriving from human activities, their impact on the environment and the technical and technological solutions that can be adopted.

In addition there are situations caused by the irresponsable intervention of man: as for example the indiscriminate cutting of trees, the arson of woods, the excessive exploitation of the agricultural ground, provoke irreparable damages that on a planetary level can be the cause of very serious unbalances. Technology can give a considerable contribution in solving the problem, but it is indispensable that the citizens have an 'ecological conscience'.

Consequently it is necessary to stimulate pupils to face this problem, that involves everyone daily.

They must be aware of the fact that to be able to live in better surroundings, precautionary measures must be taken:
- To utilize less polluted materials.
- To adopt less polluted technologies.
- To put under control substances at risk.
- To promote research to deepen knowledge on the origin of certain phenomena (See the considerable increase in cases of cancer, due to the use of asbestas and the necessity of land reclamation).
- To favour the use of technologies that are more respectful towards the natural environment.
- To strengthen citizen’s education to reproduce the pollution of the more common solid urban waste material:

- Animal and vegatable organic substance
- Paper-cardboard
- Plastic material
- Textile material
- Wood
- Glass
- Metals
- Inert material: bricks, rubber
- Industrial waste material
- Hospital waste material

Setting the question to the pupils

How to contribute to better environment?

DIDACTIC PATH	STAGES
What is the meaning of the term WASTE MATERIAL	Stg.1 Approach to the problem Questionnaire or sketch
To take conscience of the enormous quantity of waste material in daily life	Stg. 2 Search work documentation Discuss on the problem
Bringing out the interactions existing between one’s own actions whether biological or social and the problem of waste material	Stg. 3 Work on field: data collection (documentary search on differentiated collection)
To single out various types of waste materials: -Solid urban waste material -Special waste material -Dangerous urban waste material -Toxic waste material	Stg. 4 Projecting active proposals Educative realization and communication Divulgation of data

1st Action
How to reduce waste material?
(Change attitude – learn to make from waste: Reutilization of containers-jars-boxes-etc)

2nd Action
To get acquainted with the recycle system.
Concept of recycle and clearance of the most common waste material.

- Learning data collection
- Learning data processing
- Learning to formulate proposals
- Learning problem solving
- To be able to express one's own opinion on the problem of solid urban waste material.

3rd Action

ENTRANCE VERIFICATION

Questionnaire of approach to the problem

ENVIRONMENT

Mention at least 6 words or sentences – or sketches- that come to your mind when thinking about the word written in the rectangular above.

WASTE MATERIALS

What do these words remind you of?

4th Action

The pupils organized in groups, transcribe synthetically a list of urban waste materials produced in a specific context.

- domestic-single residences
- commercial – shops - bars- hotels
- offices
- handcrafts – industries

CUMBROUS WASTE MATERIAL:
- road cleaning
- greens: pruning and grass mowing
- building demolition or restructuring
- hospitals – medical and veterinary surgeries
- markets: vegatable, fish, cattle markets.

QUANTITY:

Dimension of the problem.

The average Italian man produces 1 kilo of solid waste material a day – 350 kilos every year, that means 5 times his corporal weight.

Italy produces 20 million tons of urban waste material every year, equal to a volume of 125 million cubic metres (a skyscraper of 42 floors, a square base with the side 1 km long)

THE PACKING:

An unnecessary output of waste material and waste of raw materials, represents 40% in weight and 60% in volume of all urban waste materials; foodstuff industries, confectionary and chemical industries (cleaning detergents and house products in general).

Hygienic sanitary sector and beauty sectors with the aim of attracting the customer (higher cost), (excellent fine paper uselessly-used and thrown away).

Choose ready packed products with more care.

PROPOSALS TO REDUCE URBAN WASTE MATERIAL

Correct behaviour of all citizens: avoid throwing away in the street any kind of paper , even small tickets of means of transport, plastic bags, cans, glass or plastic bottles, glass and plastic glasses, lamps and run down batteries, expired medicines, card boards, wood, metals, etc.

- To carry out the differentiated collection using the specific containers, that are normally placed along the roads, or near the shops where the above mentioned products are sold.

- Concrete and realistic verification actions to reduce waste material:
- To carry out an inquiry with experts of the “local health system” about the level of pollution in the territory where you live.
- Create voluntary committees: parents – students and teachers, to make inquiries in one’s own neighbourhood, and find out how many families respect the rules about the correct use of the containers for the differentiated collection, favouring the recycling of materials for their regular reutilization.
- All this would lead to economical advantages and it would obviously slow the increasing of any form of pollution of the air, the water and the ground, that are a welfare for the entire humanity.

5th Action

Students divided in groups plan an investigation to locate illegal dumps present in the territory (divided in zones).

- Carry out a planimetry and mark the spot with the dump.
- Use a camera and expose with photos and slides the images of the site. Or better still, use if possible a videocamera and produce a cassette to document the facts.

- Then accomplish a board to give information about the environment situation of the territory, even through the press – to invite every citizen to keep the environment clean, for a better quality of life.

- Forward all your experiences to the Major of your town, and to the environment counsellor, to stimulate to take precautions.

- Carry out a fact finding investigation, to discover how urban solid waste materials are discharged in your town of residence.

ILLEGAL DUMPS PRESENT IN THE TERRITORY

1st dump spot	kind of waste material (in order of quantity)	area (approximate) occupied in m2
2nd dump spot	same	same

CONCLUSION

To face the problem of life in the school through a technological scientific systematic study, means to weigh upon the behaviour of the pupils, either by educating them to question themselves on their habits, or also to favour the involvement of the adults towards a new technological culture, suitable for the future.

As for example to develop research of more suitable systems for the destruction of urban waste materials.

Thus it is important that the study of technical education be extended in every order and grade of the school. Promising among other things, possible competitive examinations coordinated with the competent authorities: municipal-sanitary.

Examinations motivated to favour acquired knowledge in technology are today indispensable to better the way of life and to respect human rights.

Impacts of Technology Education on the Young Generation

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> "Technology has become a powerful force in everyday life, Humans have the ability and responsibility to use technology to create an even better future. In order to this, teachers must educate future citizens now to be technologically aware, literate, and capable."
>
> Prof. Dr. W. E. Dugger, Jr.

Summary

Technology education as an essential part of general education enables the pupils and students to get acquainted with the general principles of basic production processes including the high technology and the use of computers in all the spheres of human activity and with the management of it. The understanding of the scientific base of production processes and the acquisition of general technological abilities which are used in production, constitute the bases for further development of some types of specialized education. Technology education is from that point of view understood to be a necessary precondition for success of full implementation of specialized education resulting in conscious career choice of further studies or taking a job.

The system of technology education creates within the general education a "bridge" between the school and real life and forms a precondition for the acquisition of technological literacy and for lifelong education. Technology education is a principle for providing technological knowledge, skills and attitudes required by a developed economy, and contributes to greater ability and flexibility of the future workers within the changing conditions during the introduction of modern technologies. Technology education contributes to the formation of a personality of young person by the following attributes: pedagogical, psychological, social, preparatory, ecological, aesthetic, and integrated.

From this point of view it is necessary to consider the curriculum in terms of either single or integrated teaching subjects, in which the emphasis is laid not only upon the acquisition of technological knowledge in the subject but also upon skills, abilities and attitudes towards technology, upon the pupils´ initiative, training in problem solving ability, on their ability to correctly consider social economic questions, and to develop ecological thinking in the pupils.

1. BACKGROUND

Scientific and technological innovation are growing exponentially. In no other sphere is this strong trend reflected so completely as education which must response in advance to these changes. Therefore, these trends in technologization of general education are presented in advanced countries not only from the point of view of acquisition of general technology but also information technology, computer technology, and the application of so called "cognitive engineering" with the aim to develop technology education, and to prepare the next generation for the world of "technical economic market".

The principle is that "our youths must know how to orient in the world of technology because this is the basic capital for the society of the future" (Layton, 1985) is generally accepted and is becoming one of the project bases for the Project of Technology Education for 2000+.

2. CONTRIBUTION OF TECHNOLOGY EDUCATION FOR HIGHER QUALITY OF PREPARATION OF THE YOUNG GENERATION FOR LIFE IN THE 21ST CENTURY

Technology education has the same as every educational activity two levels – level of knowledge and level of skills. Technology education develops technical abilities of each individual and follows into formation of positive and conscious attitude of a man to technique. It helps to create adequate attitudes, necessities and interest stimulating thinking and behavior of each individual. Technology education cannot be, however, oriented only to technical problems but must include even a humanist charge. Technique and technology must serve to a the mankind and cannot lead to its destruction. The engagement of the relationship of technology and ecology is connected with the above, i.e. as mutually conditioned spheres. Technology education contributes to harmonic development of a personality and enables a person to understand and rationally apply modern technique and technology at work as well as in everyday life. However, this is not concerning understanding the topic of the present technique but particularly the understanding the principles of function of technological equipment, their priorities as well as perspective possibilities. It is just the modern technique and technology which not only increases the productivity of work in any sections of national economics but which also releases a person from many mechanical activities, facilitates his/her life and open space for his/her creative activities as well as for rational use of free time according to his/her interests.

Technology education requires an exemplary approach, not encyclopedic. Understanding the substance of basic technological processes, principles and function of modern technique together with the development of skills of technological character we consider as the base of technological literacy. The pupils would during the compulsory school attendance (nine-year in the countries of Central Europe – aged from 6 to 15 years) lay a firm foundation for the development of technological skills and its introduction will have an effect on the kind of knowledge, skills and attitudes. Pupils must get the opportunity to understand the need for wealth creation in our democratic society and the function of industry and commerce in maintaining and improving the quality of life. In addition, the effects that technology can have on the environment and the effect this has on the development of values.

The importance of technology education also lays in the fact that this subject develops competencies, knowledge and skills through problem solving which enriches each individual. School technology should place the pupils into a position to participate as a problem solver, decision maker, engineer, fabricator, evaluator and consumer. We understand the importance of technology education for the young generation in a wider context, in the integration of its informative and formative function. It is also not possible to reduce technology education only to one subject due to the fact that this is concerning a principle which is realized within the whole system of education (formal and non-formal). The principle is, that “our youths must know how to orient in the world of technology because this is the basic capital for the society of the future” (Layton, 1985).

In the newly concepted system of technology education in the countries of Central Europe there is an emphasis laid not only upon the acquisition of technological knowledge but also upon intellectual and practical skills and abilities of the pupils, upon their initiative, training in problem solving and communication ability, of their ability to correctly consider social-economic problems, to develop ecological thinking in the pupils and to contribute to the development of their adaptability and flexibility.

It is necessary to take the following into consideration as the basic criteria at the reform of the system of education, i.e. that it is necessary to implement the system of technology education for all throughout the system of formal and non-formal education.

Technology education as a new feature of modern general education develops technological literacy for all and a precondition for specialized education.

The new Czech P0roject for school technology follows the UNESCO PROJECT 2000+ DECLARATION in formal and non-formal education at all the levels of general schools.

Integrated system of school technology presumes the realization of technology education at the following levels:

- in general subjects – particularly in sciences, maths, etc.
- in special compulsory technological subjects in each grade,
- in various forms in non-formal education (free activities),
- in various kinds of technological competitions,
- in practical work reflecting the age of the pupils.

2.1 General Aspects of Technology Education in the System of General Education

The development of general literacy and general development of the pupils represent particularly the following attributes of technology education:

PEDAGOGICAL

The corresponding standard of technology education shall cover intellectual activities as well as practical activities which develop motoric skills of a pupil. An optimum proportion is on the basis of research stated in a relation of 70% of manual activities and 30% of intellectual activities. The basic structure of teaching which is framed in this way, may effectively help to develop pedagogically valuable characteristic, it particularly teaches a precise, systematic and planned work. It develops the sense of responsibility, it leads to creating habits of self-control during the performed activities. The change and porosity of intellectual and practical manual activities reduces weariness from a one-sided intellectual load of the pupils.

PSYCHOLOGICAL

Manual and intellectual activities help to develop motoric skills and at the same time they develop thinking, creativity and independent action. The manual activities allow the pupils who are behind in the teaching subjects oriented to intellect, to be successful in their work. Every pupil should have the possibility to apply his/her abilities and interest and to their further development in the framework of general education even though he/she is not an intellectually oriented personality. Every person has a certain presupposition or ability and we should give him/her a chance and help to develop these abilities at school.

SOCIAL

The present level of human knowledge has processed in all its spheres so far that the period of individuals – discoverers and inventors is gone. Further development is almost in all the spheres of human activity a matter of a team work. For this reason the pupils learn the bases of team work in technology subjects, during work in workshops and laboratories, when the final result in work teams depends on work of each individual. This leads to the development of the sense of responsibility for their own work and for the work of a team, the pupils learn to control and check not only their own work but even the work of their colleagues.

PREPARATORY

Getting acquainted with various working activities, technologies, with the world of work is very important in the process of career orientation of the pupils. The work education (in the present terminology) is in debt to the pupils in this sphere. The career orientation in a wider range than only the preparation of handicrafts must form an integral part of technology education in general educational school. Excursions to production plants, laboratories, computer centers, but even to banks should become an integral part of teaching.

ECOLOGICAL
As we have already stated, the state of the environment depends on the decisions of people. Getting acquainted with the characteristics of materials, production technologies and their effect on health of a human being and the environment as a part of technology education may considerably contribute to gradual improvement of ecological situation of our countries.

AESTHETIC
One of the most important parts of utility features of every product is its form, color finish but even the selection of appropriate material for its production. When selecting subjects for the pupils´ products we have the possibility to suitably effect the perception of the pupils, to develop their aesthetic feeling by arrangement of the working environment of a workshop or a laboratory. There is fantasy being applied in independent work of the pupils, their imagination is being developed, and the individuality of a pupil is being applied.

INTEGRATIONAL
A successful production of a product or performance of a laboratory experiment from the stage of preparation to the end requires the application of knowledge and skills from many more disciplines. In the stage of preparation when producing an article, there is the knowledge of technical design – reading or projecting a design; of mathematics – measure out and drawing out the semi-finished article applied; the selection of technological process and selection of equipment depends among other on the physical characteristics of materials and equipment. The selection of surfacing then requires knowledge from the sphere of chemistry (resistance to the environment effects, or mutual reactivity of basic and laid on material, etc.). Further on it is necessary to consider even economic aspects of production (material price, the percentage of waste, correct and economical equipment treat, etc.) during the material design and working process.

2.2Formation of the Pupils´ Attitude to Technology

By way of introduction let us remind of the basic thesis: As technology is an integral part of work life and everyday life, it is said that people in industrial societies need technological capabilities to cope with practical problems of their lives, insofar as such problems are formed by technology, work, and economy. Requirement for the technology education to become an integral part of general education which is explained on a scientific basis, however, has another also important aspect. It is the formation of positive attitude of the pupils to technology and technique.

We understand the formation of the pupils´ attitude to technique as a permanent and complex process which is realized in schools or out-of- schools (in various forms this is concerning technical activities as for example technical circles, technical competitions, etc.). The formation of conscious attitude to technique has the same as any educational activity the level of knowledge and skills and includes the development of technical abilities of each individual. Purposeful, non-violent and continuous affect on the pupils enables the formation of their positive and conscious attitude to technique, to the creation of adequate attitudes, necessities and interests which stimulate thinking and behavior of each individual. Technique and technological processes cannot become something like a “taboo” for young people, something which is very difficult to understand to only, and due to which they shall not develop endeavor to understand its substance.

One of the conclusive facts is that if we are to create attitude to a certain sphere of human knowledge we must get acquainted with it. The system of technology education as a part of modern general education (formal and non-formal) forms basic preconditions for that. However, this is not concerning only informative influence of topic of technological character on the pupils. Its formative influence – formation of positive attitude to modern technique which is a necessary tool for the life in any sphere of the society, is also a very important factor. Technology education supports and helps to further develop technical interests of the pupils, it supports their desire to understand some of the technical subjects, to apply technique and to rationalize any of their activities with its support.

The formation of positive attitude to technique is a significant factor in the conscious career choice in which the pupils choose the study in any secondary technical school or at the university of technology.

The preparation of youths for the 21st century sets a task for the young generation to manage to apply information and computer technology which is becoming a necessary part of job qualification in the last period.

During the formation of technical abilities we emphasize the fact that the pupils should manage to operate with modern technique and to quickly adapt to new technical changes. We do not make difference between the boys and girls. In many professions in which feminization is expressive, i.e. banking and commerce, but also health care and other spheres the assertion of information and computer technology is one of the preconditions for successful managing of work activities. The present modern technical equipment of households with various electrical appliances also preassumes that its attendance shall know the base of their function.

The bases of attitude of youths to technique helps to create the system of school technology. This is the start line from which the intensification of technical interests in adulthood follow from in the future, i.e. not only by a form of correspondence study and participation in various educational courses and seminars to the innovation in technique and technology, in post-graduate study of these spheres at universities, at technical short-term affiliations in foreign countries, etc.

The formation of the pupils´ attitude to technique is a process which forms the base of this attitude for the whole life.

2.3. Key Skills in Technology Education within Technology Education for Youths for the 21st Century

The intensive development of science and technology at the turn of the millennium affects all the spheres of life of a human being. The school as the general institution of education should therefore provide the pupils with such education which is usable in the quickly changing conditions on a perspective and long-term basis. The problem of key skills from this point of view is coming forward, which would make the young people to flexibly response to the fast development of the scientific knowledge and the more intensified application of high technology in everyday life. We understand the term of key skills as a set of activities included in the new curricula which would enable the young people to accept and to creatively apply new information of various types in a wide context. That means that this is concerning such skills which are necessary for the performance of various professions, without which a human being cannot live in personal life, and which form a precondition for the life-long education and adaptability to the changed conditions. The key skills then do not have a particular content of topic but they are determined by particular basic types of activities and responses which are acquired by a pupil during instruction of various teaching modules in the sphere of theory as well as practice.

The following are considered as **key skills in technology education**:

- ability of problem solving and creativity,
- ability of thinking (system thinking, hierarchical thinking),
- ability of evaluation and judgment.

Other key skills of a more general character are included into the above which form one unit with the above mentioned key skills, i.e.:

- interpersonal communication,
- interpersonal interaction,
- self-management,
- application of information technology and numerical applications.

The acquisition of key skills by the pupils is a long-term process with the domination of activating teaching strategies, particularly project teaching and problem solving following by its thematic orientation to theoretical knowledge and practical skills not only in the subjects oriented to technology but even in the basic subject of natural sciences and other subjects of general education. The cross-curricullar approach is also considered as one of the preconditions for the development of key skills at the pupils. The system approach in thinking and activity forms one of the characteristic features of key skills the same as system analysis and synthesis. It is evident that it is not possible to concentrate the development and fixation of key skills at the pupils of general education school only into technology education, due to the reason that it is the task of the educational effect of the whole school. The subjects of technology character, however, create by its specific topic, many opportunities for the work out of the pupils´ projects with the application of problem solving and they particularly contribute to the development and fixation of key skills. In case we transfer the term of key skills into the present terminology, we can characterize the key skills as the basic "know-how" with which the pupils are provided into life by general education school.

2. CONCLUSIONS

The problem of approach to the technology education is very wide and in my presentation I could orient only to some up-to-date problems which we consider as key problems for the improvement of quality of the level of technology education for all at the present.

Please, allow me to remind you of that the Project 2000+ to which The World Forum organized by UNESCO in Paris in July 1993 has been devoted to, clearly formulates the tasks for this sphere of education to the year of 2000+.

Technology education as an essential part of general education for all has an unreplaceable role in the fulfilment of these requirements during an intensive scientific technological development, introduction of new technologies and information technologies into any sphere of our society. Technology education plays key role in the preparation of young people for the world of work by helping them to understand the economic needs of the society, and by assisting them to acquire the relevant skills, qualities and attitudes which they will need in order to achieve their potential and make a successful contribution to the democratic society. Key among these qualities is the commitment to life-long education which is increasingly recognized as an essential component of individual and national development with economic reform, patterns of employment in the Central European countries are already changing rapidly. Free development of personality, creativity and independence for problem solving, self-motivation as well as abilities for team work and analyzing social impacts of decision are some of the qualities the technology education should help to develop.

The newly concepted curricula of technology education shall form the base for the realization of the system of post-secondary education and technical preparation of the young people respecting not only the needs of the present, but particularly of the quickly changing labor market and the necessity of higher flexibility and adaptability of workers to the new conditions.

By way of conclusions, I would like to emphasize that “TECHNOLOGY FOR ALL – CHALLENGE FOR THE FUTURE” is an imperative for us – pedagogues as well as for the whole society.

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The Impact of Technology Education, as a New Learning Area, on In-Service Teacher Education in South Africa

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INTRODUCTION

The phenomenal increase in information and knowledge, the accelerated pace of change and the much greater variety that is foreseen for the society of the future can be accepted as inevitable (Toffler 1981:360; Coates in Streichler 1994:9). In a developing country such as South Africa where communities are exposed to both First World and Third World elements concurrently, these daunting changes can at times confuse a vision of sustainable development. However, from the perspective of strategic planning D'Amico (1988:237) maintains that:

> ***... we can influence the future ...***
> ***... today's trends can help us anticipate the future ...***
> ***... today's decisions can help us realize the future scenario that is best for us ...***

Against this background I look forward to the successful implementation of the new outcomes-based educational system [named Curriculum 2005] in South Africa with great expectation and anticipation albeit with some apprehension. Is it possible that we, in South Africa, can realise a high road scenario (Sunter 1998) for education in South Africa that would make the beginning of the new millennium also the beginning of an era where our educational system empowers all our people to develop into innovative, critical, responsible and effective citizens with the capacity to improve their quality of life by utilising available resources and opportunities? Yes, I think it is possible. However, to achieve this scenario the whole population needs to be involved and obviously one of the priorities will have to be to effectively elevate the general literacy [language, communication, numeracy] of especially that part of the population at present locked in a Third World situation. It is encouraging that the critical cross field outcomes, as envisaged by Curriculum 2005, do address this priority to a large extent (Department of Education: 1997a: 6).

Curriculum 2005, however, goes one step further. A completely new [to public schools in South Africa] learning area, namely Technology, has been introduced as a compulsory subject [learning area] to be taught in the foundation, intermediate and senior phases of the General Education and Training band [first nine years of schooling] in South African schools. The introduction of technology as one of eight new learning areas [subjects] in the educational system emphasises the notion of technological literacy and could make education more relevant to the South African society.

In fact, if technology education in South Africa is aimed at supplying the youth, as future citizens, with the necessary resources to live effectively and meaningfully in a technological world which is becoming increasingly more complex (Dugger & Yung 1995:4)(Savage 1993:41) the new Technology Learning Area does have the potential of making education more relevant to the South African society.

The time frame within which technological changes are now introduced into society has been reduced to far less than the life expectancy of an individual. People are thus exposed to many changes within their lifespan. Technology education addresses the problem of coping with these changes and has the capacity and potential to establish and nurture a culture of lifelong learning (Draghi 1993:85). This, combined with the practical, activity based, design and problem solving nature of technology education in general, opens up the possibility that the new Technology Learning Area in South Africa could also help to establish and maintain a culture of learning among our learners. By including relevant aspects from other learning areas in a cross curricular and interdisciplinary way technology education could be integrated to form a relevant whole which will empower learners to function effectively in a technological environment to the benefit of the individual, society and the natural environment. The new Technology Learning Area could thus make a definite contribution towards ensuring that the technological future of the South African society will be a meaningful one (Eisenberg 1994:5). By elevating their technological literacy, individuals should be enabled not only to become involved in the application of technology but also to enter into effective dialogue with the professional technologists, technicians and officials who make key decisions about their lives and welfare, on a daily basis. As Liao (1994:4) puts it:

> ***We must all become more technologically literate so that we can make more informed decisions about personal choices as well as societal choices. And if our democratic society is to thrive in an increasingly competitive global economy, we must use technology more intelligently.***

This is all about the improvement of basic technological literacy with the overall aim of developing technologically literate citizens who are able to:

- use, create, and evaluate technology and technological innovations,
- operate with independence in a technological environment and !
- contribute in this regard in the community, the economy and the environment.

These views are underscored by Gilberti (1994:10) as follows:

> ***Citizens in a democracy should understand the relationship of technological development to societal change. The rationale for universal technological education stems from the ideals of cultural education, the responsibilities of democratic life, and the need for economic security. Technology education furthers understanding of our technological means and empowers students to respond rationally to life=s challenges.***

But, to come back to the impact of technology education, as a new learning area, on in-service teacher education in South Africa, the curriculum for this new learning area has been formalised by the National Education Department in South Africa and is now being phased into the educational system. Technology Education thus suddenly has an impact on the day to day activities of a large number of teachers. Obviously one of the impacts in this regard has to do with the need for in-service training for teachers who now, for the first time, have to teach technology as an integral part of an outcomes-based, cross curricular and interdisciplinary approach.

THE ENVISAGED IMPACT OF TECHNOLOGY EDUCATION ON SOUTH AFRICAN SCHOOLS AND COMMUNITIES

The envisaged impacts of the new Technology Learning Area in South African schools correspond to the critical cross field outcomes of the new curriculum. These critical cross field outcomes (Department of Education 1997b:14-27) as is envisaged for all learners in the South African educational system can be summarised as follows:

Learners should be able to:

- communicate effectively,
- solve problems,
- organise and manage themselves,
- work effectively with others,
- process information,
- use science and technology effectively and
- understand the relatedness of society and the environment.

To be able to attain the goals of more relevant education, and of nurturing a culture of learning [including lifelong learning] and technological literacy, the educational authorities in South Africa have given the following rationale for the introduction of technology as a new learning area.

The **Technology Learning Area** seeks to develop in pupils

- an ability to **solve technological problems** by investigating, designing, developing, evaluating as well as communicating effectively in their own and other languages and by using different modes of communication
- a fundamental understanding of and an ability to **apply technological knowledge, skills and values**, working as individuals and as group members, in a **range of technological contexts**
- a critical **understanding** of the **interrelationship** between technology, society, the economy and the environment

This **understanding of technology** should contribute to

- the development of learner=s capability to **perform effectively** in their changing environment and to stimulate them to **contribute towards** its improvement
- the **effective use of technological products**, processes and systems
- the ability to **evaluate technological products**, processes, and systems from a functional, economic, ethical, social, and aesthetic point of view
- the **design and development of** appropriate **products**, processes or systems to functional, aesthetic, and other specifications set either by the learner or others
- the delivery of **quality education** and access and redress through its relevance to the ever-changing modern world and the integration of theory and practice
- the development of citizens who are **innovative, critical, responsible and effective**
- the **demystification of technology**
- the recognition of and respect for **diverse technological solutions and biases**
- creating **positive attitudes to, perceptions of and aspirations** to technology-based careers.

The new technology learning area will eventually be compulsory for all learners from Grade 1 to Grade 9 which forms the General Education and Training band in the new educational system in South Africa (Department of Education 1997a:85).

This might seem to be too much to expect of the implementation of the new Technology Learning Area. Obviously there should be guarded against having unrealistic expectations with regard to what can be achieved by implementing this new learning area. However, when one looks at what is said about technology education in general in the literature, some writers feel that technology education can make a significant contribution in this regard. For instance, D'Apolito (1997:4) is of the opinion that technology education is essential education for the 21st century, Wright (1996:3) feels that technology education should be an essential area of study in schools and Dugger & Satchwell (1996:13) are of the opinion that teaching technology should be a national priority in the United States of America.

According to Eisenberg (1994:5) there is a clear relationship between the amount of technology education in the general education curriculum and the contribution of industry to the gross national product of 9 countries that were analysed. In this regard it is thus perhaps not to farfetched that Wright (1994:28) puts it that technology education will be the '**The New Basic for the Twenty-First Century**'. According to Bensen and Bensen (1993:3) technology education in general could form the basis for what they call '**know how**' and lay the foundation for the designers and problem solvers of the future, no matter what particular occupation they may want to qualify themselves in. Mahlke (1993:6) again proposes that the development of critical thinking skills and creativity as early as the foundation phase should be one of the main objectives in this regard. Technology education in general could thus be used as a vehicle to teach skills in the different ways in which technological information can be manipulated and processed and by creating a learning environment that enhances motivation and positive attitudes (Starko 1995:119), technology education could also lay the foundation for the development of creativity and innovation.

The viability of attaining the above mentioned critical outcomes by applying the specific outcomes of the Technology Learning Area using an outcomes based approach in South Africa still needs to be proved in practice. I do, however share the opinions expressed above and the vision of the South African educational authorities that it is possible.

THE RANGE OF THE IN-SERVICE TEACHER EDUCATION THAT IS NEEDED

To attain the vision mentioned above the range of the in-service teacher education that is needed within the South African situation is rather extensive. The reason for this being that, although some of the practising teachers in South Africa may be familiar with some of the concepts, processes, content and methods associated with teaching technology, the vast majority have had no formal training in this regard at all. This situation is complicated even further by the fact that they also have to receive in-service training with regard to the new outcomes-based educational system in general. From the prescribed curriculum for the schools it can be deduced that the range of the in-service training for teachers will have to include at least the following topics:

- The technological process
- Technological content (energy, systems, structures, processing, etc)
- Materials and tools
- Managing the technological environment and safety
- Teaching/learning methods for technology education
- Teaching practice and internships for technology education teachers

It has to be kept in mind that in the foundation phase (grades 1-3) and the intermediate phase (grades 4-6) all teachers will have to present the Technology Learning Area in a cross-curricular way as a part of a clustered learning programme. In the senior phase (grades 7-9), however, the Technology Learning Area is one of the eight independent learning areas (subjects) and approximately 12% of these teachers will be involved in the teaching of technology. In other words at least 80% of the teachers mentioned above will have to receive in-service training over the period in which the new Technology Learning Area is phased in.

Any informed person with regard to technology education would realise that to present the in-service training mentioned above to so many teachers spread across the whole of South Africa would be a daunting task at least (Potgieter 1996: 18).

THE TECHNOLOGICAL PROCESS (DESIGN) AS A COMMON INTEGRATING FACTOR

Against the background of the curriculum that has been adapted for the new Technology Learning Area in South Africa it is important to realise that although this new subject is not called 'Design and Technology' the concept of 'design' has been incorporated into what is called the technological process.

To ascertain whether the compilers of the curriculum for the new Technology Learning Area in South Africa have succeeded in incorporating the essence of 'design' into the curriculum one has to look at what is generally perceived when one refers to 'design'. Obviously design can not been seen as unique to only technology education. Design has for a long time been an integral and necessary part of the curriculum for the training of artists, engineers, architects, industrial designers, clothing designers and so on. In the literature, however, few writers hazard to give a definition for design, they rather refer to what designers do, what the design process should look like and what the results of design are (Baynes 1976; Margolin 1989; Potter 1989; Hurlburt 1981; Lawson 1980; Jones 1991; Mayal 1979). Potter for instance puts it as follows:

> ***Every human being is a designer . Many also earn their living by design - in every field that warrants pause, and careful consideration, between the conceiving of an action and a fashioning of the means to carry it out, and an estimation of its effects.***
>
> ***In fact this book is concerned mainly ... with ... designers whose work helps to give form and order to the amenities of life, whether in the context of manufacture, or of place and occasion. The very clumsiness of this definition underlines the difficulty of using one word to denote a wide range of disparate experiences - both in the outcome of design decisions and in the activity of designing.***

McCade and Weymer (1996:41), in an article in which they define the field of technology education, put forward the following argument:

> ***As long as there have been people there has been technology. Indeed, the techniques of shaping tools are taken as the chief evidence of the beginning of human culture. On the whole, technology has been a powerful force in the development of civilization, ... Technology - like language, ritual, values, commerce, and the arts - is an intrinsic part of a cultural system and it both shapes and reflects the system's values. .... In the broadest sense, technology extends our abilities to change the world: to cut, shape or put together materials; to move things from one place to another; to reach farther with our hands, voices and senses. We use technology to change the world to suit us better.***

The similarities between the two arguments mentioned above could be one of the reasons why the Department of Education in South Africa (1997a: 85) have adopted a functional approach and describe the technological process (design process) as a cycle including the following steps:

- Problems, needs and wants are identified and explained
- A range of possible and relevant solutions are designed
- An informed choice is made
- A design is developed
- Solutions are realised according to the design
- The realised solution is evaluated
- The process is recorded and communicated

This is similar to the very general approach adopted by Winek and Borchers (1993:23) when they describe the components of the technological process in general terms as follows: identify, define, observe, appraise, try out and evaluate. From a more practical perspective Garret (1995:9) identifies the following steps for implementing the technological process in the classroom: define the situation, analyse the situation, describe the problem, do the necessary research, identify specifications with regard to the problem, generate alternative solutions to the problem, select the optimum solution, make working drawings and plan ahead, make a prototype, test and evaluate the design and write a report. Bosworth and Savage (1994: 10) also use a functional approach to describe the technological process and recommend the following steps: statement of the problem, gathering of information about the problem, analysis of the problem, modelling, problem evaluation, producing prototypes and observation and feedback.

It could thus be said that the technological process describes everything that should happen in a particular technological endeavour - from the inception (an idea) through the development (designing, making, evaluating of a product, process or system) to the conclusion (marketing) of the technological endeavour and that the technological process is usually described in terms of a set of consecutive steps that are to be followed in a cyclical fashion.

But design is much more than mechanically following one or the other of the above mentioned sets of steps. In his book titled '***Principles in Design***' Mayall (1979), for instance, names and describes the following ten design principles which should be taken into account when considering alternative designs: totality, time, value, resources, synthesis, iteration, change, relationships, skills and service. The acquisition of the necessary skills to effectively and efficiently apply the design process should be seen as one of the main focus points of technology education. Denton & Williams (1996:15) put it as follows:

> ***It is becoming increasingly recognized that the processes students use to create solutions to technological problems are a significant aspect of technology studies. These processes, often collectively referred to as the design process, have the potential to facilitate student development in a range of useful skills, ...***

The importance of this aspect of technology education is underscored by Custer (1996:8) when he says the following regarding the '**National Science and Technology Week**' of April 1996 in the USA:

> ***This year's emphasis is particularly important since it recognizes one of the critically important and unique niches of technology education in the education of all students: namely, design.***

For the technological process to be considered to be an integrating factor with regard to technology education in general there should be a balance between the factual content that is presented and the process skills that are to be acquired. This may all seem very simple and straightforward, but, the complexity of what happens during the different steps of the technological process should, however, not be underestimated. It is during the step ***design and develop alternative solutions*** in particular that the complex process of innovative and creative 'designing' happens (Denton & Williams 1996:15; Kimble, Stables & Green 1996:30).

To teach the technological process (design process) effectively learners themselves should be continuously exposed to their own design experiences and activities and not only be shown examples of the design efforts of other people. Design activities should not focus solely on successful design efforts. Learners should also experience what it feels like when design efforts fail and they have to persist and repeatedly redesign until they reach the desired result. This is of particular value when it includes having to design as part of a team or a group where positive social interaction is a prerequisite for success. Shackelford (1996:32) is of the opinion that the design process should be repeated continuously for a wide variety of problem situations as a series of dynamic interdisciplinary activities.

In this way the technological process could integrate the experiences of learners by inter alia encouraging them to reflect on and assess the design process skills that they applied, what they have learnt and what they should have learnt (Shield 1992 : 43).

THE IMPACTS OF TECHNOLOGY EDUCATION ON TEACHER EDUCATORS

The following impacts of technology education on teacher educators are derived from anecdotal experiences during the development of curriculum material and the presentation of for in-service teacher education courses regarding the new Technology Learning Area in South Africa.

- **Viability of the school curriculum for technology education.**

From discussions with other teacher educators at conferences, curriculum workshops and personal meetings I have found that there is in general a feeling of enthusiasm about the possibilities of the new Technology Learning Area. Especially the close relationship between the inherent activity, port folio, problem solving, design and continuous assessment based nature of technology education and the basic tenets of the outcomes-based approach is perceived to be a positive aspect. In other words technology education is seen to be a vehicle by which the implementation of outcomes-based education can be enhanced.

There is, however, apprehension about the fact that curricula at colleges and universities for teacher education courses regarding the Technology Learning Area would have to include not only aspects regarding the teaching of technology but also the technological content as prescribed in the school curriculum. This is mainly because most of the teachers who will be expected to teach the Technology Learning Area in especially the foundation and intermediate phases do not have the relevant academic background. This pertains in particular to the content areas of the technological process, energy, systems and control, structures, materials and processing, data processing, data communication and tool handling.

The above mentioned aspects could impact negatively on teacher educators due to unrealistically high expectations that are placed on technology education curricula for in-service teacher education.

- **Guidelines regarding the development of learning programmes.**

The implementation of an outcomes-based approach to education in South Africa places a high priority on the ability of teachers to independently develop their own learning programmes and gather their own resource material. South Africa does not have the privilege of having a recorded best practice experience and a history with regard to technology education which teachers can draw on to develop learning programmes. This has a direct impact on teacher educators because they have to contextualise best practice material from the literature for the South African situation to include as examples in curricula instead of the relevant information being directly available to teachers in schools.

- **Aspects regarding the incorporation and integration of practicals and teaching practice in a distance education mode of instruction for technology education.**

There seems to be a perception among some sceptical lecturers, teachers and administrators that because the Technology Learning Area is a ?practical subject' in-service teacher training can not be done through distance education. To my mind this 'perceived negative impact of technology education' is not based on factual information but results from people not being informed about the true possibilities of distance education and the misconception that learners [in this case teachers] can not perform practical activities at a location removed from the direct physical supervision of the lecturer.

The Faculty of Education at the University of South Africa, however, does provide in-service technology education through distance education in the form of inter alia a Further Diploma in Education: Technology Education. The curriculum is designed in such a way that learners have to complete a variety of activities [research, write, design, plan, make, evaluate, present, case study, project, portfolio, market] continuously throughout the academic year. Those activities designated as assignments have to be handed in to be assessed and contribute towards the final mark after a written examination. The students also have to attend practical face-to-face workshops totalling 10 days. The workshops are based on the completion of 15 practical projects and the observation and assessment of more that 30 demonstration projects. The learners are exposed to best and worst practice experiences with regard to managing the technological environment, individual and group activities, portfolio compilation, progression, learning programme development, project assessment and learning programme presentation.

The activities mentioned above are structured in such a way that the learners are at first exposed to the technological process and later have to report in detail on how each step of the technological process was carried out or was observed to be carried out. They are also expected to be able to indicate how the activities could be adapted to allow for progression in a school situation. With regard to teaching practice the learners are expected to do practical teaching for five days under the supervision of an experienced teacher and complete a learning programme workbook and a professional project portfolio both of which are assessed and contribute towards the final assessment mark.

When confronted with this information and examples of the work done by learners most of the sceptical people mentioned above usually become enthusiastic about the possibilities of distance education with regard to the in-service training of teachers in technology education.

One impact of technology education in this regard is that distance education teacher educators are required to do in depth and extensive curriculum design and development and that have to be prepared to accept a very heavy work load with regard to the assessment of assignments, projects, workbooks, portfolios, and so on.

Another impact of technology education as implemented in the Technology Learning Area in South Africa is that most teacher educators have to undergo a paradigm shift from associating technology education with mainly high technology products including computers to associating technology education with mainly a high touch, activity based, problem solving process involving all man made artifacts. This paradigm shift also includes the notion of improvisation and using accessible waste material for projects to ensure that technology education is perceived as a relevant and fun subject.

THE IMPACTS OF TECHNOLOGY EDUCATION ON TEACHERS

The following impacts of technology education on teachers are derived from anecdotal experiences during the presentation of in-service teacher education courses, seminars, workshops and a Science Outreach Programme [including the new Technology Learning Area] presented by the Faculty of Education at the University of South Africa.

- **Viability of the technology education curriculum for schools**

Learners at school level are reported to be very enthusiastic and positive about the new Technology Learning Area. This seems to have had a positive impact on some of the teachers involved, resulting in their enrolling for formal courses or attending workshops on technology education.

The phasing in of technology education as part of the Curriculum 2005 project has had an impact on those teachers directly involved, in the sense that they are demanding relevant in-service training and the support of their principals and governing bodies. The responses to these demands as reported by teachers are varied but most are of the opinion that as the implementation progresses and awareness increases the situation should improve.

- **Experiences during the presentation of formal technology education courses**

It was found that those students who throughout the academic year diligently completed all the activities in the curriculum for, inter alia, the Further Diploma in Education: Technology Education, as described above, experienced the impact of technology education as a positive and enriching experience.

On the other hand those students who only completed those activities designated as assignments in order to gain examination entrance experienced the impact of technology education as frustrating because they had to catch up over a very short period of time just before the examination.

From the queries of students during the courses it seems that the assessment strategies envisaged for technology education and outcomes-based education have a significant impact on the day to day activities of teachers and that they are apprehensive about whether it would be possible to sustain them over a long period of time.

Another impact that students report with regard to the implementation of technology education is that they experience a lack of support in the school situation firstly from other teachers and secondly with regard to content resource material and project or activity resource material.

- **Experiences during the presentation of a formal technology education practical course**

During the presentation of the compulsory practical courses described above the students mostly express apprehension about the impact that the implementation of technology education would have with regard to the following aspects that they have to cope with in there school situations:

- a lack of appropriate resources,
- insufficiently stocked libraries and media centres,
- overcrowded classrooms,
- inappropriate and insufficient furniture,
- no room to store materials, tools and projects in progress,
- classes where a number of different grades are combined and
- insufficient time allocation in time tables.

It is, however, encouraging to note that the students usually embrace the notion of improvisation with regard to technology education and that in spite of the limitations mentioned above they are enthusiastic about teaching technology. This is especially evident from the examples presented in workbooks and portfolios and the demonstration projects and the learning programmes that are developed.

- **Experiences during technology education community outreach workshops**

These sponsored workshops are presented to groups of teachers teaching mostly at disadvantaged rural schools. The local communities and educational authorities are involved to determine the needs and to organise the attendance and venues.

Discussions with teachers attending these workshops reveal that one of their main problems is apathy with regard to the implementation of technology education. They partly ascribe this apathy to a lack of awareness and a lack of relevant information due to the remoteness of their schools and the fluidity of their teacher employment situation. There is an uncertainty due to downsizing and redeployment policies. Although they have similar experiences with regard to many of the aspects already discussed they express the distinct need that the Technology Learning Area should receive much more exposure in their communities and that they as teachers should receive much more exposure to technology education in-service training.

COMPARING THESE IMPACTS IN URBAN AND RURAL AREAS

When comparing the above mentioned experiences as they occur in urban and rural areas the following similarities and differences are most prevalent.

- **Attitudes and perceptions regarding technology education**

It is interesting to note that the attitudes and perceptions with regard to technology education as expressed by the teachers attending the courses, seminars and workshops were similar for both rural and urban areas. The attitudes and perceptions vary from positive and informed to negative and uninformed depending on the amount of exposure to information regarding what is intended with the new Technology Learning Area.

- **The nature of parent involvement in technology education**

The same is true for the nature of parent involvement with regard to technology education as expressed by the teachers attending the courses, seminars and workshops.
The nature of parent involvement varies from enthusiastic to apathetic depending on the amount of exposure to information regarding what is intended with the new Technology Learning Area.

- **The nature of the technology education projects that are preferred**

The nature of the technology education projects that are preferred by teachers is one aspect where there was a distinctive difference between rural and urban areas.

In the rural areas there is a distinct preference for technology education projects that focus on basic technological applications that are designed to ensure sustainable development. This is combined with a distinct interest in using the environment as an organiser/theme in technology education.

In the urban areas there is a distinct preference for technology education projects that illustrate technological applications based on the use of scientific knowledge and skills to improve living conditions and leisure time. The organisers/themes for technology education that attract the most interest are communication and transport.

- **The availability of resource material for technology education**

Although the availability of resource material is perceived as a problem area for technology education in general this is especially prevalent in rural areas. Schools in rural areas are particularly disadvantaged regarding access to library material. Even with regard to improvisation schools in rural areas do not have access to the same variety of waste materials that are available in urban areas.

FINAL REMARKS

It should be obvious that the opinions expressed in this paper are just that - opinions. These opinions are not based on a particular empirical study but on experiences and observations in the field at grass roots level and on a variety of evaluation questionnaires collected after the presentation of workshops and seminars.

Although the opinions expressed here can largely be corroborated by the findings of a formal evaluation study commissioned by the Foundation for Research and Development and the Technology 2005 Project [Technology 2005: A National Implementation Evaluation Study. Confidential Report (Final Draft). 17 December 1998. p. 219] this study has not been released for publication yet and it could not be used as a reference.

CONCLUSIONS

From what has been said I would like to draw a few conclusions. These conclusions should be considered against the background of the implementation of a new outcomes-based educational system in South Africa and the fact that the Technology Learning Area is unfamiliar territory for most teachers and teacher educators in South Africa.

- From the literature reviewed it seems that technology education in general and in particular the new Technology Learning Area in South Africa does have the potential of having a significant impact on developing technologically literate citizens who are able to: use, create, and evaluate technology and technological innovations; operate with independence in a technological environment and contribute in this regard in the community, the economy and the environment.
- The range and extent of the in-service teacher education that is needed to successfully implement the Technology Learning Area in South Africa should not be underestimated.
- The successful implementation of technology education in South Africa will to a large extent depend on the provision of the necessary resources and facilities to ensure that the enthusiasm of teachers and learners is sustained.
- Exposure of teachers, learners, parents, school principals and governing bodies to information regarding to what is envisaged with the Technology Learning Area in South Africa should receive much more attention.
- The improvement of technological literacy should become a national priority.

It is hoped that the main impact of technology education in South Africa would be that the new Technology Learning Area would be accepted by teachers and teacher educators to be a viable means of empowering learners. This empowerment should be geared towards developing learners into innovative, critical, responsible and effective citizens with the competences to improve their quality of life by responsibly using available resources and opportunities to solve problems and satisfy needs and wants.

I would like to conclude by presenting you with the following quote by Foster (1996:7):

The profession of technology education is beginning to realize
that the elementary school is a formidable frontier.
Like the Western frontier of the 1800's
or the "final frontier" of outer space,
it is mysterious and quite unlike anything we're familiar with.
And it is populated by strange creatures
we don't understand and quite frankly
are a little afraid of: kids!

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Portfolio Instrument for Assessing Pre-service Living Technology Teachers

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Abstract

There were two major purposes in this research. The first purpose was to develop the Portfolio Instrument for pre-service teachers of living technology at junior high schools and their user's manual. The second purpose was to establish the validity and reliability of the Instrument.

The method of this research included the literature review, nominal group, panel discussions, formal evaluation, and questionnaires. The nominal group began this study with developing the content of the instrument. The draft of the instrument was made, tested, and then revised by researchers. Then, the draft was revised by panel discussion of six experts thoroughly to establish the validity of the instrument. Five senior teachers and a professor of living technology evaluated ten living technology teachers. The reliability (Cronbach's and Kendall Coefficient of Concordance) of the instrument was high. After that, the questionnaires were implemented to investigate the response about the usage of the instruments. Finally, the conclusion and suggestions were provided based on the result above.

I. Introduction

It is a new age of cultivating teachers after the Teachers Cultivation Legislation, Teachers' Regulations, and Teacher's Evaluation Assessment were stated and issued (Ministry of Education, 1995). There are many approaches to cultivate teachers nowadays. Teacher education is now on a transition stage. Not only can normal universities cultivate teachers, but general universities and colleges also can cultivate teachers. Therefore, cultivating capable teachers becomes a major lesson for our teacher education as well as technology education.

Assessing pre-service teachers' competencies to apply their professional knowledge and skills is a major problem in teacher education (Naizer, Gilbert Lad, 1993). How to evaluate pre-service teachers and what are the evaluation norms are urgent issues for educators to solve nowadays. Teacher education is in a new transition phase in Taiwan. The Teacher Cultivation Legislation states a certified teacher has to complete 26 credits of pedagogical courses and one year of teaching practice after graduated from university (Ministry of Education, 1995). Therefore, undergraduates and university graduates may complete pedagogical courses, then pass the examination and become a pre-service teacher. After one year of teaching practice, the pre-service teacher can become a certified teacher by reexamination or evaluation. In order to evaluate and enforce competencies and performance of pre-service teachers, the researcher developed the Portfolio Instrument for teaching practice. Then, the reliability and validity of the assessment instruments were established. After that, the instrument can be applied to evaluate pre-service teachers at junior high schools.

In conclusion, it is very important to develop the Portfolio Instrument on this study. Thus, the study becomes very urgent and necessary.

II. Literature Review

A. Methodology of the Portfolio Assessment

1. Present situation of the Portfolio Assessment

The efficient teaching is one of the major approaches for teacher education.

Thus, it is necessary to develop a new instrument to integrate all kinds of evaluation criteria for indicating qualities of being a good teacher. The new instrument may also be used to play roles of selecting and monitoring teachers, and making summative evaluation. Merton (1989) and Patton (1990) point out the evaluation instrument and system in the past were quantitative, simplified, inferable and only as role of testing. Due to there are so many different efficient teachings, the assessment instrument should be able to explain and evaluate those kinds of efficient teaching. Thus, the assessment system should be explainable, qualitative, and summative.

A study on " elementary school teaching theories and practices" at University of San Diego, there were 25 of 42 students disliked the traditional evaluation methods. They mentioned the content of the traditional evaluation instrument is not sufficient and broad to be able to evaluate students' ability and knowledge (Touzel, 1993).

Nowadays teacher education in many countries tends to be practical and professional. They focus on teachers' higher level abilities, such as analysis, problem-solving, efficient communication, and active joining and learning. In order to evaluate teachers' performance on intern and real teaching effectively, many educators, evaluation experts, and teachers advocate using "performance assessment' or "authentic assessment". Portfolio assessment gets the most attention and importance because it combines practical training and evaluation for achieving purposes of maintaining and promoting teachers' professional qualities (Tsai, 1997).

Teaching practice portfolio assessment is a constructive assessment. A pre-service teacher collects and integrates personal records of practice teaching activities. The evaluator will base on all concrete evidences in the portfolio assessment to evaluate pre-service teacher's knowledge, skill and teaching characteristics. The Portfolio Assessment includes teaching plans, writing and oral report, students' assignment, dairy of teaching practice, records of students' counseling, and students' grades. Pre-service teachers should establish related portfolio information and files through reflective writing, cooperation, and practice. Pre-service teachers could take the responsibility of self-learning through this process (Tseng, 1997; Tsai, 1997; Paulson & Paulson, 1990).

According to the definition of the portfolio assessment, the characteristics of the portfolio assessment are listed as follows:

(1) an alternative approach

Many educators study on utilizing an alternative approach to evaluate teaching performance of elementary and secondary schools' teachers. From the study, researchers have found that portfolio assessment is most suitable for evaluating pre-service teachers since 1990 (Alter & Spandel, 1992; Paulson & Paulson, 1990; Meyer, 1991).

(2) its application is clear, definite, reliable and effective

i. Flexibility

Due to the often changes of pre-service teachers' teaching content and grade, the flexibility of the portfolio assessment has become very important. A portfolio assessment with flexibility includes many directions and examples. The directions and examples are not narrated and limited. Elements of the portfolio assessment are stated carefully, including 1. What contents need to be tested; 2. What are the limitation and restriction on collecting information; 3. When will be appropriate time to collect information; 4. What roles of the portfolio assessment play?

ii. Multiple data resources

Data resources include tests, results of tests, plans, and other knowledge and comprehensive resources, such as course design, reflection dairy, teaching plans, co-teachers' observation records, and videos. Pre-service teachers should be able to provide evidences to prove their problem-solving ability, reflection and self-evaluation ability.

iii. Longitudinal data collection

The portfolio assessment provides continuity records of pre-service teachers' development and achievement. Continuous collecting pre-service teachers' data is very important because longitudinal data collection will enhance the reliability of evaluation.

iv. Integration

Analytic and holistic methods can be applied to explain broad and multiple longitudinal data.

2. Evaluation contents of the Portfolio Assessment

(1) Evaluation contents

Shulman (1986) addressed that evaluation of teacher's qualification should not only emphasize on subject knowledge or educational skills but also should combine pedagogical knowledge and skills. The pedagogical knowledge includes subject knowledge, problem-solving ability and mature mind, teaching techniques, observation ability and knowledge of courses, knowledge of learners and learning, and attitude and tendency.

i. subject knowledge

Subject knowledge contains textbooks, choice of textbooks, establishment of students' learning structure, organization and implementation of teaching.

ii. Problem-solving ability and mature mind

Shaverlson (1983) and Holmes (1986) pointed out teachers are the decision-makers. A professional teacher should be considerate, reflective, and critical. Ability of distinguishing knowledge is one important element of teaching efficiency.

iii. Teaching techniques

Some researcher mentioned that teacher's abilities include classroom management and time utilization, supporting and guiding students' activities, choosing appropriate courses, and communicating with students clearly and precisely. Kagan (1992) pointed out that obtaining teaching techniques begin with classroom management, then subject activity, and finally students' learning activity. Thus, the portfolio assessment can be applied to predict teachers' teaching performance and efficiency.

iv. Observation ability and course knowledge

Zumalt (1992) advocates macro-courses, including course knowledge, teaching techniques, and observation ability. Teachers should be familiar with those three elements to plan and convey knowledge, and to do evaluation.

v. Knowledge of learners and learning

Knowledge of learners and learning is very important for teaching efficiency. Portfolio assessment is not only to evaluate pre-service teachers' knowledge but also is to evaluate if they can apply the knowledge to real teaching.

vi. Attitude and tendency

Teachers' feelings, beliefs, emotion, and attitude can affect teachers' performance in the classroom.

(1) Evaluation data

Researchers at Auburn University (Shannon, 1994) addressed ranges of teaching practice portfolio assessment include five parts. The five parts are teaching, plans and preparation, students and course evaluation, colleague interaction, and interaction among parents and community.

(2) Validity and reliability of evaluation

Shannon (1994) addressed it is not easy to demonstrate the validity and reliability of the portfolio assessment. He suggested applying the flexible and standardized format to solve demonstrative difficulty.

3. Evaluation methods of the Portfolio Assessment

The evaluation method at Auburn University is evaluators review pre-service teachers' teaching practice portfolio, then evaluate pre-service teachers' self-reflection and self-evaluation by responses of interviews.

B. Application of the Portfolio Assessment

1. Analysis of evaluator's responsibility

A study at Akron University (Newman etal., 1993), the evaluators consist of professors and middle school administrative personnel. Touzel (1993) defined the four major responsibilities of evaluators. The four responsibilities are as follows: i. Understanding the purpose of implementing the portfolio assessment, and discussing with students before implementing, ii. Providing pre-service teachers assistance and reference, iii. Examining the portfolio assessment and providing feedback, iv. Applying evaluation broadly and emphasize on evaluators and pre-service teachers' communication.

2. Process of implementing the Portfolio Assessment

The process of implementing the portfolio assessment at Wayne State University was as follows: i. Orientation—evaluators and pre-service teachers received plan-related paper documents, ii. Students' seminars—explanation of purpose and usage of the portfolio assessment, iii. Evaluators included school principals, curriculum experts, guidance teachers, and professors, iv. Evaluators should arrive half an hour earlier than pre-service teachers, v. Pre-service teachers had 5 to 10 minutes to explain their own portfolio assessment or give improving suggestions

3. The scoring of the portfolio Assessment

Raymond (1995) at Indiana University applied portfolio assessment to pre-service teachers of mathematics subject at elementary schools and also used five- scaled assessment to measure all questions.

C. Related studies on the Portfolio Assessment

Researchers at University of Mississippi developed " teaching plan and Materials (TPM)", including 14 teaching abilities, designing teaching, choosing teaching materials, evaluating teaching objectives abilities. Evaluators included outside evaluators, intern school principals, peer teacher, subject teachers. The result of this study found the portfolio assessment can evaluate teachers' teaching ability most (Amos, N & Cheeseman, R. H., 1991).

III. Methodology and Process

The methodology of this study includes literature review, teaching observation, questionnaires, panel discussions, and formal evaluation.

The Teaching Practice Portfolio Assessment was developed and edited. In order to establish the assessment's validity, the researcher held panel discussion to revise the assessment. As to establish the assessment's reliability, the researcher, first of all, selected five pre-service technology teachers to implement this assessment. Secondly, five pre-service technology teachers were given the content of instrument and requested to collect related information for two months according to the References of Teaching Practice Portfolio Assessment of Living Technology Subject at Junior High Schools (Appendix C).

During the above two months, six evaluators went to where five pre-service teachers taught one time every a month. Six evaluators based on the portfolio assessment to evaluate the five pre-service technology teachers for two hours in one time of evaluating. As a result, there were totally two times and four hours' evaluation

IV. Results and Discussions

1. Areas and criteria of the Portfolio Instrument were developed

According to results of questionnaires and panel discussions, the researcher developed the Teaching Practice Portfolio Assessment. Then, on the basis of the analysis, the researcher composed areas and criteria for the assessment. The Teaching Practice Portfolio Assessment includes 6 areas, 17 competencies, and 62 criteria. The areas and the percentage of area's score are design and implementation of teaching plans(25%), classroom management(20%), management and maintenance of shop/Lab appliances(15%), teaching evaluation & feedback(10%), self-reflection and self-growth(15%), administrative affair management (5%) (Appendix A).

The scoring method of actual initial scores was to add up the initial scores from each criterion. After that, the initial scores will be divided by the total scores of each area. Then, multiply 100. The final score will be obtained from the actual initial score multiplied by the percentage of each area.

2. The user's manual of the Teaching Practice Portfolio Assessment was made

The researcher also developed the user's manual (Appendix B) for the instrument. The user's manual includes (1) preface, (2) the Teaching Practice Portfolio Assessment, (3) the descriptions of areas, competencies, and criteria of the instrument, (4) notifications for users, (5) how to guide pre-service teachers to collect teaching practice portfolio, (6)the process of implementing evaluation, (7) qualification and the training process of evaluators, (8) an evaluation example.

3. The validity of the assessment has been established

The formal Teaching Practice Portfolio Assessment was made after panel discussion on the draft of the assessment. The panel discussion included 6 professional experts. The validity of the assessment was established after revising. The scoring method and percentage for each area were defined.

4. The reliability of the assessment has been established

The six evaluators applied the Teaching Practice Portfolio Assessment to evaluate five pre-service technology teachers by their teaching process of performance. The researcher gained the entire correlation among the 62 criteria from their scores by the Cronbach* Coefficient. In Table 1, the researcher found the Cronbach* Coefficient value of Evaluator I to III are between .8154 to .9305 and the other three evaluators' Cronbach* Coefficient value are between ..7276 and .7805. The average value also approach .9355. Thus, the inner reliability of the Teaching Practice Portfolio Assessment was established and high (Table 1).

**p?.01

Table 1 **The Cronbach* Coefficient of Internal Unanimity Among the Six Evaluators**

Evaluators	Reliability
Evaluator I	.8154
Evaluator II	.8956
Evaluator III	.9305
Evaluator IV	.7276
Evaluator V	.7519
Evaluator VI	.7805
Cronbach* Average Value	.9355

The researcher also used Kendall's Coefficient of Concordance to test the reliability among evaluators. The value of Kendall's Coefficient of Concordance is .836 and it has the statistically significant level. (p?.01) (Table 2). On the basis of the statistical analysis, the instrument has the high reliability among evaluators.

Table 2 **The Reliability Among Evaluators (Kendall's Coefficient of Concordance)**

	W
Scores	.836**

V. Conclusions and Recommendations

A. Conclusion

1. The Portfolio Instrument for pre-service teachers of living technology can be used for supervisors' or helping teachers' evaluation.

In addition to the supervisor and helping teacher evaluation, the principal and other teachers should be encouraged to evaluate the pre-service technology teacher.

2. **The Portfolio Instrument for pre-service teachers of living technology can be used for self-diagnosis**.

The pre-service technology teacher may use the instrument to self-evaluate his own teaching performance.

3. **The Portfolio Instrument for pre-service teachers of living technology can be used for students' assisted evaluation.**

The student can make an evaluation report to assess his pre-service technology teacher's teaching performance.

4. **The result of assessing pre-service teachers of living technology by Portfolio Instrument can be used for preparing and implementing professional development.**

In order to improve the teaching, the pre-service technology teacher should write a proposal on his own professional development under the supervision of his supervisor or helping teacher.

According to the proposal, the pre-service technology teacher would watch videos on teaching, participate in a seminar, and simulate the points of other teachers' teaching to improve his own performance.

B. Recommendations

This study recommended the following:

1. It is necessary to increase the evaluation objectivity of the instrument.

In order to enforce the reliability of the instrument, evaluators need to try to increase the evaluation objectivity of the instrument when applying the portfolio instrument for pre-service teachers of living technology.

2. The user needs to review the instrument's manual in detail before evaluating.
   Before applying the instrument, the manual of this instrument should be thoroughly reviewed and understood in order to make good use of the instrument.
3. The major objectives of the portfolio instrument is for preparing professional development.
   Preparing professional development should be the major objectives of the instrument, instead of only evaluating.
4. It is necessary to increase supervisors' and helping teachers' ability in teaching practice to apply the Portfolio Instrument for pre-service teachers of living technology.

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Appendix A

The Teaching Practice Portfolio Assessment for Evaluating Pre-service Teachers of Living Technology Subject at Junior High Schools

Pre-service teacher: ________________________ **Evaluator:**________________________
Date: ______________________________________ **Time:** __________________________

Description of Evaluation:

1.This instrument is to evaluate and record pre-service teacher's performance for teaching practice portfolio of Living Technology Subject.
2. There are 6 areas, 17 competencies, and 62 criteria in this instrument.
3.The evaluator should base on competencies and criteria of this instrument to score pre-service teacher's teaching performance.
4.The scoring system is from Excellent to worst, and rating of 5, 4, 3, 2, 1.
5. The methods of scoring:
   (1) Add up the score of each criterion, then write the total score of all criteria in the blank,
   (2) Calculate the initial score by using the formula;
   (3) The actual score will be gained from initial score multiplied by the percentage of each area.
6. After gaining the actual score, evaluator will make comments on each area for pre-service teacher's teaching performance.
7. After making comments on each area, the evaluator will make comprehensive comments on the teaching portfolio.
8. The evaluator will sum up scores of the five areas, then fill in the blank of total score on this page and the last page.
9. If the pre-service teacher earns total score of 60 above, it means his/her performance of teaching portfolio has passed the evaluation.
10. Description of competencies are listed in the user's manual of the Portfolio Instrument.

The result of evaluation on this instrument: Total Score

- Pass
- Fail

Signature of evaluator:

<u>A partial Example</u>:

Area A: Design and implementation of teaching plans (25%)

Competencies & Criteria Excellent, Good, Medium, Bad, Worst
5 4 3 2 1

Competency A1: Ability of making teaching plans

Reference: teaching plans, teaching activity schemes

Criterion A1.1: be able to design teaching objectives of Technology and Life, Information and Communication, Construction and Manufacture, and Energy and Transportation systems (four technology systems)
* * * * *

Criterion A1.2: be able to draw up systematic course outline
* * * * *

Criterion A1.3: be able to edit complete teaching activity plans
* * * * *

Total of initial score
Initial Score* (Score of criteria ÷50)×100* (____÷50)×100*
Actual Score* Initial score×25%*_____×25%?

Area A?Score of design and implementation of teaching plans:

Area A: Description of design and implementation of teaching plans:
Advantages:

Disadvantages:

Appendix B

The User's Manual of Teaching Practice Portfolio Assessment for Pre-service Teachers of Living Technology Subject at Junior High Schools

Contents

A partial Example:

Area A: Teaching plans and implementation (25%)

Competency A1: Ability of making teaching plans

Reference: Teaching plans, teaching activity schemes

Criterion A1.1: be able to design the teaching objectives of Technology and Life, Information and Communication, Construction and Manufacture, Energy and Transportation (four systems).

Description: The four major units of Living Technology Subject are Technology and Life, Information and Communication, Construction and Manufacture, Energy and Transportation. Pre-service teachers should be able to set up concrete objectives of cognition, psychomotor, and affectiveness for implementing teaching activities according to contents of the four major units.

Criterion A1.2: be able to draw up systematic course outline

Description: Pre-service teacher should draw up systematic course outline that will be in accordance with teaching objectives and learning sequences.

Criterion A1.3: be able to edit complete teaching activity schemes

Description: It is important that pre-service teachers should write a complete, vivid and vigorous teaching activity schemes based on teaching contents and objectives.

Appendix C

References of Teaching Practice Portfolio Assessment for Evaluating Pre-service Teachers of Living Technology Subject at Junior High Schools

1. Teaching Plans
2. Teaching activity schemes
3. Related teaching materials (photos of teaching activities)
4. Students' works (including objectives, photos, pictures, videotapes, and cassettes).
5. Self-made teaching media (including objectives, photos, pictures, videotapes, and cassettes).
6. Records of counseling students
7. Records of students' anecdote
8. Records and reports of dealing with problems
9. Daily records of teaching practice
10. Daily records of managing safety and sanitation of shop/lab
11. Table of personnel organization of shop/lab
12. Records of maintenance of shop/lab appliances
13. Progress report
14. Evaluation form and other assessment instruments
15. The Scoring standards of evaluation
16. Evaluation results analysis and explaining materials
17. Report of teaching practice
18. Appliance purchase sheet
19. Duplication of original copy
20. Records of teaching practice observation
21. Report of assuming office
22. Records of attending seminar
23. Others

(Note: additional information regarding area, Competencies and criteria can be obtained from the author)

Academic Banding and Pupils' Attitudes Toward Technology: A Study of Hong Kong's Selective School Structure

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Abstract

Historically, the educational system in Hong Kong was designed to produce a small, English-speaking elite who were destined (for the most part) for the upper ranks of the Civil Service. Despite the fact that this system is now inappropriate to a post-colonial, post modern Hong Kong, it survives largely intact.

Students finishing Hong Kong's primary schools are allocated to their secondary schools though the results of an aptitude test which determines student placement and academic "band" or track. This "banding" determines the type of secondary education and school that a child receives, and in turn greatly influences future tertiary and employment opportunities. In Hong Kong, where the type and quality of education a student receives is influenced by their academic banding, the student's negative or positive attitudes toward technology has obvious implications for their participatory role in society.

This paper presents the results of a study on Hong Kong pupils' attitudes toward technology. Over 3,000 students from the Secondary 3 level were administered a Pupils' Attitudes Toward Technology (PATT) survey. *The results identified significant attitudinal differences for students from different bands that had technical classes such as Design & Technology.*

Academic Banding in Hong Kong

Students completing primary school in Hong Kong are allocated to their secondary schools through the Secondary School Places Allocation System (SSPA). Under this system, internal school assessments, scaled by a centrally administered aptitude test is the main determinant in the student's placement and academic "band". There are five bands of schools, each representing 20 percent of the ability range, so that Band 1 represents the top 20%, Band 2 the next 20%, and so on (Biggs, 1996). However, each school does not exclusively contain one band of student. A school categorized as "Band 1" may have some students from lower bands – although not in great proportions (Lee, 1993).

Banding and Technology Education

For the junior secondary schools, to which students are first assigned their academic band, Design & Technology (D&T) is the only subject that exclusively deals with the subject of "technology". (As is the case in most Hong Kong schools, boys take D&T, while girls take Home Economics.) The D&T syllabus at lower secondary grades may be less prescriptive and examination-oriented than other subjects, since the need to continue further studies in that area are less certain. Despite this "freedom" from the constraints of the syllabus, the craft-based, non-essential, non-academic perception and implementation of D&T is perpetuated (Volk, Yeung & Siu, 1996).

Through anecdotal evidence and interviews with experienced D&T teachers, there appears to be slight differences in the activities, manner of instruction, and expected outcomes between D&T programs in higher and lower band schools. As students in lower band schools are often steered into vocational programs, basic skills obtained through the use of hand tools to saw, plane, drill and fasten are more heavily emphasized. More repetitive and prescriptive exercises also characterize lower band schools.

The Need for the Study

Despite the aforementioned concerns and criticisms from educators about the relative merits of banding, the system will most likely continue, with little change. For instance, a review of Hong Kong's secondary school places allocation system by Hong Kong's Board of Education (1996) concluded that "as an allocation mechanism, the SSPA System is functioning smoothly and there is no ground for a replacement" (p. 152).

Research has also shown that segregating students into academic bands or tracks has influences on attitudes (Hallinan and Williams, 1990; Oakes, 1988). Given that attitudes are a "mixture of belief and emotion that predisposes a person to respond to other people, objects, or institutions in a positive or negative way" (Coon, 1995, p. 661), the attitudes students receive about technology through the vehicle of a "banded" learning environment are important to examine. In short, the attitudes students obtain about technology serve as a way to predict or influence future actions or inclinations about technology.

Criticisms and concerns about the technology education students receive in Hong Kong are also becoming apparent. For instance, the recently-released *Review of Prevocational Education* (Curriculum Development Institute, 1997) recommended major changes in many of the current courses. The Review suggested programs should fade out the skills-oriented curriculum and increase the level of information technology in all programs. The Review also went so far as to recommend the complete elimination of courses such as Metalworking, replacing them with Technology Fundamentals, which all boys and girls must take. More recently, the *Chief Executive's Commission on Innovation and Technology* (Hong Kong Government, 1998) echoed this need for change. The Commission recommended "in addition to basic academic and technical skills, our students should be equipped with conceptual, analytical, and communication skills, as well as the skills to acquire and adapt to new technology" (p. 69).

From the above discussion, it can be concluded that the practice of "academic banding' is likely to continue for the foreseeable future, D&T programs and instruction differ depending on the band of school, technology will continue to impact and play an important part in Hong Kong students' lives, and students' attitudes toward technology will influence their current and future actions. Thus, an examination of pupils' attitudes toward technology, as it relates to their specific academic band is paramount in reviewing and preparing technology curriculum and activities. The degree to which technology education influences students' attitudes toward technology is also important. The following sections describe the methodology, results and findings from a study examining these issues.

Methodology

Patterned after the work by Bame, Dugger, de Vries, and McBee, (1993) the Pupils' Attitudes Toward Technology (PATT-HK) instrument contained statements to assess respondents' attitudes toward technology. As with the PATT-USA study, the PATT-HK instrument contained 58 items to assess pupils' attitudes toward technology. The data were first analyzed to examine gender issues (Volk & Yip, In press), and now to examine banding.

A five-part Likert scale, with ‘strongly agree’ to ‘strongly disagree’, was used for student responses. The attitude statements were broadly organized under the following six categories:

1. interest in technology (Interest).
2. technology as an activity for both boys and girls (Role Pattern)
3. perception of the difficulty of technology (Difficulty)
4. consequences of technology (Consequence)
5. technology in the school curriculum (Curriculum)
6. ideas about pursuing a career related to technology (Career Aspiration)

The target population for PATT-HK was Secondary 3 students, who were in the final year of free and compulsory education. Thirty Design & Technology teachers were requested to involve their schools in the study, with seventeen subsequently participating in the study. These teachers were either current Advanced Certificate D&T students at HKIEd, or known to be active members of the local D&T teaching profession. A formal letter describing the purpose of the study, as well as how to administer the survey was sent along with the Optical Mark Reader (OMR) questionnaires.

As described earlier, a specific school’s designation of being a particular “band” does not preclude students from other bands being in that school. In fact, the Hong Kong Education Commission (1996) recognizes this “overlap” in defining “banding” as the “average banding of the school population” (p. 59). For this reason, schools were analyzed in two specific groups. The upper band schools (Band 1 and Band 2) were grouped together, while the lower band schools (Band 4 and Band 5) were grouped together. Given the potential for overlap in student bands within each school, it was decided not to include Band 3 schools, as such schools could in actuality, contain a high percentage of students from the designated “high” or “low” bands.

Results of the Study

<u>Demographics and Technical Climate in the Home</u>

A total of 3,276 usable surveys were returned from the 17 schools. There were 7 upper band schools and 10 lower band schools participating. Table I presents the details of the demographics and the students’ technical climate at home.

Table I
Cross Comparisons of Banding with Student Characteristics and Home Environment

	Upper Band (1&2)			Lower Band (4&5)		
	Total	n	%	Total	n	%
Gender	1439			1714		
	Boys	800	55.6		981	57.2
	Girls	639	44.4		733	42.8
Extent father's job has to do with technology	1433			1695		
	very little	357	24.9		657	38.8
	little	561	39.1		626	36.9
	much	395	27.6		324	19.1
	very much	120	8.4		88	5.2
Extent Mother's job has to do with technology	1478			1790		
	very little	784	53.0		1078	60.2
	little	383	25.9		370	20.7
	much	174	11.8		182	10.2
	very much	39	2.6		58	3.2
Do you have Lego or technical toys at home?	1453			1725		
	Yes	1005	69.2		982	56.9
	No	448	30.8		743	43.1
Do you have a working space for modeling at home?	1455			1733		
	Yes	260	17.9		376	21.7
	No	1195	82.1		1357	78.3
Is there a personal computer in your home?	1463			1738		
	Yes	899	61.4		725	41.7
	No	564	38.6		1013	58.3
Do you think you will choose a technological profession?	1462			1736		
	Yes	864	59.1		974	56.1
	No	598	40.9		762	43.9
Have you taken Design and Technology or any technical subject in school ?	1460			1715		
	Yes	720	49.3		755	44.0
	No	740	50.7		960	56.0

As shown in Table I, for a majority of students, the father's job had little or very little to do with technology. However, for the higher band students, more reported fathers to be much or very much involved with technology (36 percent) than lower band students (24 percent). When students were asked about their mother's occupation, an even higher percentage for both groups indicated their mother's job had little or very little to do with technology. This lack of having a mother's job involve technology was not unexpected, for Hong Kong women are generally not well represented in technical fields (Lee, 1996).

The availability and use of technical toys at home was another question asked. Approximately 69 percent of the higher band student had technical toys, while only 57 percent of the lower band students responded in the affirmative. A large difference between high and low band students having a personal computer at home was found. Over 60 percent of the high band students had computers, compared with only 42 percent for the low band. For the question regarding students choosing a technical career in the future upper band students were slightly more likely to answer "yes".

<u>Two-Way Analysis of Variance Examining Banding Differences</u>

To explore the interaction between high and low academic band characteristics (such as their having taken a technical subject such as D&T) with the six attitude categories, a two-way Analysis of Variance (ANOVA) was performed. Table II shows the results of this analysis.

Table II
Two-way Analysis of Variance on Banding Differences

Characteristics	Interest in Technology	Role Pattern	Technology is Difficult	Consequences of Technology	School Curriculum	Career Aspiration
Technical toys	**	**	**	**	**	**
Banding				**	**	
2-Way Interactions						
Working space at home	**			**	**	**
Banding				**		
2-Way Interactions						
Personal computer	**			**	**	**
Banding				**		
2-Way Interactions						
Choose tech. profession	**	**	**	**	**	**
Banding				**		
2-Way Interactions						
Taken D&T /tech subject	**	**	**	**	**	**
Banding				**		
2-Way Interactions	**				**	**

** = significance = alpha less than or equal to 0.05

Three distinct interactions were found when the independent variable of “Banding” and six demographic characteristics were analyzed with the six dependent attitude categories of “Interest”, “Role Pattern”, “Difficulties”, “Consequence”, “Curriculum”, and “Career Aspiration”. Through this analysis, the characteristic of “Taken D&T or other Technical Subject” was the only variable that was a main effect. This effect was for the categories of “Interest”, “Curriculum”, and “Career Aspiration”.

Stated another way, the analysis revealed that only taking Design & Technology or other technical studies classes had an influence on students’ attitudes. No other characteristic, i.e., students having a personal computer, when examined for the effect of “Banding” had an effect. What this suggests is the nature of the subjects and how it is taught in the two groups (bands) influenced students’ attitudes toward these categories. The difference for each of these groups is critical, as for each category, students from lower band schools had less-positive attitudes toward technology than did students from higher band schools.

<u>Summary of Results</u>

The major results of this study on academic banding and students attitudes toward technology can be summarized as follows:

- Students from higher band schools had a higher percentage of parents’ occupation being involved with technology, and technical toys and a personal computer at home.
- The characteristics of “Having Taken D&T or Other Technical Subjects” and “Banding” showed an interaction for the attitude categories of “Interest”, “Curriculum”, and “Career Aspiration”. No interactions were found for the other characteristics.

Discussion

While the concept and policy of Banding can be debated as to its merits and shortcomings, its long tradition and established position in Hong Kong indicates such a policy of academic segregation will remain unchanged (Hong Kong Board of Education, 1996). Given this scenario and (a) the results of this study showing students from “high’ and “low” band schools had different attitudes towards technology, and (b) that educational programmes such as Design & Technology influenced these attitudes, it is suggests is that, depending on a student’s band, what and how technology is taught should be examined, critiqued and perhaps changed. The results also suggest that technology subjects such as Design & Technology have a powerful influence on the attitudes students have toward technology and should thus be encouraged as an area of study for all students.

In any discussion of change, and the “what” and “how” technology is taught in different band schools, the role of the teacher is paramount. Madaus, Kellaghan and Schwab (1992) summarized the research on this as it relates to teachers’ actions.

Teachers in low-ability tracked classes generally:

- Hold expectations too low, effecting how they treat students;
- Provide less appropriate instruction;
- Pace instruction too slow;
- Provide instructional material this is less interesting and challenging;
- Provide less verbal interaction; and
- Spend less time preparing lessons

As discussed earlier, students in lower band schools are placed into D&T and technical programs in which teachers emphasize basic manipulative skills. Activities structured by teachers in lower band programs also tend to be more prescriptive, requiring less imagination, creativity and problem-solving skills. This is in part due to the assumed education and career path lower band students will follow. This may also be due to the perceived differences in student ability, discipline and motivation. However, such a traditional skills-based approach was found to influence students’ attitudes toward “Interest” and “School Curriculum”. For this reason, it is recommended teachers of technical subjects in lower band schools re-examine their programs and instructional techniques. What topics are covered, how are students viewed, and how are students are taught, are issues that need to be reviewed.

Fortunately, in Hong Kong's technology programs, some changes are beginning to occur. As a result of the aforementioned *Review of Prevocational Education* (Curriculum Development Institute, 1997) a syllabus is being developed for Fundamentals of Technology, a new course all pre-vocational students will be required to take. The proposal recommends that *all* students take this subject, a radical change from the gender-biased programs that are now the norm (Volk & Yip, In press).

New syllabi, equipment and facility designs for the existing D&T programs are also in the works. This is particularly important for the lower secondary programs, which are extremely dated and of low esteem (Chow, 1996). For the new D&T programs, features such as the increased use of information technology, computer graphics, modeling, and the use of multiple materials are being proposed. Finally, technology teacher preparation programs are being refocused and expanded, with initiatives at the Hong Kong Institute of Education (HKIEd) providing new direction. Aspects such as problem-based learning, a reduction in skill development, and more state-of-the-art technology are now common features of the HKIEd program for D&T teachers.

Conclusion

Banding is an educational approach used in Hong Kong that segregates students into different schools according to criteria such as achievement test results. In so doing, students are often provided with different opportunities and approaches to learning, depending on the band of the school. Within programs such as Design & Technology, what is taught and how it is taught varies between banded schools, often influenced by perceived student needs and abilities. The effect subjects such as Design & Technology has on students' attitudes toward technology, was shown to be significant between these higher and lower band schools, suggesting the "what is taught" and "how it is taught" may need to be examined.

Given the technological world students live and the career options available, it is imperative *all* students receive quality education relating to technology, for it is through such programs, students' attitudes can be affected. Positive attitudes toward technology as they relate to interest, school curriculum and career aspirations obviously impact future choices. As suggested in this study, *all* students, regardless of academic band, can benefit from quality technology programs which foster these and other positive attitudes.

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Impacts of Technology Education: Summary of the Conference Theme and Papers

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The rationale for the conference theme

By choosing the theme ‘Impacts of Technology Education’ we set a real challenge to the participants. In the past decennium we have seen an increase in attention for Technology Education worldwide. Many countries either made drastic changes in an existing school subject or created a new subject in the curriculum. A lot of rhetoric was developed to defend these changes and/or introductions. Technology Education according to some was to be the core subject of the whole curriculum that would integrate knowledge and skills from various other school subjects (such as crafts, science, history, economy). Technology as the basis of our modern economy should to taught to all future citizens, because technological literacy was of the highest importance for all people in a modern, technological society. And Technology Education was to be the school subject that would bring this type of literacy to our children. Big words like this were and still are used to emphasise the importance of Technology Education.

But as Technology Education in those many countries has become a more or less established element in the school curriculum by now the question can be asked if Technology Education really fullfilled all its impressive promises. Can we really say that Technology Education created technological literacy with our pupils and students? Can we say that we have been able to change their concept of and attitude towards technology, so that they have acquired a balanced perspective on technology and a positive, but not uncritical attitude towards it? Is their any empirical evidence that Technology Education is really doing the job that it was announced to do? Those are the questions that we forced ourselves to be faced with during the nineth international PATT conference. PATT since 1985 stands for Pupils’ Attitudes Towards Technology. Changing the attitude of pupils and students - a very difficult task as attitudes seem to be fixed at a quite early age, due to all the way technology is presented on television, in magazines, etc. - was one of the major tasks we saw for Technology Education when we started this international series of conferences. That was the motivation for developing an instrument for measuring it and the shocking results of a first study in the Netherlands - a very narrow and biased concept of and a naively positive attitude with 13- and 14-year old pupils - made us call attention for this worldwide. The first study in the Netherlands was followed by more than 20 studies in other countries and still new studies are planned and carried out. And for the PATT-9 conference the issue was raised if instruments like this, and others for other outcomes of Technology Education, provide any information with respect to the extent to which Technology Education has made an impact on our pupils and students.

During the conference nineteen presentations provided answers and partial answers to the question what impacts Technology Education really seems to have. Not all presentations were submitted on paper and this is why this publication of the Proceedings does not contain all of those nineteen contributions to the programme. In this summary of the conference a survey is presented of both the contributions that have been included in the Proceedings and those that have not been included. Thus we have tried to capture the outcomes of the whole conference.

A variety of claims

As stated above a number of claims have been made in the past and still are made to defend the position of Technology Education in the school curriculum. A number of conference presentations focused on the types of claims that we find worldwide. The most frequently found of such claims are the following:

- Technology Education does not only provide pupils and students with a set of (technical) knowledge and skills, but more importantly it has personal and social impacts on them. The paper by Allen Bame shows how this claim can be found throughout the history of Technology Education (formerly called Industrial Arts) in the USA. Technology Education was to change the personality of the pupils and students so that they would become creative persons, and would enable them to become socially integrated into the modern technological society. Truly a big claim for a relatively new school subject;
- Technology Education will have an impact on the values that people hold with respect to technology as an element in our society. The fact that this claim too was both heard in the past and still can be heard, was brought forward in the paper by Mike Martin. Given the naively positive ideas of pupils that we found in PATT studies, this seems to be quite a relevant claim. Pupils still seem to accept technology almost uncritically, although the increase of information about environmental problems has nuanced this somewhat. That brings us to the next claim;
- Technology Education will create an awareness of the need to care for the natural environment. The fact that it was in particular technology that both created environmental problems and also provided means of solving those problems, makes Technology Education the appropriate school subject for making pupils and students sensitive for the environment and its value for life. In the paper by Ilia Nataly examples are presented of how that can be made concrete in Technology Education;
- Technology Education can provide an understanding of the general principles underlying technological phenomena. The presentation by Matzi Eliahu contained some nice examples of how computer software can be developed and used to provide such insights;
- Technology Education has an impact on cross-domain abilities. The existence of this claim was an important element in the presentation by Ari Alamäki. In his paper he shows how this and other claims stimulated him and his colleagues in Finland to set up teacher training for Technology Education.

Thus we see a variety of claims. As Technology Education community we do not seem to have been very modest in what we saw as our contribution to the curriculum. Even if we would fulfill part of our promises we would still have an important impact on pupils and students. But is there any evidence that we do this?

A lack of empirical evidence

The two keynote presentations, by Rod Custer and by Karen Zuga, were quite revealing in that respect. Both had been asked to present a survey of research outcomes that give information about the real - rather than the promised - impact of Technology Education. In his paper Custer took the increase of political support as an example of an impact of Technology Education: the fact that we get more political support at least suggests that there are others who accept the message of the importance of Technology Education. But one of his other points was that empirical evidence of an impact of Technology Education on pupils and students still seems to be absent, or at least very scarce. This was confirmed by Zuga in her oral presentation. An extensive survey of research publications in professional journals in the period 1987-1998 she made, showed that most research still focuses on the claims we make (the intended curriculum) and that there is hardly any research done on pupils and students and the changes they go through when they experience Technology Education. According to her calculations only about 8% of all research articles included in her survey dealt with the effectiveness of the Technology Education curriculum. In fact her presentation was a plea to the community of researchers to work towards a better balance between the various aspects of Technology Education (not only curriculum content, but also pupils and students as research topic).

In general we can say that our conference theme seems to have put us in an embarassing position: although in several countries by now we have had at least a decade to prove the reality of the impact that we claimed Technology Education would make, we do not (yet) have an empirical basis for that.

A lot of complicating barriers

But does that mean that we have nothing to say against those who will now conclude that Technology Education failed, or at least can not prove that it succeeded? Or are there factors that explain why it could hardly be expected that an empirical evidence for the success of Technology Education could be provided within the period we can look back upon now? During the conference several papers made clear that there are several barriers for providing that evidence. Of course we can not forever keep using those as an excuse for not having this evidence, but at least they can make those who criticize us aware that in a number of ways Technology Education, compared to other, more traditional school subjects, is in a special position that creates particular barriers to gaining evidence of impacts. The following issues were brought forward during the conference:

- the succesfull introduction and realisation of Technology Education, as a relatively new and thus not yet generally accepted school subject, is not only a matter of Pupils and Teachers, but also of Headmasters, Local authorities, Businesses and Governments. As Joel Rotschild phrased this: we do not only have PATT, but also TATT, HATT, LATT, BATT and GATT (the title of his presentation therefore was: from PATT to GATT). The same idea was discussed by Walther Theuerkauf in his oral presentation. This variety of actors of course complicates the situation for Technology Education enormously and it makes plausible that it is not easy to realise Technology Education succesfully and furthermore collect empirical evidence of such success;
- in realising Technology Education teachers not only need knowledge of the subject content, but also of pedagogy and school issues. In their paper Frank Banks and David Barlex explored this variety of skills and showed an interesting example of co-operation to provide that variety of skills to (future) teachers. Of course this holds for other school subjects as well, but in the situation of a new school subject (or a school subject that went through dramatic changes) this broad scope of knowledge domains is an extra weight on the shoulders of teachers. It is no wonder that low scores were found in the evaluation of teachers' skills in portfolio assessment - as was presented in the paper by Kuo-Hung Tseng, given the fact that they have so many other skills needed too. Would they have had better skills in such assessment, they maybe would already have a lot more evidence of the impact of Technology Education on their pupils and students;
- there are still methodological problems with respect to the research instruments that we would like to use for gaining empirical information on the impact of Technology Education. In fact this had already become evident at the previous PATT conference, the PATT-8 conference in 1998, for which the main theme had been: Assessing Technology Education. The oral presentation by John Williams made clear that measuring pupils' attitudes in Mauritius was certainly not just a matter of simply applying the 'standard' PATT questionnaire. Previous studies in South Africa (see the PATT-8 Proceedings) had also shown such methodological difficulties;
- the arsenal of instruments to provide empirical evidence of the impact of Technology Education is still relatively small, as was brought forward by Michael Dyrenfurth in his oral presentation. There is still a big challenge to the methodologists to extend this arsenal;
- in a number of countries the circumstances - economic, political - under which Technology Education has to be realised are highly problematic. Calvyn Potgieter illustrated this in his paper by describing the South-African situation.

Again we can say that these barriers can not forever be used as an excuse for the absense of empirical evidence for success, but is does explain the difficulty of gaining that evidence.

Tokens of hope

Does all this mean that we can only hold up empty hands when asked for any evidence of the impacts that Technology Education can make? Not entirely. The conference yielded some good examples of first 'tokens of hope'. In some studies data were collected that at least suggest a real impact of Technology Education. Scattered over various papers we find such data:

- the paper by Hidetoshi Miyakawa contains information on effects of Technology Education on the creativity of the pupils;
- the study by Yaron Doppelt and Moshe Barak (presented by Doppelt at the conference) mentions effects on the pupils' interest and curiosity;
- in the study by Esa-Matti Järvinen and Jukka Hiltunen we find evidence of an impact on the pupils' understanding of underlying principles for the case of automation as part of Technology Education;
- the PATT study by Ken Volk in Hong-Kong revealed an impact of the school subject Design & Technology on the pupils' attitudes;
- the work by Alice Pritchard and Richard Gagliardi showed how gender differences can be reduced by means of Technology Education activities;
- and finally the study by Hung-Jen Yang resulted in evidence of an impact on technology teacher education teacher' performances.

Tokens of hope, that is probably an appropriate term for the examples mentioned above. They are not yet sufficient to justify a positive answer to the question if we have evidence that all the rhetoric we used to defend the case of Technology Education was realistic. But they do make us hopeful that at least part of the claims we made can be proven to have been realised. A lot more effort is needed in the future to extent the empirical basis for the existence of impacts of Technology Education. Perhaps the impact of the PATT-9 conference can be that the need for this has become clearer to us than it was before. If that is true, the time spent on organising and/or attending this meeting was a good investment.

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