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Proceedings

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PATT

Pupils Attitudes Towards Technology Sessions
Table of Contents

Preface
Marc de Vries

Teaching Design & Technology to Develop Students as Persons:
A Singapore Vision
Chia Soo Chin and Tan Seng Chong, Jason

The Human Being and Technology – a New Cross-Curricular Theme in the Finnish
General Education Curriculum Framework. Preliminary Results of the Nationwide
Evaluation of the Theme
Esa Matti Järvinen and Aki Rasinen

Robotics and Automation in Primary Teacher Education – Changing Practices in the
Faculty of Education at the University of Oulu, Finland
Jaakko Nykanen and Matti Lindh

The Stimulating Effects of Science Fiction and Films
Kuen-Yi Lin

The Nature of Educational Science in Technology Education:
Practical Example in Teaching Electricity
Matti Lindh & Jaakko Nykänen
Preface

PATT is the acronym that has now been used for almost 30 years to indicate a series of conferences and sessions at ITEEA Annual Conferences in which researchers in technology education from different countries present and discuss research studies in their field. At the 74th Annual ITEEA Conference, held in Long Beach, CA, March 15-17, 2012, PATT sessions were held and in these Proceedings the written papers have been collected and edited. Those who were there will remember the stimulating experience we had when listening to each other’s presentations and having excellent discussions. For those who were not there, these Proceedings offer the opportunity to get to know the interesting work that was presented and discussed.

I want to thank all presenters/authors for their cooperation. Also I want to thank ITEEA’s executive Director (at the time), Dr. Kendall Starkweather, who initiated the concept of PATT sessions at ITEEA Annual Conferences and has been a warm supporter for those ever since. He has been extremely valuable for the connection between ITEEA and PATT and for that he is to be acknowledged by all who gained from this fruitful cooperation. Also I want to thank Susan Perry, who has always taken so well care of the organizational aspect of the PATT sessions. Without people like these, the PATT sessions would not have been possible.

We look forward to continuing the series in Columbus, OH, in 2013.

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1. Introduction

Design & Technology (D&T) is a subject in the secondary school curriculum in Singapore. It was first implemented at Secondary One in 1986 to replace the two subjects Woodwork and Metalwork in response to Singapore’s changing economic landscape. Currently, D&T is a compulsory subject at the lower secondary level for both boys and girls. At the upper secondary level, it is offered as an elective subject. Today, about 12% (12,000 students) of each cohort from more than 120 secondary schools study the subject.

As part of the holistic secondary school curriculum, D&T engages students in designing and prototyping ideas through the mind and hands. The design process offers opportunities to understand human needs and to create possibilities to make life better. Educationally, it offers an opportunity for students to develop skills that turn ideas into reality and values like mindfulness, empathy and sensitivity in the areas of social, culture and environment.

As a preparation to implement D&T, teachers teaching Woodwork and Metalwork then were re-trained, and engineers from various fields were recruited and trained to teach the subject. With the introduction of the product and industrial design degree programme at the National University of Singapore in 1999, there is a small but growing number of designers teaching the subject. Today, the D&T teaching force is formed mainly by engineers.

2. Phases of D&T Practice

**What**  D&T was designed in the early eighties by looking closely at similar subjects offered by schools in the UK. The implementation had a strong flavour of craft and vocational emphasis akin to Woodwork and Metalwork. Generally the programme had three distinct areas, namely theory (content knowledge), design process, and practical skills training. The design process was then taught as content knowledge and deployed as a tool for project opportunities for problem-solving design activities. With a teaching force seeking to understand the new subject matter and
to teach it at the same time, treatment of the design process in a linear fashion then was understandable.

**Why** Moving into the second decade of D&T, a two-year part-time Advanced Diploma in D&T was developed for in-service training by the Product and Industrial Design Department at the Temasek Polytechnic. The objective was for teachers to further develop design skills and to gain exposure to design work. As teachers sought to better understand design and gain design related knowledge and skills, they also turned to events like design graduate shows, design forums and conferences for additional exposure to industrial design practice. Some keen teachers also began to make reference from academic research on design and design-related education for their classroom practice.

Such exposures to industry practices and research led a group of teachers to think deeply into the value of design for general education, i.e. the education of children 16 years and below. The belief that D&T offers opportunities to shape the students’ values and attitudes, and develop skills that are crucial to their development is shared by many teachers. This was expounded by Archer (1974) in his paper *Design in General Education* and encapsulated in a subsequent paper (Archer, 1975, p. 8) thus:

> There exists an area of human experience, knowledge and action, centred on man’s desire and ability to mould his physical environment to meet his material and spiritual needs, which is as important to his well-being as such well-recognised areas of learning as literacy and numeracy. We call this area of experience, knowledge and action, design.

This forms the foundational lead in the search for a philosophy of practice in D&T education that will contribute to the holistic development and education of the young.

**How** As teachers gain deeper understanding of design practices and sharpen design skills, they grapple with mediating the demands of the multi-faceted and complex nature of the design process for the D&T classroom. Design process knowledge and skills, materials, technology, values and attitudes inherent in the fields of designing guide and drive the teaching and learning of D&T. Contents from these various domains are largely organised for projects in a just-in-time manner. The integrative approach, a shift from the early approach of distinct areas of learning, offers experiences for students to make better meaning of their learning.

In recent years, D&T practice grew more vibrant. Relating to real life becomes an impetus for more meaningful learning. For example, students experienced the ritual of tea drinking and discussed the design of related products to surface design needs. Folding bicycles featured in one programme in which students tried various models to understand the design features and to surface design opportunities. Establishments like furniture company, marine centre, child care
centre, senior citizens corner and health care centre also provided real situations and real users for students to work on their projects. This is in contrast with the usually fictitious contexts and design needs that were formulated for projects in the initial years. The real life setting gives added meaning to classroom learning and heightens sensitivity in the areas of social, culture and environment.

In seeking to further understand what it takes to facilitate the design process in the classroom and to enable students to think design, pockets of research related to facilitating and scaffolding took place. Tan (1996) surfaced the theory of Double Looping Learning Model to help explain the dynamics of facilitating and scaffolding students in the design process. It aims to serve as a framework for the D&T classroom practice. In another research (Imram, 2010), students were observed to inevitably get stuck in the design process. The researcher coined this as the Stuck Syndrome and that it offers opportunity for knowledge construction and intervention to develop skills and to shape values and attitudes.

The pursuit of a D&T pedagogical content knowledge is on-going. There is firm belief that the teacher should model the design process through thinking aloud and through sketching for students to emulate and to better understand what it means to be engaged in design thought process. An example of the teacher modelling the design process is to show in action how he/she morph a design solution from scratch or visual reference, to an end product to serve a design need. This process is termed idea growing (Tan, 2010) and is currently beginning to propagate in the classrooms through in-service training.

3. Philosophy of D&T Practice

Many researchers, especially design educator-researchers, have long been looking closely at design as an epistemological domain of knowledge liken to literacy and numeracy, and design-and-make as another important platform that may contribute to the holistic human development (Archer, 1975; Cross, 2007).

In his justification for design education within the context of general education, Cross (2007, p. 29) identified five aspects of ‘designerly’ ways of knowing:

- Designers tackle ‘ill-defined’ problems.
- Their mode of problem-solving is ‘solution-focused’.
- Their mode of thinking is ‘constructive’.
- They use ‘codes’ that translate abstract requirements into concrete objects.
- They use these codes to both ‘read’ and ‘write’ in ‘object languages’.
From these five aspects, three main areas of justification for design education within general education were defined (Cross, 2007, p. 30), namely:

- Design develops innate abilities in solving real-world, ill-defined problems.
- Design sustains cognitive development in the concrete/iconic modes of cognition.
- Design offers opportunities for development of a wide range of abilities in nonverbal thought and communication.

These three main areas of justification suggest a probable reference for the D&T fraternity to reflect on how D&T can contribute to general education. This seems logical as was pointed out by Cross (1980):

> Since general education is in principle non-technical and non-vocational, design can only achieve parity with other disciplines in general education if it is organised as an area of study which contributes as much to the individual’s self-realisation as to preparation for social roles (p. 202).

Now that D&T is in its third decade of implementation, the quest for an educational philosophy to inform and to guide classroom practice becomes necessary. The above arguments have influenced the thinking of D&T education in the local context, and to a certain extent provided a direction for the D&T fraternity to continue to grow a philosophy of practice. They are instrumental in shaping the ‘visuacy’ and ‘graphicacy’ orientation and the concept of manipulation of three-dimensional object that are central to the D&T subject matter.

The three areas of justification, namely, developing abilities in solving real-world, ill-defined problems; cognitive development in the concrete/iconic modes of cognition; and the development of a wide range of abilities in nonverbal thought and communication (Cross, 2007) serve as sound and reasonable tenets for a philosophy of D&T practice to evolve, and for D&T education to work towards playing an important role in the Singapore school curriculum to develop the students in an area of cognition offered by design education.

The articulation of a philosophy of D&T practice serves to anchor a practice and provides good reason for the demanding role of being a teacher of design education that is well described by Adams (1991, p. 170):

> The teacher's task is a complex and demanding one. It requires them to create opportunities for learning, to manipulate situations to stretch able pupils and support weaker ones; to introduce unfamiliar concepts and new ways of working appropriate for their pupils. It involves them in a variety of roles: organiser, mentor, devil's advocate, information source, guide, supervisor,
instructor, commentator, demonstrator, facilitator, referee, critic, interpreter, counsellor and fellow traveller.

The meaning of fellow traveller may be interpreted as co-designers and co-learners alongside students as suggested by Tan (1996). This pedagogical stance is beginning to take root in the D&T classrooms as teachers begin to appreciate that design cannot be taught but to be coached and learned.

In conclusion, it is therefore reasonable to suggest at this infancy stage the philosophy of a practice in design education be centred on Nigel Cross’s three main justification for design education within general education. Such understanding would bring about a more profound depth of practice that goes towards contributing to the human development - the development of students as persons.

4. Implications

It is understandable that a philosophy of practice did not exist when D&T was first implemented more than twenty years ago in Singapore schools. Today as D&T teachers grow in their pedagogical knowledge, there is an inclination to also question how the subject matter may educate students as suggested by the syllabus (SEAB, 2011).

With an emergent philosophy articulated, it offers the D&T fraternity a collective understanding of how D&T education can contribute to the development of students through design education. The understanding could help propagate an area of research-teaching practice among D&T teachers in seeking to build D&T pedagogical stances and related pedagogical knowledge.

The philosophy hence would provide assurance for a grounded focus in gearing and driving the diverse D&T curriculum practices in schools. It also paints a clear picture for D&T teachers to articulate the why and how to what they are teaching. This heightens their awareness in their pedagogical approaches, in particular their facilitation process in the teaching and learning of D&T. Last, the philosophy of D&T practice offers an initial framework for like-minded educators to rationalise the practice of D&T education; to have a common notion that D&T is not about training and developing future designers; and that it exists in the curriculum as a niche area that would contribute to the students’ holistic education and development.

5. References


The Human Being and Technology – a New Cross-Curricular Theme in the Finnish General Education Curriculum Framework
Preliminary Results of the Nationwide Evaluation of the Theme

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1. Introduction

On top of the different subject areas, the National Framework Curriculum (hereinafter NFC) 1985, 1994 and 2004 also introduces, various cross-curricular themes. For the first time in the history of Finnish general education curriculum planning, the 2004 Framework Curriculum introduced a cross-curricular theme: *the human being and technology*. The concept of technology is mentioned in the 1985 national framework curriculum in connection with craft (technical and textile), but it is not defined.

Before the 2004 NFC the teaching of technology was not operationalized in any manner, neither were teachers obliged to teach it. According to the present NFC the cross-curricular themes *must* be included in studies of various subject areas. Teaching technology thus also became *obligatory*.

Technology education was introduced in the 2004 NFC, but it remained undefined in any depth. As a cross-curricular theme, the human being and technology remained at a general level. This has resulted in ignorance and even misinterpretations of the contents and objectives of technology education.

In 2009 Finnish Ministry of Education and Culture commissioned the National Board of Education an assignment accomplish a nationwide evaluation of all the seven cross-curricular themes. The evaluation is one of the largest education evaluation projects the National Board of Finland has ever organised. The authors were invited to carry out the evaluation of the theme “Human being and Technology”. Data was collected during fall 2010. Ninth grade pupils (last grade in Secondary School) around Finland answered the questionnaires. The National Board of Education delivered and instructed the questionnaires and during 2011 managed the data processing. The study reported herein provides insights to preliminary results of the evaluation.

2. Objectives of the cross-curricular theme

What should be studied under the title”The Human Being and Technology” (HBT) is the meaning of technology in our everyday lives and the dependency of human beings on modern technology. This theme offers basic know-how about technology, the development of technology and its effects, guides pupils to make reasonable choices and to consider ethical,
moral and equality questions related to technology. Teaching should also improve their ability to understand how different devices, equipment and machines work and how to use them. The aims are as follows:

A pupil will learn

- to understand technology, the development of technology and its impacts on different fields of life, different sectors in society, and on the environment
- to use technology in a responsible and critical manner
- to use information technology equipment, programs and networks for different purposes
- to express one’s opinion concerning technological choices, and to consider the effects of today’s decisions about technology on the future

The core contents

- technology in everyday life, in society and in local trade and industry
- the development of technology and factors affecting the development in different cultures and different fields of life during different eras
- the development, modeling, and assessing of technological ideas and the life-span of a product
- the use of information and communication technology and information networks
- the ethical, moral, well-being and equality concerns related to technology

3. Description of the questionnaire

Mastery of and know-how related to the HBT cross-curricular theme among 9th graders was studied using a questionnaire. The aim was to find out in which classes and in which contexts the pupils had studied subject matter dealing with the HBT cross-curricular theme. Additionally the aim was to find out if the pupils had studied technology in their daily school routines, outside the school and at home. The actual study of the learning results was divided into questions about activities, attitudes and knowledge. The questionnaire study was preceded by a pre-test and the final questionnaire was compiled on the basis of the pre-test. To orientate the pupils to the task in hand, a short definition was introduced at the beginning of the questionnaire. This definition was also the starting point of the study.

The Human Being and Technology cross-curricular theme deals with the relationship between human beings and technology in our everyday life. It studies, among other things, the principles connected to technology, using technology and the applications of technology in the individuals’ life. All the technology around us is designed and made by human beings. One important content area of learning is to give pupils opportunities to develop technological ideas.

The questions and statements related to the HBT cross-curricular theme were derived from the above definition. A questionnaire was developed to find out pupils’ knowledge of technology, attitudes to technology and activity know-how. ‘Activity’ in this case means pupils’ perception
of their skills in technology to use various craft tools as well as devices like digital camera, washing machine etc. Pupils activity to use social media (Twitter, Facebook, etc.) was also in the point of interest. We utilized this research methodology because we wanted to find out the pupils’ views on the issue in hand. If observational or other qualitative methods had been used while pupils were developing ideas, or solving and evaluating technological problems, the study might have focused too much on the researcher’s viewpoint.

3.1. Knowledgesection
The number of questions in the knowledgesection was 15. The aim was to measure some of the issues central to understanding the human built environment. Some of the questions dealt with subject matter in the natural sciences (e.g., electricity), some dealt with other topical themes (e.g., recycling, sustainable development). The questions comprised ‘right’ or ‘wrong’ statements, multiple-choice questions (some with pictures) and one open-ended question.

In the first question the pupils had to choose from various alternatives those which they regarded as technology. There were twelve options, eight of which were connected to technology. A short definition worked as an introductory remark: “Technology can be understood as the human built environment”.

Ten of the questions consisted of statements, such as: “Technology has nothing to do with sustainable development”, “LED lighting consumes less power than a bulb (incandescent bulb)”, “A paper bag is a more ecological choice than a plastic bag” and “Copper is used as an insulator because it does not conduct electricity”.

The knowledge section included three assignments using pictures. The first was connected to the understanding of the concept of an electric circuit. The second pictorial assignment in the knowledge section involved identifying different types of bridges.

The third pictorial assignment depicted an arch in which the respondent was supposed to identify the keystone. The pictorial question about the arch was a kind of introduction to the next question, which was the only open-ended task in the knowledge section. The respondent was asked to explain what makes the arch a sturdy construction. This was the last question in the knowledge section.

3.2 Attitudes
Attitudes towards technology-related issues were studied by means of 20 statements which the pupils assessed using a 5-step Likert scale (1 totally disagree… 5 totally agree).

This section looked at attitudes towards technology and opportunities for developing technology. It also included questions related to gender equality and sustainable development. Some examples of the statements: “Technology improves the quality of life”, “Technology can assist in improving sustainable development”, “I can affect the direction of the development of technology through my choices”, “I try to avoid everything that is connected
to technology”, “Men are better developers of technology than women”. The structure of attitudes was studied by factorial analysis.

3.3. Activity know-how

There were 15 questions dealing with activity know-how. Of these, 14 were statements with a ‘yes’ or ‘no’ answer. They dealt with both modern technology (including, among others, social media, ICT, consumer electronics) and more traditional themes to do with manual skills. One of the statements referred to the use of various tools: “I have learnt to use various tools”. Eight separate tools were presented, which the respondent said she/he had (‘yes’) or had not (‘no’) learnt to use. The tools in question were: a drill, a soldering iron, a hammer, a saw, a battery-driven drill, pincers, a screwdriver and a sewing machine. Examples of the other statements are: “I have developed technological ideas”, “I know how to upload videos onto YouTube”, I know how to load and start a dishwashing machine”, “I know how to repair a flat tyre on a bicycle” and “I know how to adjust the clock on a DVD player”.

In the single open-ended assignment the pupils were asked to think up as many new uses for a clothes peg as possible. The aim of this part was to give respondents a chance to apply their creativity and inventiveness. One of the objectives of this particular cross-curricular theme is the “development of technological ideas” and, accordingly, pupils should be given opportunities for technological creativity and for identifying and solving problems.

4. Preliminary results emerging from the data

A total of 1181 grade-nine pupils responded to the questionnaire. In this context having good knowledge was regarded as knowing discrete information. A deeper understanding or ability to define complex concepts and phenomena was not demanded.

The knowledge section

What is technology?

Less than one third of the respondents considered rubber boots, a chair, outdoor clothing and a tent as technology. The understanding pupils have of what technology is, is in line with the general narrow understanding of technology as related only to information and communication technology. The result corresponded to studies conducted in the USA (e.g., Dugger 2010, 36). Similarly, the analysis of the curriculum of 50 Finnish municipalities (which are responsible for about 400 schools) carried out by Rasinen, Ikonen and Rissanen (2008, 31) reveals the narrow interpretation of technology. Matters clearly dealing with the natural environment (not man-made) were understood as not belonging to technology. At a general level, therefore, there seems to be a division between the human built and natural environment. The learning materials for natural science in the Finnish primary stages divide the environment into the natural and built environment.

Developing technology, sustainable development and manual skills
Questions dealing with ecology, sustainable development and energy proved that young people are well aware of these matters. Dakers and Dow (2009, 386-387) also found that girls felt ethics to be an important part of technology education.

The young respondents also felt that "an ordinary citizen" can affect the direction of the development of technology, and that it is not done only in the R&D departments of big companies. This view was shared by almost 90% of the respondents. Youth feels that it can have an influence on the development of technology. This attitude is well in line with the cross-curricular theme: first comes the human being and then the technology developed by the human being.

It is also worth noting that technology is not regarded as some big polluting "bogeyman" which destroys the environment. According to Virtanen (2011, 395-396) girls were statistically significantly more motivated to: “learn how to protect nature” and “find solutions for keeping the environment tidy”.

Of the respondents 90% regarded manual skills and technology as interrelated. An analysis of the National Framework Curriculum (Rasinen et. al. 2008, 31) shows that there are a few references to technology education in the contents and objectives of science but considerably many in craft (particularly in technical work). In this respect it seems that the understanding of the pupils is in line with the curriculum objectives. In many countries (e.g., Australia, England, New Zealand and the United States) the craft curriculum has been developed in the direction of technology education (Rasinen 2000).

**Open and closed circuit**

The concept of open and closed circuit proved to be quite difficult to understand. Almost two thirds of the pupils thought that when there is no light in the torch the electric circuit is closed. This result demonstrates the contradiction between the definition of the electric circuit and daily life experiences. Parikka (2010, 48-53) writes:

“A good example of a contradiction between the facts and everyday experiences is the interpretation of the concept of an open and closed electric circuit in terms of the everyday life experiences of the pupils. If an electric circuit is open (in electrical terminology), there is no electric current flowing. In everyday life if a door is open (and in Finnish a radio, TV and tap are also 'open', or turned on), it means human beings, sound, picture and water, for instance, have unrestricted flow. Closed in scientific terms means that the electric circuit has been switched on and there is electricity flow... In everyday life closed, in turn, means that flow has been restricted.”

Also Pirttimaa (2008) observed similar effects of everyday life. None of the pupils participating in his study was able to explain the closed circuit properly.

**Arch**

The answers to the open-ended question indicate that both Finnish and Swedish speaking pupils had understood the idea of the sturdy construction of the arch. The pupils used their own terminology when explaining the construction. It is, however, evident that they understood the essence of the question. They refer to the wedge shape of the stones.
McCormick (1997), Twyford& Järvinen (2000) and Dakers & Dow (2009) have found similar results: the participants have understood the phenomena although they have not used the correct professional or academic terminology.

Examples of the pupils’ answers:

“The pieces have no room to move down”
“The stones have been ground at an angle and fit together nicely”
”The stones interlock tightly because of their shape”
”The energy which forces the stones down travels downwards via the upper stone”

This assignment gives some added value to the bridge and keystone questions by giving us a glimpse into pupils’ understanding of the basics of sturdy construction. The data gathered can be utilized in further studies on this theme.

In the knowledge section the boys managed statistically significantly much better. The Finnish speaking pupils were statistically significantly better than the Swedish speaking pupils. There were no differences between municipalities and provinces, although pupils in the former Oulu province performed best.

**The attitudes section**

Generally speaking the pupils had a reasonably positive attitude towards technology. Examples of this include their positive impression that technology improves the quality of life, it can be used to promote sustainable development and it serves human beings.

Youth does not think that technological development has ceased. Neither do they think that there are too many functions on mobile phones. This observation gives an interesting viewpoint on the development of technology. The human built environment can and must be developed. The objective of the HBT cross-curricular theme, “developing technological ideas, modeling, assessing and the life cycle of artifacts” also points in this direction. Young people have a clear picture of the world as not being ready yet. They also clearly disagreed with the statement “technology is developed by engineers only”. The results reveal, however, that young people do not believe in their ability as developers of technology.

From the gender equality point of view it is interesting to note that about half of the respondents regarded men as not being better developers of technology than women, although about one-third were unable to express an opinion. Slightly less than one-fifth of the respondents considered men better developers of technology than women.

**The activityknow-how section**
Activity know-how was studied through 14 statements and one open-ended assignment. When interpreting the results of the activity know-how section, it has to be noted that the answers of the pupils represent their own assessment of their activity know-how. It was not possible to study the actual level of activity know-how in this study.

Analysis of the statements shows in general terms that the pupils claim to have many-sided skills in both traditional and modern technology. Most of them stated that they were able to use basic tools, for example a drill, a screwdriver, a hammer and a saw.

It is particularly interesting to note that much less than one third of the pupils admit to having “developed technological ideas”. The results are in line with similar questions dealing with attitudes. It seems that although the pupils believe that technology will also be developed by people other than engineers, they do not feel they are active agents in technological processes. According to the HBT cross-curricular theme, however, pupils are to be encouraged to undertake this type of activity.

5. Pupils’ views on the teaching of the cross-curricular theme

The pupils consider that they have mainly studied HBT-related matters during regular classes. It seems that in this respect the idea of studying cross-curricular themes during normal lessons has been realized. A slightly different viewpoint is revealed by the fact that 70% of the respondent say that they have studied technology-related issues outside school, with as many as 75% saying they have studied such issues at home. The ideal situation would be that schools and the surrounding society would consciously educate pupils in the same direction in pursuit of the same objectives. Or is a matter of school not offering much more education in this field than the home and surrounding society? If this is the case, school education does not bring any added value to the life of young people, not at least in this respect.

Just less than half of the pupils feel that they have studied the HBT cross-curricular theme as shared teaching in various subject areas. Only slightly more than one-fourth feel that the cross-curricular theme has been “included in joint events such as assemblies”. Slightly more than half think that the cross-curricular theme has been visible in school routines. The results are not very encouraging the theme should undoubtedly be more conspicuous also in these school activities. According to the Framework Curriculum, cross-curricular themes should also be integrated into optional studies as well as joint events (assemblies, festivities, etc.) and “they are to be manifest in the schools’ operational culture”.

The results seem to indicate the difficulty of integrating learning into the school’s operational culture and other school events, rather than only into subject teaching. There is still a lot to do to develop schools towards a more holistic learning environment.

6. Some observations on achieving the objectives of the cross-curricular topic
A central role in achieving the cognitive objectives of the HBT cross-curricular theme is played by the content matter taught in various classes. Mathematics and science play an important part, for instance with regard to subject matter in electricity and electronics. An analysis of the National Framework Curriculum (Rasinen et al. 2008) indicates that references to technology are slight in the contents and objectives of physics but particularly many in the contents and objectives of craft (particularly technical craft). The results of the study show that pupils understand the connection between manual skills and technology: 90% of respondents think that manual skills and technology are related. In the study of technology, learning by doing cannot and should not be avoided. It is a central method of learning and in this respect pupils seem to strongly agree. The objectives to do with making a link between manual skills and technology presented in the curriculum seem to have been achieved, at least to some extent.

The results reveal that young people have a clearly positive attitude towards technology, which, however, does not mean that their attitudes are unreserved and uncritical. Most of them seem to weigh up the ethical, moral and equality issues connected to technology. They also tend to pay attention to the responsible use of technology and sensible choices. They see technology and sustainable development as interconnected. These observations are in line with the objectives and contents of the cross-curricular topic concerned. Young people’s attitudes indeed paint an optimistic picture of the future. The future needs citizens who have a positive attitude towards technology, but who are also able to constructively criticize technology and act and make choices accordingly.

As far as developing technological ideas, modeling and studying the life-span of artifacts is concerned, the curricular objectives have barely been achieved. The objectives of the HBT cross-curricular theme, however, should have offered the pupils these types of opportunities.

7. Conclusions and suggestions for development

It seems that the development of technological ideas has not been implemented at all in HBT cross-curricular teaching, even though this particular section of the cross-curricular theme could have introduced something new and concrete that would steer towards innovativeness and creativity. Paying more attention to this aim would better link visual art and craft education to this cross-curricular theme. This would also have been important with regard to the fact that only in visual arts and craft studies is the learning of innovation processes stated as one of the learning objectives. It is particularly the contents of craft education that refer to the learning of a technological innovation process. (RasinenRasinen, Virtanen, Endepohls-Ulpe, Ikonen, Ebach, & Stahl-von Zabern, 2009) The attitudes of youth towards technology and the development of technology were in line with the objectives of the Framework Curriculum. Nevertheless, neither in this particular cross-curricular theme nor in school routines has the wide-ranging utilization and application of technology been made possible, let alone the further development of technology. A positive observation, however, was that
the majority of young people understood the connection between technology and manual skills.

Not really anywhere in the objectives and contents of the cross-curricular theme is much emphasis placed on the application of know-how. In technology and its development applied know-how has an essential relevance. This observation, together with learning by doing, brings to technology education a pedagogical approach oriented to active doing and making—the very substance of technology education.

The fact that technology was not defined in the Framework Curriculum affected the interpretation of the objectives and contents of the HBT cross-curricular theme. In spite of having a positive attitude towards technology, young people have quite a narrow understanding of technology, mainly as a subject area connected to ICT. Even the introductory note in the questionnaire, “technology can be understood as human built environment”, did not change this narrow view of technology.

In forthcoming Framework Curricula it is essential to define the concept of technology. It also has to be noted that learning by doing and supporting the technological ideation processes of children must play a central role. In addition, one of the learning objectives should be identifying and solving problems. The valuable legacy of Uno Cygnaeus also obligates us to this. This view is also in line with many international interpretations of technology education. Among others Layton (1993) has written about technological problem solving, especially in technology education. Problem solving starts with identifying a flaw or need in the built environment. Although it is important to prepare pupils to understand the human built environment and the core principles linked to its functioning, it is even more important to give the pupils opportunities to design, develop and apply technology in a creative and innovative manner (Järvinen 2006, 32-35). When planning the new curriculum these views have to be taken into account and have to be defined so clearly as to avoid any chance of misinterpretation.

A recent article (Sulonen et al., 2010) examines the functionality of the curriculum system in preschool and basic education. In the abstract (pp. 7-10) they present, for example, the following conclusions:

- The status of skill-based and arts subjects as well as that of cross-curricular themes should be enhanced (principals' viewpoint)
- The cross-curricular themes are felt to be discrete and disconnected but their contents are important (teachers' view)
- There should be more time for skill-based and art subjects and more opportunities for optional studies (pupils' view)

Korkeakoski et al. (2010, 55) mention that: “When the municipalities and schools were asked what were the most difficult issues to apply in local curriculum planning, the answer was: the cross-curricular themes.” One-third of the respondents wanted to have more information on how to teach the cross-curricular themes and how to make learning and teaching more holistic. This is a powerful message to be heeded in drawing up the future Framework Curriculum. On the other hand, teachers should also be obliged to pay attention to the cross-curricular themes in their daily routines. This could be aided, for instance, by assessing achievement in the cross-curricular themes. It is also essential to provide in-service education
for teachers by giving them concrete ideas and learning materials for their daily routines, which would assist in implementing the objectives and contents of the curriculum. Several articles dealing with technology education offer suggestions on how to organize technology education. Co-operation between various subject areas is regarded as important, but other worthwhile options include establishing a new subject area or developing craft education in the direction of technology education (UPDATE Final Report, 2010, Segregaationlieventämistyöryhmänloppuraportti Final report of the work group on the alleviation of segregation 2010). One conclusion to be drawn from the study is that girls should be encouraged more to study technology and particularly to develop technological ideas.

8. References


1. The Basis of Technology Education: Matter, Energy and Information

In the Department of Educational Sciences and Teacher Education at the University of Oulu technology education is considered as Lindh (2006, 95) states as an area of knowledge and skills where the learning process of technology is based on learning the interaction of matter, energy and information. Raat and de Vries (1986, 16) regard matter, energy and information as the three pillars of technology (see de Vries 2005, 25). Whereas matter and energy are quite easily understood and objectified for example in streetlights, information is far more complex as it is formed in our minds. As Maartens (2007) states, “information is a term with many meanings depending on context, but is as a rule closely related to such concepts as meaning, knowledge, instruction, communication, representation and mental stimulus”. For example when streetlights go suddenly out it may have different meaning for different people. Some may think “the lamp broke down” – some may think “there must be a blackout”. The point is, “although information requires the perception of a difference, the difference will require a matter-energy carrier, e.g. a page in a book, electrical circuits in a computer or sound waves in air” (Maartens, 2007). In the case of streetlights, the carrier is the light. And as we live in our continuously developing technological world, it is essential that we understand the interaction of all those three elements: matter, energy and information.

On the basis of previous statement and according to Lindh (2006, 75) the goal of technology education is that children and youngsters:

- understand and are able to explain the logics and mechanisms of the everyday technology,
- cope with technological problem situations by applying their technological knowledge and skills,
- appreciate technology and understand its meaning for welfare and
doing themselves to vocational and scientific education that apply technology.

2. Technology Education and Technology Oriented Primary Teacher Education since 1996
Technology Oriented Primary Teacher Education –program (TTE) has been one of the Master’s degree programs in Faculty of Education at the University of Oulu since 1996. In TTE –program students study technology education in the context of educational science. Studies are directed to students who are interested in technology and applying it in comprehensive school. By orientating in mathematics, natural science and technical sciences students embrace readiness to integrate technology through different school subjects in different school levels and ability to create and develop new learning environments. (Technology Oriented Primary Teacher Education, 2011).

Technology education is also carried out in the context of technical work through two different studies: TECHED BASICS (7 credits) and TECHED ADVANCED (25 credits). Like shown in table 1 below, the 7 credit TECHED BASICS-studies is divided either in three or four courses depending on the target group and the 25 credit TECHED ADVANCED-studies is divided in five courses. The latter studies give students readiness to teach technical work in primary school.

Table 1
TECHED BASICS (7cr) and TECHED ADVANCED (25 cr) studies in Primary Teacher Education at the University of Oulu.

<table>
<thead>
<tr>
<th>Course</th>
<th>Extent</th>
<th>Content</th>
<th>Working Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handicraft and Technology in the Context of Technical Work</td>
<td>2 credits</td>
<td>Practical Work + Written Assignment</td>
<td>Lectures 6 h + Exercises 20h</td>
</tr>
<tr>
<td>Devices and Control</td>
<td>1 credit</td>
<td>Practical Work + Written Assignment</td>
<td>Lectures + Exercises 13 h</td>
</tr>
<tr>
<td>Mechatronic Applications</td>
<td>2 credits</td>
<td>Practical Work + Written Assignment</td>
<td>Lectures 4 h + Exercises 22 h</td>
</tr>
<tr>
<td>Electronics Applications</td>
<td>2 credits</td>
<td>Practical Work + Written Assignment</td>
<td>Lectures 6 h + Exercises 20 h</td>
</tr>
</tbody>
</table>

For Broadly-Based (BTE), Creative Arts Oriented (ATE) and Intercultural (ITE) Primary Teacher Education Students

<table>
<thead>
<tr>
<th>Course</th>
<th>Extent</th>
<th>Content</th>
<th>Working Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Handicraft in the Context of Technical Work</td>
<td>3 credits</td>
<td>Practical Work + Written Assignment</td>
<td>Lectures 6 h + Exercises 33 h</td>
</tr>
<tr>
<td>Mechatronic Applications</td>
<td>2 credits</td>
<td>Practical Work + Written Assignment</td>
<td>Lectures 4 h + Exercises 22 h</td>
</tr>
<tr>
<td>Electronics Applications</td>
<td>2 credits</td>
<td>Practical Work + Written Assignment</td>
<td>Lectures 6 h + Exercises 20 h</td>
</tr>
</tbody>
</table>
TECHEDADVANCED – Crafts, Technical Work and Technology studies (25 cr) – Third Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Extent</th>
<th>Content</th>
<th>Working Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material and Manufacturing</td>
<td>7 credits</td>
<td>Exam (2 cr) + Practical Work 1 (3 cr) + Practical Work 2 (2 cr)</td>
<td>Lectures 15 h + Exercises 75 h</td>
</tr>
<tr>
<td>Robotics and Automation</td>
<td>7 credits</td>
<td>Exam (2 cr) + Programming Exercises (2 cr) + Practical Work (3 cr)</td>
<td>Lectures 15 h + Exercises 75 h</td>
</tr>
<tr>
<td>Technological Design</td>
<td>3 credits</td>
<td>Exam (1 cr) + Technical Drawing Exercises (1 cr) + Circuit Diagram and Printed Circuit Board Exercises (1 cr)</td>
<td>Lectures 10 h + Exercises 45 h</td>
</tr>
<tr>
<td>Technology and Pedagogics</td>
<td>5 credits</td>
<td>Exam (2 cr) + Practical Work (2cr) + Teaching Practice (1 cr)</td>
<td>Lectures 20 h + Exercises 35 h + Teaching Practice 10 h</td>
</tr>
<tr>
<td>Educational Scopes of Technology</td>
<td>3 credits</td>
<td>Textile Work (1 cr) + Study Visit (1 cr) + Work Safety (1 cr)</td>
<td>Textile Work 16 h + Study Visit 10 h + Work Safety 10 h</td>
</tr>
</tbody>
</table>

Developing and Changing Practices – Robotics and Automation in Primary Teacher Education

The latest development in TECHED BASICS studies has been the change of extent of these studies from 6 credits to 7 credits. In Broadly-Based, in CreativeArts Oriented and in Intercultural Primary Teacher Education programs the extent of Traditional Handicraft in the Context of Technical Work course has increased to 3 credits instead of previous 2 credits. In Technology Oriented Primary Teacher Education program (TTE) previously optional Devices and Control course (1 cr) has changed to be obligatory course in the future.

The goal of these changes has been to create a greater continuum in the contents of technology (education) between TECHED BASICS and TECHEDADVANCED studies. This is the case especially among TTE-program’s students and the contents of robotics and automation: After students are familiar with common materials used in technical work and know how to machine them they will learn the very basis of automation by controlling different devices and systems like electrical toys and simple robots in Devices and Control course. Students will learn the very basics of mechanics and electricity while familiarizing them with different ways to control electrical toys. Students also learn to identify and explain open and closed-loop control systems and program simple open-loop control system robots which are designed to be used at the primary school level.

After the Devices and Control course students learn to apply the basis of mechanics and electricity in Mechatronics Applications course by designing and making a “Moving toy” (See Appendix 1).

The Moving Toy assignment:
“Design and manufacture a moving toy which runs with electrical motor and changes direction as it bumps into an obstacle. Toy’s transmission, size and building materials can be chosen freely. The operating voltage of the toy must be 3 – 6 volts. Frame structure can be made:

- of plastic with vacuum former,
- of sheet materials by bending or
- of recycled material or goods”.

After mechatronics TTE-students will learn to understand the fundamental principles of electrics and electronics through individual design, experiments and construction in the Electronics Applications course (See Appendix 2).

The goal is that by accomplishing these TECHED BASICS courses students learn to design, implement and evaluate small-scale theme works from the viewpoint of technology education in primary school technical work and furthermore embrace the adequate orientation basis for learning robotics and automation in TECHED ADVANCED studies.

In this case orientation basis is defined as an achieved level which comes into existence with thinking and acting processes and which gives students a possibility to form their own perceptions of certain theme or subject, evaluate it and solve challenges and problems associated with it. (Galperin 1979, 33-35; Engeström 1998, 76; Kosonen&Lakkala&Hakkarainen 2010, 27).

In TECHED ADVANCED studies the adequate orientation basis for Robotics and Automation course consists of necessary knowledge and skills of mechanics, electricity and electronics which students need in logical and creative problemsolving among robotics and automation. First in mechanics section students familiarize themselves with simple mechanisms and the Newton’s laws by automata - mechanical toys. Students learn how levers, cams, cranks, ratchets, gears and pulleys work.

In electricity and electronics section students learn to use the most common components and understand the fundamental principles of electrics and electronics. By learning these basics students can learn to combine mechanics and electricity into technological entireties as in robotics and automation through individual design, experiments and construction.

**Background of the Robotics and Automation course**

According to Siciliano et al (2009, 1) robotics is about the study of machines that can replace human beings in the execution of a task, both in physical activity and decision making. In this study robot is defined as follows:

“A robot is a machine that gathers information about its environment (senses) and uses that information (thinks) to follow instructions to do work (acts)” (The Tech Museum of Innovation, 2005).

In other words when a robot senses, it recognizes or detects – when a robot thinks, it processes information – and when a robot acts, it performs the task it has been given exactly as programmed, not creatively.

The first Robotics and Automation course (7 cr) was implemented in spring 2011. The idea was to introduce to students an inexpensive way to build robots and teach robotics to pupils in primary school. The completion of the course did not require earlier experiment in robotics or even the completion of TECHED BASICS studies. The goal was that as many students as
possible can choose the optional *Robotics and Automation* course and familiarize themselves in everyday automation and their applications in primary school. The goal was that by accomplishing the course student will be able to

- explain the principles of open and closed-loop control systems and present examples of automation systems in everyday life.
- program simple open-loop control system robots which are designed to be used in primary school.
- apply the basics of mechanics, electronics and programming in the context of robotics and automation.
- design, build and program a simple closed-loop control system robot or automation system.
- apply the basics of robotics and automation into primary school technical work.

In the beginning of the year 2012 the Robotics and Automation course had taken shape where at first students were familiarized to the basics of automation by simple examples that exist in everyday life applications. The goal was that students learn to explain the principles of open and closed-loop control systems. In this stage students used *PIXIE* and *PIP* robots.

Next students were familiarized more profound to closed-loop control systems with LEGO NXT Mindstorms robotics building system. The goal was that students learn to program simple robots with the *LEGO Mindstorms Education NXT Software* and to explain how different sensors work.

After LEGO system students were introduced to PICAXE system with 18A and 18M2 microcontrollers. Programming was made with BASIC in the Programming Editor Software platform. In this stage students were given an assignment to design, build and program a simple *Flat Surface Robot* or as demanding automation system.

**Flat Surface Robot Assignment**

In this case the focus is in the year 2011 when the actual study took place. The main course assignment was given in a written form to students. Their task was to “design and make a Flat Surface Robot which moves incessantly on a flat horizontal surface which has barriers. The robot is not allowed to fall off the surface or get stuck in barriers. Framework, transmission and building materials can be chosen freely but the robot must fulfill the following terms:

- Operating voltage must be 1,5 – 6,0 V.
- Structures and solutions can be carried out in primary school technical work or technology lessons.”

As the assignment was introduced to the students there was also a discussion about the real life applications that could be linked with *Flat Surface Robot*. Every step of the manufacturing process was discussed and rationalized. The microcontroller used was PICAXE 18A and the programming was carried out with BASIC language.(See Appendix 5).

**Why robotics and automation?**

As a Finnish engineer Tuomi (2008, 14) notes: “*automation is not a separate island in the ocean of technology but an interdisciplinary place where various technologies meet and merge*”. What we have experienced robotics and automation can be one of the easiest ways to
learn to understand the interaction of matter, energy and information as robotics include the vital three elements: mechanics, electronics and programming. (See Verner & Hershko 2003). Norton and Richie (2009, 425) state that the “use of technology practice as a framework for the learning of mathematics and science offers considerable potential for students to develop deep understanding of phenomena in relevant contexts”. They justify this with three elements: additional time, additional representations and frequency of engagement. This means that students have more time than usually to apply scientific and mathematical thinking as they build robots for example. Students also have to explain and represent their solutions about gearing for example. And finally students have to engage themselves in their own project totally no matter what “subject content” is the case they have to understand and learn to think to solve the problems along the way.

Wicklein and Schell (1995, 59-60) suggest that integration of mathematics, science and technology education is the right way to help students learn and appreciate the relevancy of how school subjects are tied together and how each subject builds on the other. Norton and Richie (2009, 425) see in Wicklein’s and Schell’s statements a suggestion “that specific knowledge of mathematics and science concepts mutually supports the design, production and evaluation processes of technology”.

Based on above-mentioned factors it should be rather easy to understand why robotics and automation should be a part of our comprehensive school’s contents and especially part of our Finnish technical work contents.

3. Purpose of the Study

The objective of this study was to examine students’ overall attitudes towards robotics and automation and moreover their way of learning in designing, making and programming robots. We also wanted to find out how students evaluate and reflect on designing and making the flat surface robot with comprehensive school in mind. The focus was on the following research questions:

**Students’ actions**

1. What students learn through designing, making and programming a flat surface robot?
2. In which problem solving situations students find the solution mainly through their own experience?
3. In which problem solving situations students find the solution mainly through their own experiments?
4. In which problem solving situations students find the solution mainly through teacher’s instructions?
5. Do the experiences formed by students’ own experiments lead to different kind of solution comparing the solutions made with their earlier experiences?

**Students’ attitudes**

6. How students react on the flat surface robot project in the beginning of it, during and after?
7. How students assess their success in designing, making and programming a flat surface robot?
8. How robotics and automation suit in the context of primary school’s technical work?

The Group of Examinees
The examinees were all primary teacher education third year students who had chosen the optional *TECHED ADVANCED* (25 cr) studies. Altogether 12 students participated on the *Robotics and Automation* (7 cr) course – 10 students from Finland, 1 from New Zealand and 1 from Russia. Five of these students were from *Technology Oriented* (TTE), three from *Creative Arts Oriented* (ATE) and two from *Broadly-Based Primary Teacher Education* (BTE) and two from *Intercultural Teacher Education* (ITE). Their earlier studies in the field of technology education at the university level were limited to 6 credit *Craft, Technical Work and Technology* studies.

4. Research Methods

The study was carried out as an action research which allowed the researchers to participate the teaching and observe the whole project. Like Carr and Kemmis (1986) say all action research aim to improve and to involve. Typically action research aims at improvement in three areas: “firstly, the improvement of practice; secondly, the improvement of the understanding of the practice by its practitioners; and thirdly, the improvement of the situation in which the practice takes place” (p. 165).

The goal behind our actions was to improve technology education practices and learning environment in the primary teacher education by strengthening and diversifying robotics teaching. Obviously our goal was also to increase the students’ knowledge in robotics and automation.

After building the PICAXE-robot students had to write an essay of the topic “*Teaching Automation in Comprehensive School – Possibilities and Challenges.*” The assignment was as follows:

“Write an essay about topic Teaching Automation in Comprehensive School – Possibilities and Challenges. Examine the possibilities and challenges of teaching automation thoroughly from the viewpoint of your own concrete making and from the viewpoint of comprehensive school’s technical work. Examine and reflect on the contents of automation through “Flat surface robot” exercise on three sectors: 1. Mechanics, 2. Electricity and electronics, 3. Programming. Examine the teaching of automation in the context of comprehensive school’s technical work from the viewpoint of student and teacher. The extent of your essay should be max 10 pages."

Along the essay assignment students were given also questions which guided their answers (See Appendix 3). Purpose of these accurate questions was to insure that the students’ answers would give as much valid information as possible.

Furthermore six students were interviewed after they had completed the course. Interviews were recorded on a camera. Interviewees were mainly students who were not discussed with the solutions they had made during the robotics process. Interviews were carried out individually in a loosely standardized, open-ended way where the basic questions were same
to everyone. Every student brought one’s flat surface robot to the interview so that they could point out the solutions along the process while answering the following questions:

How did you end up the solution you made?

1. Did the teacher or the instructor tell you how the problem should be solved?
2. Did you know on the basis of your own experiments what can be done to solve the problem?
3. Did you decide to try, test or experiment how the problem can be solved despite your own possible opposite experiments or what others said?

5. Results

After two months since the Robotics and Automation -course had ended April 12th 2011, eight students out of twelve had returned theiressays and six of them had been interviewed. In addition to that some notes were written down along the course. Here is a short review of someresults.

Students’ actions in designing

After students had been given an adequate orientation basis they were told to create sketches and make technical drawings of their Flat Surface Robot in 1:1 scale. Everyone had to make at least three views of their future robot: top view, side view and front view. They were instructed to use battery holders, gears, wheels or tracks, microswitches etc to understand the proportions of their robot and to help their designing process. They were also advised to take into account their own printed circuit boards for PICAXE-ship and motor driver IC. The PCBs were already been made during the previous Technological Designcourse with the help of the PCB Wizard software.

After all students had designed their robots or at least a few sketches of one’s robot it became obvious that everyone would use pine wood bars for the framework (See Appendix 4). When students were asked how they ended up with pine wood bar structure answers really showed the remarkable impact of the teacher’s example. Yet there was only pine wood bars glued together in teacher’s model. One of the students explained:

“I didn’t have my own idea about the framework so when I saw the example of that structure it was easy to copy the structure and just make it bigger…” (ITE-student 5)

Another student said:

“...in your (means teacher) example which you showed in the beginning of our design process you had just wooden sticks glued together and I thought that it would be simple and sure way to make the framework... at some point I thought that what if I make the frame out of plastic plate but it felt that plastic was a bit too unknown material for me...” (ITE-student 6)

One student had his own experience of similar structures with building bricks:

“I thought it would be the easiest way because of the gearing and in addition to that pine wood sticks were already made and available...and if I would have done the framework out of metal, all of the drillings and cuttings would have been much more difficult and slower ... and this kind of pine wood structure
reminded me of LEGO Technic bricks and beams which I played with when I was a child…” (TTE-student 2)

ATE-student 9 said that the design process of a robot sounded so challenging that he decided to listen to other students’ ideas first:

“...I didn’t have enough knowledge to estimate what kind of transmission would be the best... only thing I did was listened to others what they discussed. The weight and the movement of a robot seemed to be the key challenges. On the basis of that I reasoned out that I need a slow and powerful transmission. I chose a big gear for the wheel axle and a worm gear for motor and a small gear between them. I had a feeling that it would work. Mainly I tried to keep it simple...” (ATE-student 9)

The solutions ATE-student 9 made with gearing worked well. Actually his flat surface robot was one of the best robots as it was both functionally and esthetically well built (See Appendix 4, pictures 1-3). It was quite light and nimble and had one of the most interesting castor wheels, a kind of a top of a roll-on deodorant container, only with rolling steel ball. He explained how he ended up with that solution:

“I think the best example of my own design was the castor wheel. I was attracted by the idea of a freely rolling castor wheel which would have as low friction as possible. I got few ideas from our technical work instructor and finally I came up with the idea of a steel ball inside a hollow...my steel ball had a diameter of 14 millimeters, so I drilled a hollow which had diameter of 15 millimeters. The depth of the hollow was less than 15 mm because the ball had to be slightly out of the hollow to roll. I locked the ball in its place with thin plastic sheet which had a diameter of 13 mm hole...The steel ball rolled even more easily when I put a spacer on the bottom of the ball hollow. I’m extremely happy with the result.” (ATE-student 9)

The making of this castor wheel was a good example how some students planned their actions. Although ATE-student 9 made some sketches, mainly he tried different things as long as he came up with solution that he was happy with. He tried different plastics and finally decided to use both acrylic and polycarbonate plastic. He drilled different size holes to see the best solution for steel ball’s smooth operation. Sowhat kind of knowledge and skills he had before he started his “castor wheel project”? At least he knew how to drill and cut plastics and how to use bolts and nuts. He also understood the concept of friction and above all, how the robot should act and how the design of a castor wheel would affect to robot’s movement. But the final solution was something that he didn’t know exactly beforehand. He wasn’t able to draw and calculate accurately enough so he had to try. One could ask, is this the way how things should go with children also?

Overall the design process went so that only few students put an effort on their designs while others settled for more modest designs. Like some of the students said they should have paid more attention to their design because it took so long to try different solutions without proper plans. In spite of this there was no visible indicators that those who had modest designs and plans had significantly more problems or did more mistakes than the others.

Students’ actions in making
When students started to manufacture their robots they were instructed to be accurate and think twice before act so that they would make as few mistakes as possible. In spite of this some students had a problem with the drillings when they did the drillings for the axels with hand drills, even if they were advised to use bench drills. The result was usually not accurate enough as one of the students found out:

“…when I tested my robot with three 1,5V batteries the gearing worked ok, but when all the connections had been made and the battery voltage had dropped just a little there was not enough torque... so I decided to add extra gears to get some more torque...I didn’t calculate I just reasoned and tried out...and actually I found out the real reason why my robot didn’t move with the first transmission was that I didn’t drill those axel holes accurate enough and I had to install metal plates with accurate perpendicular drillings for axels...with the bench drill...” (TTE-student 2)

BTE-student 1 said that the frame structure and the gears became his biggest problem and he had to make almost totally new frame after the first one. He had built the frame out of 10 mm x 10 mm pine bars and drilled too big holes for the axels. As a result transmission did not work because of the loose connections of the gears. He had thought that the teacher’s instructions about drilling the axel holes were not to be taken so word for word. He also said:

“The function of gears and worm gears is something that everyone should understand. I have calculated and drawn physical quantities of forces which are generated with gears but never before I have internalized what to do with those quantities in tangibly way. The disappearance of substance somewhere within primary and secondary school is a sad thing because a significant part of understanding of everyday technology is lost at the same time.” (BTE-student 1)

ITE-student 5 had similar problems as BTE-student 1 but he also had problems in understanding the gear ratios. In addition to that his robot did not have enough power to turn because the distance between drive wheels and castor wheel was too big. Although he had difficulties he thought that his solutions were important as they taught him many skills that he needs to work with in technical work as well as other subject areas. He also thought that it is important to teach this kind of robotics in the comprehensive school from grade five onwards when pupils have the motoric skills required. He justified his view:

“They (children) are forced to solve problems through experimentation and guided practice, and have the chance to come up with their own solutions. This fulfills the core curriculum standard for making the connection between applications and problems that appear in technical work, and with other subjects like art, science and mathematics. In practice in the context of this project this means that when something in the mechanical apparatus of the robot is not working, pupils must find solutions to the problem. It is very important however that the teacher is able to guide them through this process.” (ITE-student 5)

Also TTE-student 7 and TTE-student 6 had a problem with gear ratios because their robot was so heavy. TTE-student 7 solved his problem by lightening the robot’s overall frame structure and TTE-student 6 changed the gear ratio. TTE-student 6 stated about the process:
"It was really a good idea to learn to calculate ratios during the design process of gearing. I knew how much different spur and worm gear combinations will drop the speed between the motor and the wheel." (TTE-student 6)

TTE-student 6 thought that in primary school it is also possible to integrate physics to technical work in this kind of gearing designs:

"...you can teach physics’ mechanics in robot’s gearing designs, for example how the torsion increases as you slow down the speed with gearing. At the same time you combine mathematical thinking in the context of technical work. In designing you learn technical drawing which of course is obvious in technical work, but it can also develop children’s readiness of visual art and visual perceiving." (TTE-student 6)

Overall the students’ solutions with mechanics, including robot’s chassis and gearing, were based on their own experiments and experiences, as well as tips and instructions from teacher and instructor. Some of the students worked as much as possible by their plans and designs and some tried different solutions, often without asking for help. The point is that none of these methods should be ruled out, whether we’re talking about teacher students or children. More important is how pupils and students are taught to think and understand different concepts. As it was seen in this robot project, especially in that “castor wheel example”, it is important for pupils and students to know what are the key elements for successful solutions in every problem solving situation.

Like in mechanics, also in electronics some of the students faced problems and challenges they weren’t expecting. ATE-student-9 – who had a contact problem in his printed circuit board because he had drilled too big holes for the components – was confused with electronics as he wondered what he was supposed to know beforehand and what he was supposed to learn. He felt that learning electronics was laborious. It was hard for him to remember the names of the components and understand their function. He said:

"During the electronics process it became obvious what I was lacking. They were very simple things like the function of a switch. Because of this I connected the wires to the switches in a wrong way... In this project I should have had enormous knowledge beforehand. Nothing was obvious for me. I knew nothing about the difference between PIC-microcontroller and other microchips before the course." (ATE-student-9)

Although ATE-student-9 made one of the best flat surface robots of the course he thought that he hadn’t learned as much as he should have. He also thought that robotics was so demanding theme that he will not teach it in primary school. In spite of this he thought that robotics would be suitable from grade six onwards.

BTE-student 1 said he made too many human errors and wasn’t thinking enough. He thought that:

"...electronic components were the most challenging part of the flat surface robot. It felt that when working with cheap components one had to add diodes and resistors here and there. Nevertheless I am satisfied that by solving these problems I achieved a better understanding to use electronic components. This was a big step for me because I had earlier worked only with “half-done electronic kits”. (BTE-student 1)"
BTE-student 1 stated also that teaching electronics and electricity should have more focus in primary school. For example opening an electrical motor and investigating its internal components during the course had given him a spark to study his old physics textbooks and learn more about principles and formulas that he had not understood before. He said:

"At the same time I achieved both conceptual and substantial understanding about function of coils, magnets, motors and even generators. Why this can’t be taught to children?” (BTE-student 1)

TTE-student 2 – who had a similar contact problem in his PCB like ATE-student-9 – thought that children in grades 5-6 (age 11-12 years old) can learn the same things about electronics that he did in the robotics course. In his opinion during this kind of project children can learn to use at least microcontrollers, diodes, transistors and LEDs. They can learn the basic laws of electricity through practice. For example with the Ohm’s law they can learn to calculate the resistance of a LED’s resistor which is very simple as long as you understand electrical background. In addition to this he stated:

“Children should be taught also how to use a multimeter in fault finding. It is a useful device in many contexts and the use of it can help you in your everyday life situations. You could say it is a part of technological education.” (TTE-student 2)

Although many of students considered the electronics as a challenging part of this kind of robotics projects they learned the necessary contents and managed to build their own functional flat surface robot. One can just wonder what they would have been able to create if they had studied electronics in their childhood.

The methods that students used to find the adequate solution in different problem solving situation varied with no exceptions. Every student solved some problems with the help of his own experience or teacher’s instructions and some through his own experiments. One of the interesting things was how often students tend to experiment stubbornly their own ideas even if they were told to do it otherwise. In some cases a student tried out his own method or idea although both the teacher and the instructor had advised to it differently. Usually it ended in failure. This was the case for example in accurate drillings of the axle holes to robot’s framework or the component holes to PCBs. Some students ignored the instructional discussions with the castor wheel and tried different castor wheel solutions without thinking enough of its function. And although there were discussions about the balance of a robot and the positioning of motors, some students tried out what happens if the motors are far back in the robot. In many cases one had to move the motors towards the central part of robot to get the balance right. Some students justified their motor positions that there would be more space for other components – which actually makes no sense, but they couldn’t justify it more properly.

Overall students’ experiments can be divided roughly to two different categories: ones that took place mainly because of the student’s haste and negligence, and ones that were carefully thought through and successful solutions. It seems that one of the most important things is – no matter how old the pupil or student is – how teacher guides them to find the key elements in every problem solving situation. The leading idea is to teach them to think and then act – with the interaction of matter, energy and information in mind.

Students’ actions in programming
In programming some students tend to rush without thinking enough what they actually wanted their robot to do but in general there were no problems with the simple BASIC-programming of the flat surface robot (See Appendix 5). Like TTE-student 7 said:

"There’s no need to be afraid that BASIC-programming would be too difficult for children. In flat surface robot and similar automation projects the logic is quite simple to understand." (TTE-student 7)

**Students’ attitudes toward robotics**

Students’ general attitudes towards Robotics and Automation course were all quite positive. One of the statements which described this was:

“Automation, even as a word sounded so difficult that I was terrified to begin to study this modern like theme. But the truth was surprising: there is nothing more miraculous in automation than in common everyday technology and to understand the basics of automation does not need incredible substance knowledge. Of course automation in larger scale and in more complicated processes needs more focused knowledge but the basics stay basics and that is what we should teach to children in schools.” (BTE-student 1)

Another student stated:

“Building automation systems requires exact designing, understanding of technological devices, understanding and familiarizing of the electronic components and mechanical parts and of course trying and mistakes. A self-made automation device rarely works perfectly at the first time. It needs adjustment and deliberate structural changes. All this requires understanding how the device works and what are the most essential parts to its function. In this stage, the worker or pupil can’t work without thinking. And that is the most essential idea of technology education.” (TTE-student 2)

When students evaluated their overall success in designing, making and programming a flat surface robot the answers varied a little. ATE-student 8 thought that although building a flat surface robot is a great way to introduce inventing to children it is difficult, maybe too difficult for him. He thought that PICAXE is a great way to develop and contribute technology education but it will be just a nice memory from teacher education. TTE-student 6 stated that the robotics course was a very interesting project and at the end of the course he could only wonder how much his understanding had increased in the field of technical work and physics. BTE-student 3 considered he started from the same level than a sixth grade pupil and yet he succeeded and the course clarified his knowledge in programming, electronics and mechanics. He thought that a flat surface robot would be a good work in the context of primary technical work because children would need to integrate so many subjects along the project.

6. **Conclusion**

Overall the Robotics and Automation -course was success despite of some problems along the way. The problems were mainly linked with transmission and accuracy or gear ratios. It seems that in some cases teacher should have pay more attention to those students who had
problems with gears and teacher should have made more accurate handouts or exercises about
transmission and gear ratios. Yet in some cases students should have taken part in those
lessons when the gear ratios were discussed.
Anyway the study showed that several students were interested in robotics and they thought it
should be taught also in primary school. Some of the students thought that robotics would be a
natural context for children to learn simple mathematics and physics. All of the students
thought that building a flat surface robot or similar device would be suitable for six grade
pupils or older. Yet some thought that it would be too big project for them.
The study indicated also some methods how students tend to solve technological problems. In
this case there seemed to be many variables that affected to student’s decision of the method
one used. In some cases it was important to get the robot done quickly and get the credits, in
some cases one had so many other things in mind that one couldn’t focus properly on ongoing
robot project. Yet in some cases some students showed rather advanced technological
thinking as they tried to find the best possible solution. For example some students made
several designs and prototypes out of different materials of their castor wheel before they
chose the best solution.

One of the most interesting observations was though that many students, like many technical
work teachers in Finnish primary schools, are curious to try out different technological
solutions in their own projects. But why this feature so often disappears when working with
children? Why so often children are ordered to do exactly the way teacher tells them? Why
they are not allowed to experiment and at the same time deepen their technological
knowledge?

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Appendix 1

“Ladybug” – a moving toy which changes direction as it bumps into an obstacle (Mechatronics Applications course’s student work, 2011).
Appendix 2

“Art of Light” – LED decorative lighting with brightness control (Electronics Applications course’s student work, 2011).
Appendix 3

“Assistance questions” – questions which helped students through the essay writing.

1. MECHANICS

   Evaluate and reflect on designing and making of the flat surface robot’s (or similar automation system) framework, drivetrain and microswitch levers through following questions:

1.1. What materials, joints, procedures and tools can be used in manufacturing of the flat surface robot?

1.2. How the procedures and the use of tools mentioned above can be learned in comprehensive school’s technical work?

1.3. What alternative solutions there are according to drivetrain and switch levers?

1.4. How the solutions mentioned above are suited to teaching automation in the context of comprehensive school’s technical work?

1.5. What mechanical components or mechanisms should be purchase completed and what could be made in comprehensive school’s technical work?

1.6. What kind of challenges can be experienced with children when they design and manufacture flat surface robot’s framework, drivetrain and microswitch levers?
1.7. How the challenges mentioned above can be eliminated when working with children?
1.8. What contents of different subjects and/or mechanics children can possible learn by designing and manufacturing flat surface robot’s framework, drivetrain and switch levers?
1.9. How important are the contents mentioned above in the comprehensive school?

2. ELECTRICITY AND ELECTRONICS

Evaluate and reflect on designing and making of the flat surface robot’s (or similar automation system) electrical and electronic connections through following questions:

2.1. What electrical and electronic components or parts are needed and can be used in designing and making a flat surface robot?
2.2. What tools and working methods are needed with components mentioned above?
2.3. How components, tools and working methods mentioned above can be used in the context of comprehensive school’s technical work?
2.4. What electrical and electronic parts should be purchase completed and what could be made in comprehensive school’s technical work?
2.5. What kind of challenges can be experienced with children when they deal with flat surface robot’s electrical and electronic parts and connections?
2.6. How the challenges mentioned above can be eliminated when working with children?
2.7. What contents of different subjects and/or electronics children can possible learn when they deal with flat surface robot’s electrical and electronic parts and connections?
2.8. How important are the contents mentioned above in the comprehensive school?

3. PROGRAMMING

Evaluate and reflect on the programming of PICAXE microchip with BASIC programming language and how BASIC can be suited in comprehensive school.

4. GENERAL

4.1. What contents can be taught by teaching automation in the context of comprehensive school’s technical work?
4.2. On what grades automation projects are suitable for?
4.3. How long should automation projects last in the context of comprehensive school’s technical work?
4.4. How the design and making of a flat surface robot or similar automation system is suited for children?
Appendix 4

“Flat Surface Robots”
Appendix 5

An example of a simple BASIC-program of a flat surface robot with PICAXE-18A (Programming Editor Software).

mission: let pins = %10100000 ;switch output 7 and 5 on (motor L and R forward)
if pin1 = 1 then panicleft ;jump to label "panicleft" when input 1 is "on"
if pin2 = 1 then panicright ;jump to label "panicright" when input 2 is "on"
goto mission ;jump back to label "main"

panicleft: let pins = %01010000 ;switch output 6 and 4 on (motor L and R backward)
pause 1000 ;wait 1s
let pins = %10010000 ;switch output 7 and 4 on (motor L forward, motor R backward)
pause 500 ;wait 0.5s
goto mission ;jump to label "mission"

panicright:
  let pins = %01010000 ;switch output 6 and 4 on (motor L and R backward)
  pause 1000 ;wait 1s
  let pins = %01100000 ;switch output 6 and 5 on (motor L backward, motor R forward)
    pause 500 ;wait 0.5s
    goto mission ;jump to label mission
1. Introduction

With rapid technological development and changing social trends, Lewis (2005) believes that technology education must rely not only on the knowledge of materials, the mastery of special technical skills and techniques, or the correct usage of tools and instruments, but should also develop creative insight in students through technological design education. Many scholars believe that creativity is an important item regarding technological design education at the present stage. Johnson and Daugherty (2008) further believe that research on creativity in technology education has been an emerging research topic in recent years. For example, Siu (2003) indicates that the product design taught in technology education is often limited in its over-emphasis on obtaining technological knowledge and skills, and the subsequent lack of cultivation of critical thinking skills. Thus, Siu (2003) proposed that product design courses focus on factors such as creation and critical thinking, to strengthen product design education. Cropley and Cropley (2010) have echoed the perspective of Johnson and Daugherty (2008) in confirming the importance of creativity to technology design education. Therefore, using technology design education to cultivate student creativity is an important issue worth exploring at the present stage.

Though creativity is very crucial to technology design education, as technology education is a relatively new discipline, it lacks a large research base and comprehensive classroom experience (Mawson, 2007). Thus, the question of how student creativity and product design performance can be improved during the process of student product design has generated the background for this study. As research relevant to the field of technology education is comparatively lacking, related research from scientific fields can be referenced. To improve student science learning effectiveness, a number of studies have attempted to integrate science books and science education to explore methods to assist teachers in teaching scientific concepts, improving student problem-solving skills, teaching scientific principles, and improving student creativity and thinking skills (Daisey, 1994; Fang, Lamme, Pringle, Patrick, Sanders, Zmach, Charbonnet, and Henkel, 2008; Janke and Norton, 1993; Nordstrom, 1992; Rice, 2002). Focusing on the contributions made by science books, Ross and Frey (2002) believe that the primary reason behind the success of science books is their ability to provide more in-depth explanations of single scientific concepts. Furthermore, students are able to select different science books according to their reading ability. Thus, science books are more beneficial to student science learning than textbooks.

As a result, based on the benefits of applying science books to student creativity and thinking skills, the authors of this study believe that the use of science fiction to stimulate student creativity or imagination may also have a certain degree of effectiveness, and be beneficial to
student product design performance. In addressing this thesis, Blythe and Wright (2006) believe that science fiction can be used as an important source of user centered design. For instance, fifty years before Bill Gates began living in a smart home, Isaac Asimov had already proposed this concept. Satellite communication technology was achieved twenty years after Arthur C. Clarke proposed the concept of satellite communication. Thus, Blythe and Wright (2006) utilized the pastiche scenarios in the Miss Marple story, and discovered that pastiche scenarios are a useful complementary method that can assist designers to consider the social and cultural impacts of a new technology from a broader perspective. Blythe and Wright’s (2006) study induced the research results by exploring three individual case studies; this study focuses on integrating Science Fiction and films into technology design education activities, and stimulating student imagination through the fictional plots of science fiction or films and the subsequent application of that imagination to ideas for improvement of everyday products. The authors believe that the implementation of this study will be able to provide definitive contributions to the cultivation of student innovation in technology design education.

Based on the origins and motives of this study, the primary research purposes of this study are to:

1. Analyze the efficacy of Science Fiction and films on stimulating middle school student ideas for product improvement
2. Analyze the differences in product design improvement ideas of middle school students with different cognitive styles generated during the science fiction and films learning activity
3. Study the learning process performance of middle school students with different cognitive styles during the product design improvement activity

2. Literature Review

In recent years, technology education research has gradually emphasized exploring what happens to students in classrooms. In other words, the context of technology education research has gradually moved from “what is” to “what ought to be”, representing an improvement over past technology education research, which only focused on classroom provisions (such as technology education classroom curriculums and equipment standards), and subsequently neglected student classroom learning behavior (McCormick, 2004). This study primarily focuses on the effective use of the plots of Science Fiction and films to stimulate student imagination, and the effectiveness of applying this imagination to product improvement ideas. Furthermore, to further understand whether students with different text and graphic learning styles will produce different results based on the medium, this study will consider cognitive style as an important factor. The following section primarily emphasizes the review of research relevant to Science Fiction, science fiction films, and cognitive styles for use as the basis of the results and discussion of this study.

Relevant Studies on Science Fiction
Glynn and Muth (1994) indicate that reading can support constructive learning, an inquisitive mind, and problem solving. Students are able to expand their scientific knowledge, deepen question-based learning, and cultivate life-long reading habits through the application of suitable reading strategies to high quality and varied science-themed reading materials (Fang, Lammer, Pringle, Patrick, Sanders, Zmach, Charbonnet, and Henkel, 2008). Snow and Sweet (2003) categorize reading comprehension into three primary elements, including the comprehending reader, the comprehended book, and comprehension of the occurring activities. Yore, Bisanz, and Hand (2003) also indicate that one of the reasons as to why articles require interpretation is because the meaning of the sentences lies not only in the combination of the surface meanings of the words and phrases, but also in the background knowledge of the reader, and the social context of the communication.

To explore the impact of reading on scientific learning, many scholars use Science Fiction to assist in science education. For example, Reis and Galvão (2007) performed a qualitative analysis on science fiction stories about scientists written by two 17 year old high school students, and evaluated their conception of science through semi-structured interviews. Their research results showed that a preference exists for describing the characteristics of the scientists, scientific activities, and the interactions among science, technology, and society. Based on the results of relevant research, the researchers also believe that providing learning opportunities for critical debate and focusing on the nature of science activities are important issues for the future. Yazıcı and Altıparmak utilized Science Fiction and films to assist 8th graders in learning biotechnology. Science Fiction were used to assist students in performing debates on bioethical issues, while films were used to assist students in contemplating developments in new biotechnology. The research results indicate that the students showed positive changes in their attitudes towards academic achievements in biotechnology and bioethics.

Apart from applying Science Fiction to assist students in learning science, some scholars have also focused on exploring the science fiction themselves. For example, Idier (2000) has emphasized the relationship between technological vision and Science Fiction, and indicates that Science Fiction are a form of symbolic creativity that reflect the effects of technology on human beings and society. However, as the plots of Science Fiction are not technological visions, they differ in both form and specification from technological visions. In his study, Idier (2000) primarily focused on comparing two Science Fiction, and induced the benefits of Science Fiction to technological visions.

Based on these previous studies on Science Fiction, current relevant research on Science Fiction emphasizes their use in assisting science education. Though some scholars have noted the connection between Science Fiction and creativity, none have used Science Fiction to stimulate student product design performance.

Relevant Studies on Science Fiction Films

The application of science fiction films to education is not a new concept (Barnett and Kafka, 2007); Reedman and Little (1980) indicate that science and physics education have already verified the intrinsic value of science fiction films in teaching the basic concepts of science and physics to university or senior high school students. Efthimiou and Llewellyn (2004) have
developed a physics curriculum that effectively uses films in allowing students to use scientific principles to analyze video clips. The results show that students are able to view films or television from a critical scientific perspective. Regarding the previously stated benefits of science fiction films on the learning of scientific concepts, numerous educational scholars have indicated that the primary reason for this is the ability of films to induce longer lasting mental images (Barnett and Kafka, 2007). This is beneficial in assisting students to further understand concepts related to science, especially in the fields of physics and chemistry (Liberko, 2004). However, though many studies have verified the use of science fiction films to the learning of scientific concepts, not all studies support this premise. For example, Barnett, Wagner, Gatling, Anderson, Houle, and Kafka (2006) have indicated that previous research shows that science fiction films have a detrimental effect on student understanding of science. Thus, the impact of science fiction films on the learning of scientific concepts still requires further study.

Other than studies using science fiction films to assist students in learning scientific concepts, there are studies that have utilized science fiction films to stimulate student interest in learning science. For instance, Blake and Thornton (2003) believe that using film clips to teach science can strengthen student interest in science, primarily due to the high degree of relation between these films and the daily lives of the students. Furthermore, Laprise and Winrich (2010) have also attempted to use science fiction films to generate student interest in learning science. Based on the data obtained from this study, science fiction films are able to stimulate interest in science in students that are not majoring in science. Thus, the positive effects of using science fiction films are supported by a majority of studies.

In addition, a study conducted by Larson (2008) on science fiction films has less of a relationship to scientific concepts or interest in learning science, but primarily focuses on analyzing 10 popular science fiction films. The results of the study indicate that the future computing developments and trends illustrated by the 10 films were very limited in their scope. In other words, the content and vision of science fiction films are often largely limited by the present state of technology. Thus, the predictive power of science fiction films remains highly inadequate. According to Larson’s (2008) research results, the impact of science fiction films on stimulating student imagination appears to be limited. However, whether or not the combination of science fiction films and product design activities is effective in stimulating student contemplation of product improvement is a topic worth further studying, so as to understand the actual benefits of science fiction films on student concepts of product design improvement.

Relevant Studies on Different Cognitive Styles

Cognitive styles refer to stable and constant personal preferences and data organization and processing habits that can be obtained through observing individual learning processes. Furthermore, cognitive styles do not experience substantial changes over the course of time or changes in the environment (Jonassen and Grabowski, 1993; Riding and Cheema, 1991; Riding and Rayner, 1998). Riding and Cheema have analyzed cognitive styles and categorized cognitive styles into the categories of “wholist-analytic” and “verbal-imagery”. The “wholist-analytic” cognitive style primary reflects the individual method of data organization,
and primarily focuses on overall messages and seeks to understand the relationships between various objects. Its analytical style is characterized by emphasis on particular details and the step-by-step processing of data (Riding and Cheema, 1991). “Verbal-imagery” primarily refers the preference for individual attention to and processing of visual or verbal signals. Verbal-type individuals specialize in text-based work and are particularly proficient at semantic processing and analysis. Thus, words are the optimal learning medium for these individuals. Imagery-type individuals enjoy obtaining information from “watching”, and therefore have a preference for the use of non-text representations such as images, tables, or mathematical symbols (Jonassen and Grabowski, 1993; Kirby, Moore, and Schofield, 1988; Schuyten and Dekeyser, 2007).

This study uses Science Fiction and films as the primary method of learning. Science Fiction are verbal representations, while science fiction films are non-verbal. Thus, the following section focuses on the research relevant to “verbal-imagery” cognitive styles. With regard to studies on “verbal-imagery” cognitive styles, many scholars have emphasized the correlation between cognitive style and learning effectiveness. For example, Effken and Doyle (2001) indicate that learners with different cognitive styles will have different preferences towards the representation methods of interactive multimedia software, which will further impact learning effectiveness. Riding and Cheema (1991) show that when learners are placed in environments where conform to their own learning styles, they achieve superior learning performance. However, if learners are placed in environments that do not correspond to their learning styles, they exhibit inferior learning performance. Schuyten and Dekeyser (2007) have emphasized the relationship between student cognitive styles, the frequency of usage of different representational modes, and learning performance. Their results show that educational representation modes that do not correspond to learner cognitive representations will have limited benefits in facilitating learner understanding.

In addition to exploring the correlation between cognitive styles and learning performance, some scholars have also gradually placed their focus on exploring student learning processes. Riding and Sadler-Smith (1997) believe that differences in learner cognitive styles primarily reflect qualitative instead of quantitative differences in thinking processes. For example, learners will use their preferred representation method (verbal/imagery) to contemplate and achieve problem solving. Thus, apart from exploring differences in the performance of product improvement concepts between cognitive styles under different learning environments (Science Fiction/science fiction films), this study also further analyzes whether or not learners can use their preferred representation mode to propose concepts for product improvement.

3. Research Design and Implementation

The focus of this study is on exploring the benefits of Science Fiction and films on product improvement concepts in middle school students, and analyzing the representation of product improvement concepts of middle school students with different cognitive styles under different science fiction and film learning activities. To achieve this research purpose, the design and implementation of this study is as follows:
Research Design

The research design of this study primarily utilized quasi-experimental design and unequal control group pre-test and post-test design models, as shown in Table 1. To explore the effects of science fiction and film learning activities on middle school student concepts for product design improvement, this study primarily used the Williams Creativity Scale as the pre-test to remove the influence of pre-existing differences in middle school student imagination. The post-test mainly analyzed differences in student performance in product design improvement concepts after science fiction and film learning activities. Furthermore, to understand whether or not learners with different cognitive styles produce different results based on the learning environment (science fiction and film learning activities), this study performed an analysis of covariance on learners with verbal and imagery type cognitive styles to understand the correlation between cognitive styles and learning environment. This study selected specific case studies for qualitative analysis of product improvement design to explore the learning process performance of middle school students with different cognitive styles under different learning activities. In addition, this study will integrate Science Fiction and films into the teaching method for product design activity to provide concrete recommendations for a reference in future technological education.

Research Subjects

This study used students from 4 eighth-grade normal placement classes of a certain school in Taipei City, with 64 students of two classes selected as the control group, and 73 students of the other two classes selected as the experimental group. The former engaged in product design activities primarily using Science Fiction, while the latter engaged in product design activities using films. The technology education course of the school selected by this study meets once a week for 45 minutes. Furthermore, as this middle school has not been negatively influenced by an over-emphasis on credentialism, the teaching method of the course is highly normal. In addition, the teaching environment and equipment are quite sufficient. Thus, the school and research subjects were able to meet the requirements of this study, and allowed the researchers to control the relevant variables (such as the teaching method, implementation of the technology class, etc.) impacting the school as much as possible, ensuring the reliability and validity of the experimental teaching results.

Research Implementation

The implementation of this study was performed from April to June in 2011 over the course of 10 weeks, for a total of 10 hours. The first week primarily emphasized the use of the Williams Creativity Scale developed by Hsin-Tai Lin and Mu-Rong Wang (1994) to measure student creativity. This scale was drawn from the Creativity Assessment Packet created by F. E. Williams. Furthermore, the Style of Processing Scale (SOP) developed by Heckler, Childers, and Houston (1985) was used to determine student cognitive styles. The second to fourth weeks were mainly used to allow students to read and watch Science Fiction and films,
respectively. Here, as Science Fiction cannot be completed within 2 hours, students were allowed to bring the Science Fiction back home for reading. The fifth and sixth weeks were used to assist students to deepen their understanding of content relevant to Science Fiction and films. This study designed science fiction and film worksheets to assist students in reflecting upon the content of the science fiction and films, and guide students in recollecting passages in the science fiction and scenes from the films that were most effective in stimulating imagination. This was performed to stimulate student imagination to facilitate the implementation of the following product design improvement activities. The seventh to tenth weeks were used to perform creative improvement proposal activities on daily products. This study used creative power outlet products as examples to facilitate student imagination and ideas for improving daily products. Students were required to propose three daily product improvement concepts through this ten week learning activity, and draw the best design to create a product design schematic. The researchers then invited teachers to evaluate the product design schematics to understand the product design improvement performance of the middle school students after the learning activities.

Research Tools

1. Science Fiction and Films
The science fiction and film used by this study was “I am Legend”. The primary reason behind selecting this science fiction and film was the availability of a Mandarin Chinese translation of both the science fiction and the film. Furthermore, the science fiction is limited to a single volume, unlike many other science fiction series. Thus, the application of “I am Legend” to the teaching experiment was simpler to implement.

2. Williams Creativity Scale
To measure middle school student creativity, this study utilized Hsin-Tai Lin and Mu-Rong Wang’s (1994) creativity tendency scale. This scale includes adventurousness, curiosity, imagination, and challengingness as its four dimensions. The creativity portion can be used as the pre-test data for the analysis of covariance to exclude the variation caused by students with different degrees of creativity. Furthermore, there were 2294 effective samples obtained with the creativity tendency scale, with the norm for elementary to high school established by the end of 1994. The internal consistency coefficient ranged from .401 to .877, and the test-retest reliability was between .489 and .810. The reliability between each grade was between .878 and .992. The above correlation coefficients all reached levels of significance (.05) (Hsin-Tai Lin and Mu-Rong Wang, 1994).

3. Cognitive Style Scale
To measure middle school student cognitive styles, this study primarily utilized the Style of Processing Scale developed by Heckler, Childers, Houston (1985). This scale categorizes cognitive styles into: (1) Verbal, meaning that the learner has a preference for the perception and processing of language and text information; and (2) Imagery, meaning that the learner has a preference for the perception and processing of visual information (such as shapes and tables). Furthermore, this scale has a high degree of reliability. The Cronbach’s α coefficient
for the verbal portion was 0.81, while the Cronbach’s \( \alpha \) coefficient for the imagery portion was 0.86 (Heckler, Childers and Houston, 1985).

4. Science Fiction and Films Worksheet
The primary purpose of the science fiction and film worksheet was to assist students in reflecting upon relevant science fiction and film content, and to guide students in remembering the portions of the science fiction or film that were most stimulating to their imagination. Thus, this worksheet included the three items of “content which gave the deepest impression”, “content most able to stimulate imagination”, and “learning situation” (such as student interest in Science Fiction or films, and whether or not the science fiction or film was read/watched completely). This research tool was obtained with substantive content examination by two current technology instructors and was revised three times through discussion. Thus, this research tool should have a high degree of content validity.

5. Daily Product Innovative Improvement Proposal Design Activity
The daily product creative improvement proposal design activity used daily living products as the subject for middle school students to freely utilize their imagination to propose concepts for improvement. The learning process of this activity included the definition of requirements, the proposal of initial concepts, the selection of the optimal design concept, the development of concrete design proposals, and the evaluation of design proposals. The daily product innovative improvement proposals submitted by students after being exposed to Science Fiction or films were thus evaluated. This research tool was obtained with substantive content examination by two current technology instructors and was revised three times through discussion. Thus, this research tool should have a high degree of content validity.

6. Creativity Improvement Proposal Assessment
To analyze the actual performance of middle school students in designing improvement concepts, this study primarily referenced the product innovation assessment developed by Yu-Shan Zhang, Da-Wei Li, Guang-ZhaoYuo, and Ya-Ling Lin (2009) as the basis for this assessment. The original seven content items were consolidated into materials, model, structure, and function. The evaluation standard was divided into five levels, ranging from 5, “excellent”; 4, “good”; 3, “acceptable”; 2, “poor”; and 1, “extremely poor”. For the evaluation of concepts for product design improvement, this study invited two current technology instructors to assess the improvement design concepts of the 64 control group students and the 73 experimental group students. The correlation coefficient of the two evaluators was .92, achieving a level of significance.

Data Analysis and Interpretation

1. Analysis of Quantitative Data
To explore the impact of Science Fiction and films on middle school student product improvement concept performance, this model primarily used an analysis of covariance (ANCOVA). Here, middle school student imagination measured by the Williams Creativity Scale was used as the total variance to exclude the preexisting variance between the levels of
students' imagination. Researchers were able to understand the impact of Science Fiction and films on middle school student product improvement concepts through this quantitative analysis. Furthermore, to explore the relationship of cognitive style and experimental grouping (science fiction/science fiction film) on product improvement concepts, this study also adopted ANCOVA to achieve this research purpose.

2. Qualitative Data Analysis
This study performed a qualitative analysis on product improvement design case studies to understand the actual performance of students with different cognitive styles under different learning environments, to explore the learning process performance of students with different cognitive styles. Based on the results of data analysis, this study also integrated Science Fiction and films into product design activity teaching methods to provide a reference for future technology education.

4. Results and Discussion

The Benefits of Science Fiction and Films on Stimulating Product Design Concepts in Middle School Students

As can be seen from the data analysis results shown in Table 2, the interaction between different grouping (Science Fiction/Film) and covariation (imagination) did not reach a significant level of 0.05, representing that the relationship between covariates (imagination) and the dependent variable (product design improvement concepts) was not affected by the different processing standard of different groups. In other words, the slopes obtained from performing regression analysis on the dependent variable using covariates did not differ. Thus, ANCOVA can be continued. As can be seen in Table 3, the variance F value caused by the different groups after excluding the effects of student imagination on product design improvement concepts was 9.69, and reached the significant level of 0.01. In other words, the performance of student product design improvement concepts was affected by differences in the experiment processes. The average adjusted post-test score for the control group (Science Fiction) was 12.88 points (standard deviation of 0.38), while the average adjusted post-test score for the experimental group (science-fiction films) was 14.50 points (standard deviation of 0.36). This illustrates that the use of science fiction films was more effective in stimulating student imagination and increasing the quality of product design improvement concepts in middle school students.

The Performance of Students with Different Cognitive Styles in Science Fiction and Film Learning Activities

To explore the performance regarding the product improvement concepts of students with different cognitive styles in science fiction and film learning activities, this study divided students into those with verbal-type and those with imagery-type learning styles, based on the
results of Heckler, Childers, and Houston’s (1985) Style of Processing Scale. Seventeen students had verbal-type learning styles, while 119 had imagery-type learning styles. In addition, there was 1 student whose learning style could not be determined after the test, and was subsequently excluded from data analysis.

Of the 17 students with verbal-type learning styles, 6 performed daily product design improvement activities under the environment of learning through the science fiction, while the other 11 performed daily product design improvement activities under the science fiction film environment. As can be seen from Table 4, after excluding the effect of student creativity on product design improvement, the variance F value caused by the different groups was 5.41, reaching the significant level of 0.05. In other words, the improvement in product design performance of students with verbal-type cognitive styles was affected by differences in the experiment process. The adjusted average post-test score for the control group (those under the science fiction learning environment) was 15.43 points (standard deviation of 0.99), while the adjusted average post-test score for the experimental group (those under the science fiction film learning environment) was 12.63 points (standard deviation of 0.68). This illustrates that the design performance of students with verbal-type cognitive styles is superior under science fiction learning environments.

Of the 119 students with imagery-type learning styles, 58 performed daily product design improvement activities under the environment of learning through Science Fiction, while the other 61 performed daily product design improvement activities under the science fiction film environment. As can be seen from Table 5, after excluding the effect of student creativity on product design improvement, the variance F value caused by the different groups was 12.97, reaching the significant level of 0.01. In other words, the performance in product design improvement of students with imagery-type cognitive styles was affected by differences in the experiment process. The adjusted average post-test score for the control group (those under the science fiction learning environment) was 12.77 points (standard deviation of 0.39), while the adjusted average post-test score for the experimental group (those under the science fiction film learning environment was 14.73 points (standard deviation of 0.38). This illustrates that the design performance of students with imagery-type cognitive styles is superior under science fiction film learning environments.

As can be seen from the above data analysis results, verbal-type learners present superior design performance under learning activities emphasizing the use of Science Fiction, while imagery-type learners present superior design performance under learning activities emphasizing the use of science fiction films.

Product Design Activity Learning Process Performance of Middle School Students with Different Cognitive Styles

In addition to exploring the correlation between cognitive styles and product design improvement performance through quantitative analysis, the learning process performance of middle school students in product design activities is also worth studying. This study selected the three students among those with a verbal-type cognitive style who obtained the highest scores, and the three students among those with an imagery-type cognitive style who obtained the highest scores as the primary subjects. Of these, one student obtained high scores in both
verbal and imagery type activities, and was selected; thus, this study selected a final total of five case studies. The following important discoveries were obtained from the qualitative data on the product design improvement activity drawn from the five students:

1. Though students with verbal-type cognitive styles filled out worksheets more thoroughly, they were not necessarily able to apply this to product design explanations.

Fig. 1 shows a conceptual product schematic titled “cane” produced by a verbal-type student. This design added neon lights to a cane for the use of the elderly. Though this design is highly creative, the textual explanations were composed of only simple labels and phrases. Thus, the student’s sensitivity to words and the suitable use of words to explain product design concepts were not demonstrated.

2. When students with imagery-type cognitive styles draw design improvement concepts, they are not necessarily able to create complete product concept schematics.

Fig. 2 shows conceptual product improvement schematics respectively titled “television glasses” and “cup”, produced by imagery-type students. Here, the television glasses primarily combine the function of regular glasses and an antenna to allow its users to watch television, while the design of the cup immediately displays the ingredients of a drink that is poured into the cup. Though these designs are also highly creative, these middle school students are only able to draw simple sketches, and cannot produce detailed key structural portions.

3. Students with both imagery and verbal type cognitive styles are more able to comprehensively express product design improvement concepts.

Fig. 3 shows a conceptual product design improvement schematic titled “portable electronic book”, produced by a student expressing both imagery and verbal type cognitive styles, with the aim of replacing traditional books. Though the originality of this design is not high, this student is able to appropriately express the primary structure of the product and provide complete, detailed textual explanations of important functions. Thus, as stated by Heckler, Childers, and Houston (1985) in defining cognitive styles, this student with both imagery and verbal type cognitive styles does indeed show superior performance in processing textual and image information.

As can be seen from the analysis results of the above described qualitative data, though verbal and imagery type learners should have superior performance when processing textual or graphical signals, they do not necessarily have the ability to effectively apply their cognitive types to the drawing of product design improvement schematics.

5. Conclusion

The primary emphasis of this study is the integration of Science Fiction and films into practical technological education, allowing students to apply their imagination to daily product improvement designs after the creative stimulation of the imagery expressed by
Science Fiction or films. The following concrete conclusions were obtained from the implementation of this study.

The effective use of science fiction films can stimulate the creativity of middle school students and improve their performance in product design improvement.

Based on the data analysis results of this study, middle school students exposed to practical technology design education activities utilizing science fiction films exhibit superior performance compared to students exposed to practical technology design education activities. Thus, though Larson (2008) indicates that the efficacy of science fiction films in depicting future developments in computer technology are limited, the integration of science fiction films into practical educational activities remains beneficial to stimulating student imagination and improving their performance in product design improvement. When the researchers were designing the practical educational activity primarily utilizing science fiction films, certain technology instructors held that perhaps only a selection of films more relevant to product design would have significant effects. In addition, other technology instructors believed that the science fiction content of “I am Legend” was outdated, due to the rapid technological development of the current society. However, as can be seen from the data analysis of this study, the effectiveness of “I am Legend” in stimulating middle school student imagination and subsequent improvements in product improvement concepts is supported. Thus, the effective use of science fiction films to stimulate student imagination can be considered when developing practical technology education design activities.

Planning suitable activities based on student cognitive styles is effective in improving student performance in product improvement

Based on the data analysis results, this study discovered that learners with verbal-type cognitive styles have superior performance when engaging in practical technology education design activities primarily using Science Fiction. Similarly, learners with imagery-type cognitive styles have superior performance when engaging in practical technology education design activities primarily using science fiction films. This result is consistent with those of Cheema (1991), Effken and Doyle (2001), and Schuyten and Dekeyser (2007). In other words, learners placed in environments matching their own cognitive styles have superior learning performance. However, as prior research emphasized scientific knowledge and cognitive learning, and this study emphasized practical skill learning, it can be indicated that teachers should design learning environments that match learner cognitive styles in cognitive and technical education to effectively improve student learning performance.

High scores in the cognitive style scale do not mean that middle school students are able to apply their aptitudes to practical product design activities

Based on the results of qualitative data analysis conducted by this study, it can be seen that verbal and imagery type learners are not necessarily able to apply the characteristics of their cognitive styles to practical technology education design activities and their drafting of
product design improvement schematics. This result is not consistent with those of previous studies. Riding and Sadler-Smith (1997) believe that learners with different cognitive styles are able to contemplate with the mode of expression that they are proficient in (verbal/image) to achieve problem solving. As to the results of the data analysis performed in this study, the authors believe that high scores in Heckler, Childers, and Houston’s (1985) Style of Processing scale does not necessarily represent the ability to apply the characteristics of their cognitive styles to product design activities. Thus, future studies should further elaborate on how technology instructors can guide learners with different cognitive styles to create product design improvement schematics using their proficient modes of expression.

6. References


Fang, Z., Lamme, L., Pringle, R., Patrick, J., Sanders, J., Zmach, C., Charbonnet, S., &


Science and Children, 38(6), 18-22.
### Table 1 Research Design Model

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### Table 2 Summary of Intragroup Regression Coefficient Homogeneity Test Result Analysis

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### Table 3 Summary of ANCOVA

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### Table 4 Summary of ANCOVA of Verbal-type Middle School Student Product Improvement Performance under Different Environments

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### Table 5 Summary of ANCOVA of Imagery-type Middle School Student Product Improvement Performance under Different Environments

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Figure 1 Product Design Improvement Concept Produced by a Verbal-Type Student

Figure 2 Product Design Improvement Concepts Produced by Imagery-Type Students (Television Glasses, Cup)
Figure 3 Product Design Improvement Concept Produced by a Student with both Imagery and Verbal Type Cognitive Styles
The Nature of Educational Science in Technology Education: Practical Example in Teaching Electricity

Matti Lindh & Jaakko Nykänen
University of Oulu

1. Introduction

Usually, educational sciences are to be seen as scientific basement to educational treatments on practical school level (Ausubel 1968; Brezinka 1994; Wulf 2003). In technology education it means continuous comparison between educational theories and operations on the level of technology education (see de Vries 2005, 84, 115–125). So to think, educational theories are providing general rules for organizing and interaction in education. Then, technology education gives special expertise concerning technological world surrounding us. When educational theories are applicable in several context the theories of technology education are specialized for teaching and learning technology. As a consequence, technology education is highly in connection with technological substance what is to be learned (Todd, McCrory & Todd 1985, 319–322; Norman et al. 2000). Because the technological substance is the same in everyday life and on school level also the intrinsic values of technology education are the same (Cross 1986, 104–121).

Connection between educational sciences and technology education on teacher training level means that the entity of technological substance will be essential. Technological substance in this meaning includes science and mathematics as well (Lindh 2006). When nature of technology is relations between mater, energy and information also the intrinsic values must be in connection with those (Raat & de Vries 1986, 16; de Vries 2005, 25). It means that teacher training and education must have subject matter what is explaining that entity according the intrinsic values of technology education (Booth 1989, 112–120). On teacher training level it also means there must be an organization which curriculum gives the possibility to fulfill these conditions (see ITEA 2003). In University of Oulu it means the curriculum of Technology-Oriented Teacher Education.

2. Technology Education and the Technology-Oriented Teacher Education Programme

Aware of the importance of technology in modern society, the Faculty of Education, University of Oulu, has developed a Technology-Oriented Primary Teacher Education Programme. The major subject in the programme is education, but it also comprises modules in technology education. The Technology-Oriented Primary Teacher Education programme consists of a Bachelor of Education degree of 180 credits and a Master of Education degree of 120 credits. The programme is directed towards students, who are interested in technology and its applications in comprehensive education. (See Faculty of Education 2011.)

In this connection technology education means an area of knowledge and skills in which it is possible to deepen one's understanding of technology in such a way that the learner can cope with technology and with problems related to its learning, can apply technological knowledge and skills and is able to provide vocational and scientific education applying technology (Lindh 1997).

The main idea of the Technology-Oriented Primary Teacher Education Programme is that every citizen should have knowledge and skills of technology such that he/she can cope with a society based on technology and with its development.

Technology education is an integrative area of knowledge and skills by nature, connecting education and technology. In the Technology-Oriented Primary Teacher Education Programme,
technology education is implemented in all the studies in the school subjects through integrative themes and contents typical of the subjects.

The Technology-Oriented Primary Teacher Programme means a learning environment in which it is possible to apply the opportunities offered by mathematics, science and technological substance to the various school subjects. In this context technological problem solving is essential. As a consequence, this programme is also developed according the conditions of relationship between educational science and technology education. So, the subject matter thought has been developed taking account the entity of relations of matter, energy and information. As a curricular solution this area is divided modules which are realized in seminar projects. (Lindh 2006.) These three technology education seminar projects are the core of Technology-oriented Teacher Education.

3. The nature of seminar projects

According the statement of concept technology education the relation of matter, energy and information is to be learned by developing technological skills. For that reason these seminar projects comprises both theoretical and practical items. The theoretical items are combining educational sciences and technology education by explaining the importance of knowledge on basis of everyday life. So, the duty of students is to find out for what reason it is important to primary level pupils to know thinks belonging to projects. These are in the connection with intrinsic values of technology education.

Training of technological skills is happening both on the level of students planning the projects and producing equipments and on the level of pupils realizing the plans in the school. By making the devices needed for teaching technology in the school the students of Technology-Oriented Primary Teacher Education will be trained to plan and product didactical equipments for other school subject as well.

To ensure the development of technological skills of students there are three seminar projects which are realized as group work (see Denton 1995, 144–151). First one is concerning statistics. In autumn first year students of Technology-Oriented Primary Teacher Education must be able to make a kit for building a meccano-bridge model with pupils. Students have not so much knowledge of educational sciences and for that reason they have to concentrate to gather the information of learning process of pupils. Afterwards this written information will be analysed according the theories of educational science and technology education.

The second seminar project will take place on first year spring semester and it is handling electricity. The main aim of project is to learn to teach basics of electricity to small children. Both first and second project belong to Bachelor of Education degree.

The third seminar belongs to Master of Education degree and students are free to choose subject matter thought they are going to teach on primary level. The only demand is that the project is handling technology education and is applicable for primary level pupils. (See Faculty of Education 2011; Lindh 2007.) According experiences seminar project of electricity is most challenging, because thematic entity is new both for pupils and for students.

4. Seminar project of electricity

According Raat and de Vries (1986, 16) the three ‘pillars of technology’ are matter, energy and information (see de Vries 2005, 25). Nowadays, the meaning of energy is more and more essential on curricular level as well (Rogers 1996, 45; Verner, Shlomo & Kolberg 1997, 11–12). For that reason it is important to become acquainted with electricity also on primary level (Wertenbroch 1992, 19–22; Braun & Mohr 2008, 22–30). According their experiences elder pupils
and even students can have some biases and misunderstands to electricity (see Barak 2002). For that reason seminar project of electricity was planned for small school children age 8 – 9 year. Even though students of Technology-Oriented Primary Teacher Education are studied physics comprising electricity education they are quite uncertain in applying their theoretical knowledge in practice (see Bernhard & Carstensen 2002). So, the teaching – learning situation was quite new both for children and for students.

For successful teaching – learning event students become advices to acquaint to educational theories concerning concrete learning situations. According Piaget (1975) learning on primary level is most effective if it is concrete, because children are on the level of concrete operations in cognitive meaning. So, the connection with pupils and students was possible to create through hands-on activities and at the same time on theoretical level the connection between educational sciences and technology education was able to create (see Dugger & Gerrish 1994).

Due to concrete aim it was necessary to build up some concrete didactical devices for teaching. For that reason students made a kit comprising all components they posited to need for teaching (see appendix 1). Components of electric kit was chosen so that pupils and students were able to predict the function of equipments they build also by calculating according the values of components (see Engelhardt & Beichner 2004, 98–115; LaPorte & Sanders 1996). Because children were only 8 – 9 year old calculations were very simple. In didactical meaning the aim was to explain to children it is possible to apply mathematics and science also in this case (see appendix 2). In this way pupils learned relations between quality and amount of components and they had to remember that in problem solving when they were constructing electric equipments (see Figure 1).

**Figure 1. Description of teaching – learning situation in the groups.**

5. **Students’ proceedings concerning teaching – learning situation**

When students had accomplished their plans for teaching they kept a 90 minute lesson for pupils. Students and pupils were working in small groups (4 – 5 each, see Appendix 2). The groups of students were shaped so that members of the groups were both men and women. That was the only limitation to students and pupils. During 90 minute lesson one of students in each group made a literal description of teaching – learning situation.

Afterwards students had still possibility to accomplish their proceedings adding explanations of educational events they were face up to teaching. They were encouraged to concentrate to following phenomena in teaching and learning:

A. Description of subject matter thought according national curriculum.

B. How to explain the teaching – learning situation according to Educational Science in this context.
C. Reasoning of importance of Technology Education.

D. Reasoning of using science and mathematics in explanation of function of equipments pupils had constructed.

E. Importance of hands-on activity.

F. Problem solving as learning method in Technology Education.

During four years (2008–2011) 22 groups were participating in seminar. Instruction for the groups has been the same. Descriptive content analysis (Neuendorf 2002, 53–54) of these features was made by sorting the students descriptions in proceedings and are shown in figure 2. A cross (X) means that students in that group have been considered the item (A. – F.) and described it seminar proceeding.

<table>
<thead>
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Figure 2. Analysis of seminar proceedings.

Some features of contents of seminar proceedings:

- Only four seminar groups were attended to all items described above. One could say that those groups can analyses connection between educational science and technology education in versatile way taking account the meaning of science and mathematics also in this context.

- Those who (5 groups) did not emphasized the importance on national curriculum were explaining the importance of technology education in itself. They also emphasized the importance of problem solving as learning method in technology education.

- Influence of educational sciences seems to be remarkable when importance of science and mathematics was described. 15 groups expressed that in their seminar papers.
Reasoning of importance of technology education is in tight connection with importance of hands-on activity and vision that problem solving as learning method is important on this area. Those nine groups who were pointing that also argued with importance of national curriculum.

6. Conclusions

In Finland, there is a long tradition of handy craft (Whittaker 1965). As a separate school subject connection betweentraditional handy craft and science-mathematics has been insignificant. Role of technology education as subject matter taught is quite a new. (SeeKananoja2002, 51–83.) This can be one reason, why students see important connection between technology education and hands-on activity. Problem solving is more to be seen as concrete hands-on activity than abstract cognitive process connected with science and mathematics.

12 of 15 groups who were noticed connection between educational sciences and science-mathematics looked also the importance of problem solving in technology education. Those students could realize that science and mathematics is also a way to solve technological problems.

The role of national curriculum is interesting. Both those who are pointing the importance of hands-on activity and role of science and mathematics in problem solving are argued according national curriculum. Those five groups who are not pointing the importance of national curriculum are also keeping important the role of problem solving in technology education. Maybe this is because national curriculum gives ‘free hands’ to teachers to apply teaching methods.

In students proceedings are to be seen the connection between technology surrounding us and technology included electric kit. This made easy for pupils to adapt intrinsic values of technology education in the meaning of similarities. In the contrary, none of the working groups explained this phenomenon according educational sciences. The tradition of separate school subjects was to be seen and the role of technology education was just beginning to influence to conceptions of students.

According this short study the nature of educational science in technology education is more didactic than giving curricular framework to teaching– learning situation. The role of technological substance, including matter, energy and information, is more determining when this kind of learning situations are organized.

7. References


Appendix 1.

**Electric Kit**

The components of Electric Kit

1. **Electric battery 1,5 V (2 pieces)**
   - electric energy sources

2. **Fuse (1 piece)**
   - protects against damages
3. Bulb 1,5V/0,2A (2 pieces)
- change electric energy to light

4. Light emitting diode LED (1 piece)
- change electric energy to light

5. Switch ON-OFF (1 piece)
- opens and closes electric circuit

6. Switch ON-OFF-ON (1 piece)
- chooses the direction of current

7. Resistor 10 Ω (1 piece)
- resisting the amount of electricity

8. Electric motor (1 piece)
- changes electric energy to mechanic energy
9. Piezo buzzer (1 piece)
- changes electric energy to voice

10. Electrolyte condensator (1 piece)
- storing electric energy

11. Conducting wire (12 pieces)
- conducting the components
Appendix 2.

School children and students of Technology-Oriented Primary Teacher Education are working with electric kit.