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Traditional Craft or Technology Education: Development of Students' Technical Abilities in Finnish Comprehensive School

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Abstract

Changes in the economy, nature, production and society together with increasing scientific and technological knowledge make demands of transforming school teaching in the field of technology education. The aim of the article is briefly to explore the integration between science, technology and traditional craft education by analyzing the current trends in Finnish technology education. Additionally, the research tried to explore, in a preliminary way, whether or not a curriculum which retains the traditional textile and technical crafts, or new technology education, would enhance technical abilities better? The data of the empirical part suggest that there was a difference between students' who received education based on the traditional craft or technology education curriculum. The difference was mainly seen in technological knowledge and in attitudes towards technology. Hence, still much of the learning is focused on production skills, and approaches that are now dominant in craft education do not prepare students to meet the challenges of modern technology and working life.

Key words: Technology education; Craft education; Science education; Curriculum; Technical abilities

Introduction

During last twenty years there has been an active discussion about the role of technology education in Finnish compulsory education. Several development projects have been started aimed to develop the curriculum and technology education (Järvinen, Lindh & Sääskilahti, 2000; Lavonen, Autio & Meisalo, 2004; Parikka & Rasinen, 2009). Moreover, many public and private institutions claim that there is a growing need for employees, who are able to think critically and also to solve a range of problems (Grabinger, 1996). On the other hand, several researchers maintain that various cognitive, metacognitive and problem solving skills needed in the working life are seldom obtained at school (Resnick, 1986). The national discussion, the results obtained from the various development projects in the field of technology education and the international discussion about the role of technology education should have had an effect on the formulation of the goals and contents of technology education in the national curriculum framework for compulsory school.

In the beginning of 2000s, a discussion took place between the authorities and the spokesmen of the craft industry. Although, technology education was introduced for the first time in the framework curriculum, a separate technology education subject was not, however, been established. Nevertheless, technology was introduced as part of a specific cross-curricular theme, entitled 'The Human Being and Technology'. As a result of that, technology education should be taught in all subjects as an integrated subject. Officially, Finnish technology education was named handicraft which is in practice divided into two sections: Technical - and Textile Craft. Hence, the main importance in the curriculum is still in the developing students' handicraft skills, within the context of the complete process of handiwork. In addition, the development of students' personalities and the growth of self-esteem were also emphasized.

However, the 2004 curriculum emphasized the meaning of technology from the point of view of everyday life, society, industry and environment, as well as human dependency on technology. The students should be familiar with new technology, including ICT (information & communication technology), how it is developed and what kind of influence it has. Students' technological skills should be developed through using and working with different tools and devices. Studying technology helps students to discuss and think about ethical, moral and value issues related to technology. There is a high compatibility with the goals mentioned in our new curriculum and the nature of literacy in technology described in the publication: International Technology Education Association (2007) Standards for Technological Literacy: Content for the Study of Technology. However, it is important to notice that Finnish Craft and Technology education curriculum gives just common aims but leaves

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the teacher significant freedom in planning the content of lessons; for example, there may be a greater emphasis on traditional craft than on technological studies.

The article concentrates on the literature concerning the teaching of Craft and Technology education. In addition, it defines related terms and subsequently explores several research projects. In order to evaluate students' technical abilities, research instruments were devised, to measure cognitive, psychomotor and affective areas of Craft and Technology education. In the empirical research, we wanted to explore, in a preliminary way, whether or not a curriculum which retains the traditional textile and technical crafts, or new technology education, would enhance technical abilities better. The research questions were:

1. How is Finnish Craft and Technology education formulated in practice?
2. Is there a difference in students' technical abilities in traditional Craft and Technology education?

Craft and Technology Education in Practice

Although, we have moved long ago from an agricultural society to a post-industrial society, out–of–date technological processes, such as the making of wood and metal artefacts, are more common than processes, such as working with plastic, service and repair of technical equipment and construction of electronic equipment. Computers are not used in technology education to a large extent, but usage is expected to increase in the near future. Moreover, in many schools, the students reproduce artefacts on their own, according to given models without any creativity. Students only occasionally plan and generate alternatives in small groups. Learning is focused on production skills, with the aim of teaching students how to replicate demonstrated skills. Approaches that are now dominant in technology are based on old fashioned Craft education and they do not prepare students to meet the challenges of modern technology and working life. Craft education is a very practical school subject with small integration of science and technology aspects in the teaching and learning. Its purpose is thought to be simply for practicing manual dexterity without reflective discussions. Often such thinking is based on views that require students to merely copy and reproduce similar products, such as wooden boxes and other wooden artefacts commonly used in households.

On the other hand, it is important to notice that students are highly motivated to work with their hands (Autio, 1997, Autio, 2013). It is not surprising that both boys and girls are attracted to technology education because they enjoy working with their hands and like the independence and chance for creativity provided by these classes (Silverman & Pritchard, 1996). Students who typically enroll in technology education are attracted to the types of projects they will be engaged in (Weber & Custer, 2005). It seems that several other school subjects have more motivational problems than technology education. Craft lessons are unlike subjects such as physics or mathematics considered more practical than theoretic.

The current orientation in Finnish Craft - and Technology education is described in Figure 1. It shows how, in traditional craft education, children reproduce artefacts according to given models. It is adequate for teaching the basic skills, like learning to use a saw or soldering station. However, there must be time for learning creative problem solving and, from the design perspective, this is already happening in "creative handwork". In technology education, there is still the same problem as "textbook technology" overshadows practical innovations and creative problem solving. Therefore, we have developed "innovative technology" education programs for teacher education where learning in small groups is based on the creative process rather than just a product (Autio & Lavonen, 2005; Lavonen, Autio & Meisalo, 2004).

Traditional Craft or Creativity

The general aim of Finnish Craft and Technology education is to increase students' self-esteem by developing their skills through enjoyable craft activities; it also aims to increase students' understanding of the various manufacturing processes and the use of different materials in craft. Furthermore, the subject aims to encourage students to make their own decisions in designing, allowing them to assess their ideas and products. Students' practical work is product orientated and based on experimentation, in accordance with the development of their personality. The role of the teacher is to guide students' work in a systematic manner. They must encourage pupils' independence, the growth of their creative skills through problem-based learning and the development of technical literacy. Finnish handicraft traditions are also of importance throughout the whole curriculum (Framework Curriculum Guidelines, 2004).

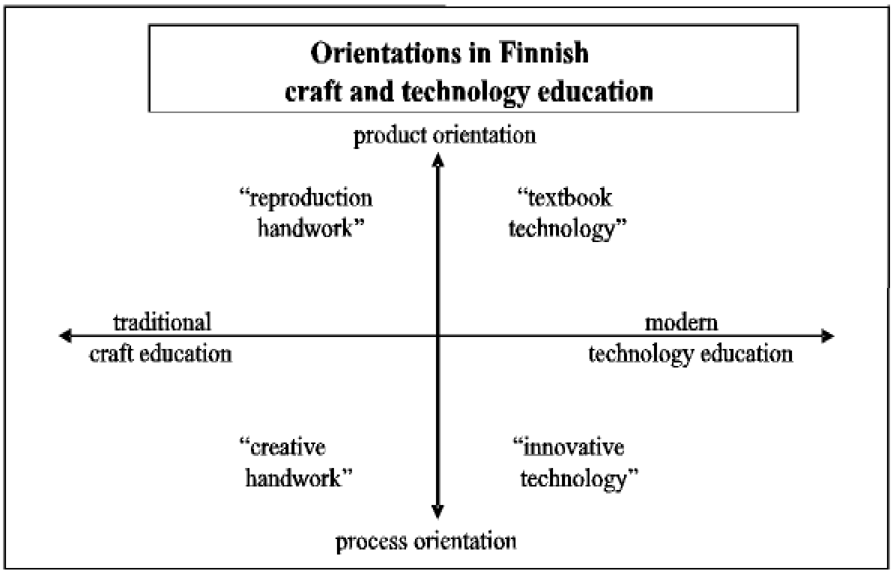

Figure 1. Current orientation in Finnish craft and technology education

However, the main problem with the current technology education approaches is linking the learning of knowledge to the learning of for example different designing skills. This is happening in reproductive handwork as students reproduce artefacts according to given models and the teaching of design is based on simple sketching or direct shaping from the material. Instead, systematic creative problem-solving and planning models are seldom used. In the two dimensional model, planning is divided into three phases: initial planning, sketching and detailed planning. Each phase includes analysis, synthesis and assessment (Lawson, 1983). In more advanced, spiral process designers seem to backtrack at certain times and repeat a series of activities again and again, trying to resolve new problems with each repetition (Zeisel, 1995). Moreover, knowledge and understanding of design should not emphasis only art related self-expression with artefact constructions. Designing should refer to technological design as well and the turning of making into thinking (Mitcham & Holbrook, 2006). According to Norman (1993), it is not guaranteed that if students' have expertise in artistic design they can automatically operate in technological design, for example in electronic circuits and mechanical movements. Competence in different Craft areas requires the development of different knowledge, skills and understanding. Therefore design and associated techniques are essentially independent (Lawson, 1983). That is clearly seen in traditional craft education, even if students' work with systematic planning models and uses their creativity, esthetical design usually overshadows technological issues.

It is not the main problem that in lower grades (1.-4.) most of the learning is focused on production skills, with the aim of teaching students how to replicate demonstrated skills and to achieve more knowledge of materials. We should be more concerned of whole-class teaching methodologies, with the teacher as expert and the student as the passive recipient of knowledge. Approaches that are now dominant in traditional craft education do not prepare students to meet the challenges of modern technology and working life. In spite of some progress, the legacy of behaviorist, teacher centered teaching methodologies; repeatedly appear as the dominant orthodoxy in technology education (Dakers, 2005). An important function of technology education should be the opportunity to transcend from routine activities and low-level thinking. Different ways to emphasize creative problem solving in small groups have been suggested (e.g., Grabinger, 1996; Dooley, 1997; Hill, 1999). A common feature of these approaches is to place students in the midst of a realistic, ill-defined, complex and meaningful problem, with no obvious or correct solution. Students work in teams, collaborate and act as professionals, confronting problems as they occur - with no absolute boundaries. Although they get insufficient information, the students must settle on the best possible solution by a given date. This type of multi-staged process is characteristic of effective and creative problem solving. The process is non-linear and follows no particular rules, because rational approaches miss the entire point of creative problem solving (Fisher, 1990).

Textbooks or Real Technology

A common problem in science and technology education in grades 5–9 is that many teachers teach the typical presentation-recitation way (chalk and talk), while students can also do, for example, routine practical work or solve simple textbook problems (textbook technology), but those activities do not encourage students to construct scientific concepts or meanings, neither does it help them to see phenomena and objects in the environment (Arons, 1997). In addition, many schools have poor laboratories and equipment for practical work. Therefore, these schools face considerable problems in carrying out practical student work, concretizing science education and linking it to the environment. About five out of six schools have the proper ICT equipment for teaching Science. Moreover, it is a considerable problem that ICT is inadequately used by Physics teachers.

The goals set for technology education have already been realized in the new science textbooks. More applications of science, for example, are described and there are even new chapters introducing technological themes, like the basics of electronics and the life cycle of products. It is obvious that teachers will, in future, based on the new textbooks, teach more technology in science. In grades 1–6, technological themes are also taught as part of Environmental and Natural Studies. This forms an entity containing aims and content from science and technology, environmental studies and civics. The different areas of Environmental and Natural Studies are: matter and energy; organisms and their environments; the globe and its areas; man and the environment. Besides technology education, in grades 7–9, there are three Science subjects, Biology, Physics and Chemistry, which contain technology education. The common aims of these subjects are to give a picture of man's living environment, and the interaction between man and the environment. Moreover, they help to realise the significance of individual and collective responsibility based on knowledge of the natural sciences and technology.

In technology education learning is based on practical work rather than in theoretical issues. Production emphasizes students' ability to expand the technological understanding and the ability to create new innovations by using different tools, machines and materials. According to Blomdahl and Rogala (2008) students will not just discover, create or develop useful technical products in technology education but will instead gain insight and knowledge about the origin and function of technology and its importance to people, nature and society. In practice, technology education can be used as a vehicle for teaching scientific knowledge in craft education as well as adding practical craft knowledge in science education (Ginns, Norton & McRobbie, 2005). From this point of view, contents (knowledge and concepts) and process (skills for construction and design) are equally important. In addition, one aim is to understand the need to manage in everyday life with mundane technologies in the continuously changing world (Michael, 2007; Stables, 2009).

Empirical Research

In the empirical research, we wanted to explore, in a preliminary way, whether or not a curriculum which retains the traditional textile and technical crafts, or new technology education, would enhance technical abilities better. Data were collected on 296 students in grades five to seven. The student respondents were 10 - 13 - years - old. The technology education group consisted of classes with male and female students. Lessons were based on a modern curriculum that combined application of craft tools and technology based craft projects. In practice, this curriculum included some traditional wood and metal work, but also problem solving, ideation and technical drawing with computers, as well as "hands-on" projects in electronics. In the traditional craft group classes worked mostly on practical projects that included wood, metal and textile work. Each class used more traditional crafts curriculum and pedagogical methods than in the technology education based groups. Moreover, it is important to notice that Finnish Craft and Technology education curriculum gives just common aims but leaves the teacher significant freedom in planning the content of lessons; for example, there may be a greater emphasis on design and craft than on technological studies. Hence, it was possible that there was a greater emphasis on technological studies for older students and more traditional activities in craft lessons for younger students.

The main problem from the conception stage of the study was - how is technical ability to be defined and how can it be measured in a way that would be simple, easy to use with large groups, and still be reliable and valid enough to be generalized to other student populations? Furthermore, the test instrument needed to cover all three dimensions (psychomotor, cognitive and affective) of human personality, which are considered the outcomes of craft education. However, it is almost impossible to separate the dimensions, because in every psychomotor exercise there is a lot of cognitive thinking involved and in every cognitive act the affective domain is prominent. In the study described here the impact of the traditional Craft education and Technology education based curriculums were examined using three different measurements. Technical abilities were assessed with three different tests:

- Cognitive domain - "Technological knowledge"
- Psychomotor domain - "Technological skill"

- Affective domain - "Technological will"

In the cognitive area, the instrument was called 'a test of technical knowledge and reasoning'. It consists of 28 questions. The questions deal mainly with physical laws, often observed in simple machines. Other aspects of technical knowledge are also involved, e.g., tool design and application. The reliability of the test, measured with the Cronbach Alpha, was 0.881. Some examples can be seen in Figure 2.

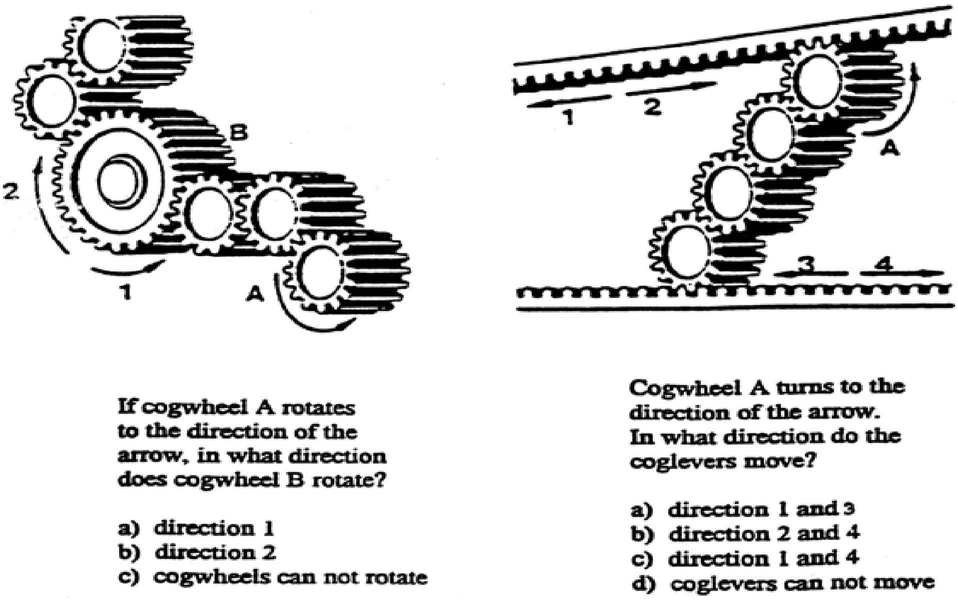

Figure 2. Example questions of technical knowledge and reasoning

The test of "technological skill" was called X-boxes and it is based on the theory of Powell, Katzko and Royce (1978) presented in Figure 3. In this test of motor skills all the elements of bodily orchestration, precision, motor reactivity and dynamism are involved. The reliability of this test was 0.819 as measured with the Cronbach Alpha.

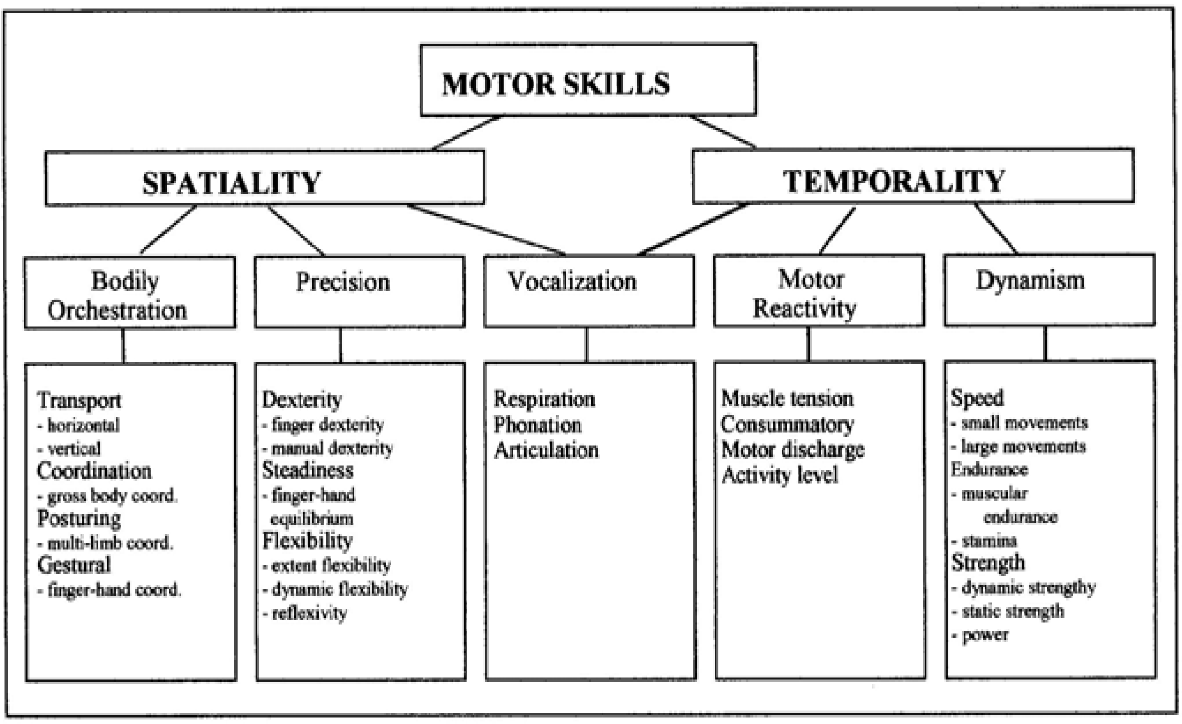

Figure 3. The hierarchical structure of motor skills (Powell, Katzko & Royce, 1978)

The affective area was measured with a questionnaire based on the PATT (Pupils Attitudes towards Technology) material designed and validated by Raat & de Vries (1986) and van de Velde (1992). From their studies six factors associated with technical attitudes were found: interest in technology, favourite role models, understanding that consequences are a reality, some aspects of project work are difficult, attitudes towards school and technology, and career aspirations. These factors were used to establish the final questionnaire with fourteen Likert scale statements. Although attitudes are not best measured with paper and pencil tests, the test worked quite well, especially in detecting differences between the groups. Test reliability was 0.853.

Results

In the area of technological knowledge statistically very significant (F=7.09, p<0.001) differences were found between traditional craft and technology education based test groups. Technology based test group had better results in the measurement of technological knowledge and reasoning among both younger (5.grade) and older (7. grade) students. The average number of correct answers to 28 questions was 12.2 among 5.grade students in traditional craft education, whereas the figure was 15.2 among 5.grade students in technology education. The difference was quite similar among 7.grade students. In traditional craft education test group students had 14.8 correct answers, whereas in technology education group the figure was 16.7. Standard deviation remained quite stable (3.80-4.04), although it was a bit lower (3.37) in 5.grade traditional craft education. As expected it was quite obvious that there was a difference between younger (5.grade) and older (7.garde) students. This is most probably due to normal maturation caused by the amount of lessons in two years concerning Craft and Technology. Transfer from hobbies and the use of technology related textbooks in other subjects is assumed to be another reason.

Table 1. Difference between traditional craft education and technology education in the measurement of cognitive area - "technological knowledge"

"Technological knowledge"			
	n	**average**	**std.**
5. grade Traditional craft education	56	12,2	3,37
5. grade Technology education	71	15,2	4,01
7. grade Traditional craft education	82	14,8	4,04
7. grade Technology education	87	16,7	3,8

In the area of technological skills the difference between traditional craft and technologically based groups was also statistically significant (F=4.94, p=0.003), but only among younger (5.garde) students. The average in traditional craft education test group was 2.39 and in technology education the figure was 3.10. Interestingly, among 7.grade students the difference was diminished. It seems that students excel at psychomotor activities in all project areas; hands on activities are very important in both traditional craft and technology education lessons. Standard deviation was lower (1.57-1.67) in 5.grade than in 7.grade (1.90-1.92). The difference among younger students need to be researched further, but it is possible that the lower level of technological reasoning in traditional craft education test group has an impact on the performance in psychomotor test as well. In every psychomotor action some elements of cognitive area is needed. In this case 3-dimensional perceptive skills may be the distinctive factor.

Table 2. Difference between traditional craft education and technology education in the measurement of psychomotor area - "technological skill"

"Technological skill"			
	n	**average**	**std.**
5. grade Traditional craft education	56	2,39	1,57
5. grade Technology education	71	3,10	1,67
7. grade Traditional craft education	82	4,10	1,92
7. grade Technology education	87	4,08	1,90

The results in the affective area followed the same pattern as those in the cognitive. The difference between traditional craft and technology education was statistically very significant (F=10.73, p<0.001). Attitudes are assumed to be rather stable during the school years (Arffman & Brunell, 1983; Bjerrum Nielsen & Rudberg, 1989; Autio, 2013). This seems to be the case in this research as well among technology education test group. However, there was a serious decline between younger (3.34) and older (3.04) students in traditional craft education. Standard deviation remained quite stable in all test groups (0.46-0.56.). The impact of the traditional craft education curriculum on attitudes is problematic especially in the older age group. The fact that only 9.7 % of all boys would like to choose both textile and technical craft, does not improve the motivation (Autio, 2013). Instead, it seems that in technologically based curriculum test group students can concentrate in greater detail to the subject area that they are really interested in. In addition, in the near future, we should find an answer to a question - how can both traditional craft and technology education benefit from the fact that especially girls are interested in technological everyday solutions rather than technological details as reported in several other researches (Eccles, 2009; Mitts, 2008; Weber & Custer, 2005; Wender, 2004).

Table 3. Difference between traditional craft education and technology education in the measurement of affective area - "technological will"

"Technological will"			
	n	**average**	**std.**
5. grade Traditional craft education	56	3,34	0,53
5. grade Technology education	71	3,81	0,48
7. grade Traditional craft education	82	3,04	0,46
7. grade Technology education	87	3,74	0,56

Discussion

During last twenty years there has been an active discussion about the role of technology education in Finnish compulsory education. However, the optimal solution how technology education could be realised in practice proceeds with great difficulty. Among public servants, office holders and teachers as well as researchers or teacher educators a great consensus has not been found. Others think that technology education should be design-process based with the emphasis on wood and metal work and others feel it should be a more theoretical "classroom-type" school subject. Moreover, the basic concepts and the relationship between Craft and Technology are not clear for all parties, although Parikka (1998) has presented a logical etymological foundation of technology presented in Figure 4.

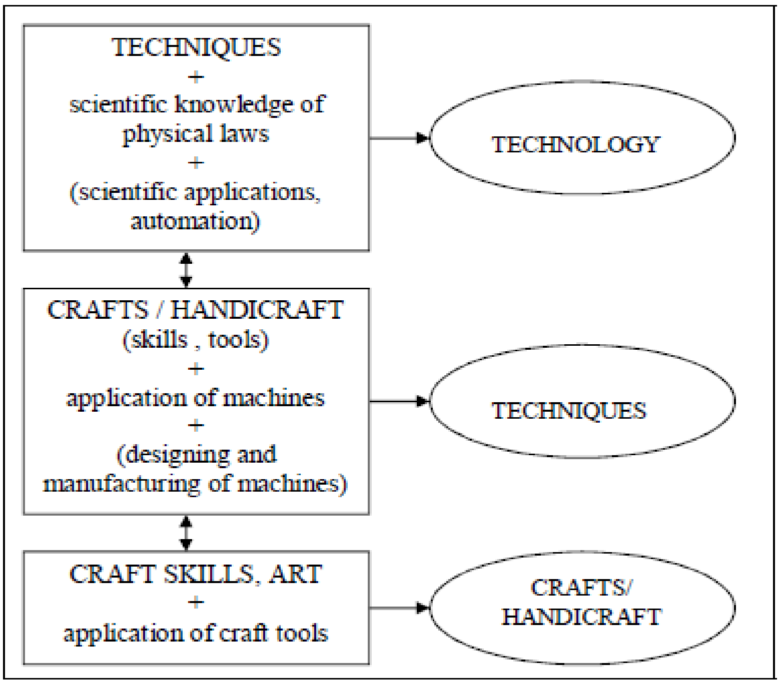

Figure 4. Etymological foundation of technology (Parikka, 1998)

In technology education, we should be more concerned about what children should learn rather than what kind of craft tools they use or artefacts they make, because learning does not only take place upon completion of the product but also occurs through creative problem solving and reflection in every phase of the technological process. It is important that children understand that technology does not develop by itself, but is directed by human needs and wants. Technological development, control and mastery stop if technology is not taught from generation to generation. However, every generation also needs to understand how artefacts are made and what artistic and scientific knowledge is needed in technological production and utilization

As we try to develop technology education in the future, it would be advisable that every student be given the basic skills required in everyday life situations in both traditional craft and technology education but that every student must also be given an opportunity to concentrate more seriously on the area in which they are most interested. In addition, the difference between boys and girls in technological knowledge and attitude must be taken into account by designing technology studies for different genders in a particular age group. As early as in the nursery school, teachers may need to concentrate more on crafts that place equal emphasis on mechanics and softer materials.

Although there is evidence about the lack of transferring (Cree, & Macaulay, 2000; Pugh & Bergin, 2006); we expected that there was more transfer effect between the content of practical work in traditional craft education and the results in technological knowledge and reasoning. The students should have been more familiar with the content of the survey as a result of their Craft studies and the use of textbooks in other subjects, such as physics (Kohl, Rosengrant & Finkelstein, 2007). It seems that there is still much to do in practice, because learning in Craft education lessons is too often focused on production skills instead of technological reasoning. It seems that just practical work or traditional pedagogical methods do not encourage students to construct scientific concepts or meanings, neither does it help them to see phenomena and objects in the environment (Arons, 1997).

Technology education as part of education in Finland has a long and rich history dating back to the 1800s when Uno Cygnaeus defined “sloyd” (handicraft). Since the first days of craft education over 150 years ago, students have made things using a variety of craft tools. In the beginning, work was based on copying and imitation, and was mainly geared toward the development of lower-level thinking skills. On the other hand, several goals set for the technology education were already presented in the general part of the National Framework Curriculum of 1994 and also in the goals of Science and Craft education. At present, both Science and Craft education are quite far from the goals set for technology education. In school Physics and Chemistry, theoretical constructs easily overshadow practical applications of various physical phenomena, and connections between these two remain superficial. Likewise, in Craft and Technology, practical applications may overshadow the very basic physical phenomena and laws that lie behind the operation of any machine used. Furthermore, for example, if concepts and processes, like electric circuits and energy production, are met during Science or Craft and Technology lessons, they are seldom discussed in broad contexts such as environmental, ecological, and social perspectives (Alamäki, 1999, Autio, 1997).

Right now there is an obvious need for young technology teachers to act as agents for change. Moreover, it is obvious as well that more research and development effort should be directed towards introducing creative problem-solving approaches in technology education (Lee, 1996; Gilbert & Boulter, 2000). Instruction and teaching models experienced during teacher education often serve as learning models for students.

References

Alamäki, A. (1999). *How to educate students for a technological future: Technology education in early childhood and primary education*. Publication Series B: Research Reports No. 233, Turku: The University of Turku.

Arffman, I. & Brunell, V. (1983). *Sukupuolten psykologisista eroavaisuuksista ja niiden syistä [Psychological gender differences and the reasons for them]*. Jyväskylän yliopisto. Kasvatustieteiden tutkimuslaitoksen selosteita ja tiedotteita 283.

Arons, A. (1997). *Teaching Introductory Physics,* New York: John Wiley and Sons

Autio, O. (1997). *Oppilaiden teknisten valmiuksien kehittyminen peruskoulussa* [*Student's development in technical abilities in Finnish comprehensive school*], Research Reports No. 117. Helsinki: The University of Helsinki, Department of Teacher Education.

Autio, O. (2013). Oppilaiden teknologiset valmiudet – vertailu vuoteen 1993 [Students’technical abilities - a comparison to year 1993], *Kasvatus 44 (4),* 367-380.

Autio, O. & Lavonen, J. (2005). Defining a Process in a Creative and Co-operative Technology Education Course. *Journal on School Educational Technology 1 (2),* 57-65.

Bjerrum Nielsen, H. & Rudberg, M. (1989). *Historien om jenter og gutter. Kjonnsosialisering i ett utvecklingspsykoligisk perspektiv*. Oslo: Universitetslaget.

Blomdahl, E. & Rogala, W. (2008). Technology in Compulsory School – Why? What? How? *Design and Technology Education: An International Journal, 13(1*), 19–28.

Cree, V. E., Macaulay, C. (2000). *Transfer of learning in professional and vocational education*. Routledge, London: Psychology Press.

De Luca, V. W. (1993). Survey of Technology Problem-Solving Activities. The Technology Teacher, 51(5), 26-30.

Dooley, C. (1997). Problem-centered learning experiences: Exploring past, present and future perspectives. *Roeper Review*, *19*(4), 192–196.

Eccles, J. (2009). Who Am I and What Am I Going to Do With My Life? Personal and Collective Identities as Motivators of Action. Educational Psychologist 44(2), 78-89.

Fisher, R. (1990). *Teaching Children to Think*. Oxford: Basil Blackwell, Ltd.

Framework Curriculum Guidelines (2004). Helsinki: Opetushallitus.

Gilbert, J. & Boulter, C. (2000). *Developing Models in Science Education*. Dodrecht: Kluwer.

Ginns, I. S; Norton, S. J & McRobbie, C. J. 2005. Adding Value to the Teaching and Learning of Design and Technology. *International Journal of Technology and Design Education*, *15(1),* 47-60.

Grabinger, R. S. (1996). Rich Environments for Active Learning. In R. Jonassen (Ed.) *Handbook of Research for Educational Communications and Technology*. *A Project of the Association for Educational Communications and Technology (AECT)* (pp. 665–691). London: Prentice Hall International.

Hill, J. R. (1999). Teaching Technology: Implementing a Problem-centered, Activity-based Approach. *Journal of Research on Computing in Education, 31*(3), 261–280.

International Technology Education Association (ITEA). 2007. Standards for Technological Literacy: Content for the Study of Technology.

Järvinen, E.M., Lindh, M. and Sääskilahti, E. (2000). *Planning a New Technology Education Centre in Finland: An Investigation of the Need for Systematic In-Service Training Activities on Technology Education*. A paper presented at the PATT-10 Conference in Salt Lake City, 6th -8th April, 2000.

Kankare, P. (1997). *Teknologian lukutaidon toteutuskonteksti peruskoulun teknisessä työssä [The context of technology education (technical handicraft) in schools]*, Publication Series C. Research Reports No. 139, Turku: The University of Turku.

Kohl, P. B., Rosengrant, D. & Finkelstein, N. D. (2007). Strongly and weakly directed approaches to teaching multiple representation use in physics. *Physics Review Special Topics - Physics Education Research, 3*, 1-10.

Lavonen, J., Autio, O. & Meisalo,V. (2004.) Creative and Collaborative Problem Solving in Technology Education: A Case Study in Primary School Teacher Education. Journal of Technology Studies 30 (2), 107-115.

Lawson, B. (1983). *How Designers Think*. London: The Architectural Press.

Lee, L. -S. S. (1996). *Problem-solving as Intent and Content of Technology Education*. Paper presented at the Annual Meeting of the International Technology Education Association (58th, Phoenix, AZ, March 31-April 2, 1996). ERIC ED391959.

Michael, M. (2007). How to Understand Mundane Technology: New Ways of Thinking about Human-Technology Relations. In J. R. Dakers (ed.) *Defining Technological Literacy. Towards an Epistemological Framework* (49-63). Palgrave Macmillan.

Mitcham, C. & Holbrook, J. B. (2007). Understanding Technological Design. In J. R. Dakers (Ed.) *Defining Technological Literacy. Towards an Epistemological Framework.* (pp.105-120). Palgrave Macmillan.

Mitts, C. (2008). Gender Preferences in Technology Student Association Competitions. *Journal of Technology Education 19 (2),* 80-93.

National Board of Education (1994). *Framework curriculum for the comprehensive school (in Finland)*, Helsinki: State Printing Press and National Board of Education

Norman, D. (1993). *Things that makes us smart*. New York: Addison-Wesley.

Parikka, M. (1998). *Teknologiakompetenssi. Teknologiakasvatuksen uudistamishaasteita peruskoulussa ja lukiossa.* (Technological competence: Challenges of Reforming Technology Education in Finnish Comprehensive and Upper Secondary School). Jyväskylä Studies in Education, Psychology and Social Research 141

Parikka, M. & Rasinen, A. (2009). *Teknologiakasvatus tutkimuskohteena* [*Technology education as a research subject*]. Jyväskylä: Jyväskylän yliopistopaino.

Powell, A., Katzko, M., Royce, J. (1978). A Multifactor system theory of the structure and dynamism. *Journal of Motor behavior, 194-200.*

Pugh, K. J., & Bergin, D. A. (2006). "Motivational influences on transfer". *Educational Psychologist* 41 (3): 147–160

Raat, J. & de Vries, M. (1986). *What do Girls and Boys think about Technology?* Eindhoven, University of Technology.

Resnick, L. (1986). Learning in School and out. *Educational Researcher 16*(9), 13–20.

Sellwood, P. A. (1991). The Investigative Learning Process. *The Journal of Design & Technology Teaching 24(1),* 4–12.

Silverman, S. & Pritchard, A. (1996). Building Their Future: Girls and Technology Education in Connecticut, *Journal of Technology Education 7(2),* 41-54.

Stables, K. (2009). Educating for Environmental Sustainability and Educating for Creativity; Actively Compatible or Missed Opportunities? *International Journal of Technology and Design Education, 19(2),* 199-219.

van der Velde, J. (1992). Technology in Basic Education. In Kananoja, T. (Ed.) *Technology Education Conference*. Helsinki: The National Board of Education (151-170).

Weber, K. & Custer, R. (2005). Gender-based Preferences toward Technology Education Content, Activities, and Instructional Methods, *Journal of Technology Education 16* (2), 55-71.

Wender, I. (2004.) Relation of Technology, Science, Self-Concept, Interest, and Gender. *Journal of Technology Studies 30 (3*), 43-51.

Williams, A., & Williams, J. (1997). Problem based learning: An appropriate methodology for technology education. Research in Science & Technological Education, 15(1), 91-103.

Wu, T.F., Custer, R.L., and Dyrenfurth M.J. (1996). Technological and Personal Problem Solving Styles: Is there a Difference? *Journal of Technology Education,* 7(2).

Zeisel, J. (1995). *Inquiry by Design. Tools for environment - behaviour research*. Cambridge University Press.