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Technological Knowledge and Reasoning in Finnish and Estonian Technology Education

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Abstract

The main idea of this research was to find out if there is a relationship between students' undertakings within Craft and Technology education and their ability to understand technological concepts. Study participants' technological knowledge and reasoning was measured with a questionnaire regarding mechanical systems connected with simple physical phenomena. The research was undertaken in Finnish and Estonian schools during the years 2014-2016. The research model was quantitative survey and the data was collected using a questionnaire distributed to 303 students in Estonia and 317 in Finland. The age of study participants was eleven and thirteen. The results highlighted general lack of technological knowledge and reasoning, which could be due to old-fashioned pedagogical methods in teaching technology. The total average of right answers to 28 questions was in Estonia 15.4 and in Finland 15.0. Main difference was found between Finnish and Estonian 11-year-old students while the Estonian figure was 14.9 and 14.1 in Finland. For 13-year-old students, the difference was almost diminished while the average in Estonia was 15.8 and 15.7 in Finland. This is explained by curriculum differences. In Finnish technology education both Technical craft and Textile craft are compulsory for both boys and girls. In Estonia, students can choose the subject based on their wishes and interests. This allows students to study in greater detail the subject that they are really interested in. In addition, boys' and girls' different interests and earlier experiences obviously have an impact on motivation for learning about technology.

Introduction

In practice, the goals of the Finnish and Estonian national curriculums for Craft and Technology are similar. The curriculums are supposed to provide students with the knowledge, skills and attitudes required to develop technological reasoning and increase their ability to solve problems (Framework Curriculum Guidelines, 2004; Autio & Hansen, 2002; NC, 2010). Both curriculums are based on models for learning that includes technological knowledge based on handicraft skills and design principles within a problem-solving context. Teaching aims to give students necessary skills and knowledge to manage in their daily lives and possibly earn a living in society through innovative thinking and an entrepreneurial approach. The subjects also aim to develop students' understanding how to assess, understand use and manage technology in a broad context, both at home and in the community. Furthermore, the goal is to enhance students' abilities in ensuring that there is personal growth in their personality.

Although, the goals in Estonian and Finnish curriculum are quite similar, the main difference seems to be that Finnish Craft and technology education is nowadays officially named Handicraft and it is claimed that Technical craft and Textile craft should be compulsory for boys and girls in grades 3–9. Instead, Estonian curriculum has in practice two different craft subjects – the technologically based Technology Education and Handicraft/home economics separately problems (Framework Curriculum Guidelines, 2004; NC, 2010).

In the beginning, the article looks at the literature concerning the teaching of technology to young students. Later on, the research defines technological reasoning and subsequently explores some earlier research projects. In order to evaluate students' technical understanding and reasoning in Estonia and Finland, a questionnaire was devised, concerning mechanical systems based on simple physical principles. The age of research students was 11 and 13. Both boys and girls were represented as equal amount. Finally, a statistical analysis was done and some valuable data was found to be further discussed. The research questions were:

1. What is students' present level of technological understanding and reasoning in Finnish and Estonian schools?
2. What is the relationship between students' Craft and Technology education studies and their technological knowledge and reasoning?
3. Are there differences between students' technological understanding and reasoning in the two countries?

Craft and Technology Education and Technological Reasoning

Finnish Craft and Technology education is, at the present, named *handicraft*, which is a subject divided in two different subject areas: Technical craft and Textile craft. However, there are common aims for both areas. The general aim of Finnish Craft and Technology education is to develop students' craft skills and support their self-esteem through enjoyable craft activities; it also aims to increase students' understanding about the various manufacturing processes and the use of different materials. 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 encourage pupils' independence and the growth of their creative skills through problem-based learning. In addition, gender issues are important throughout the whole curriculum (Framework Curriculum Guidelines, 2004).

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. In grades 5 – 9, there are two Science Subjects Physics and Chemistry. They contain technology education mainly from theoretical perspective. 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 realize the significance of individual and collective responsibility based on knowledge of the natural sciences and technology. From the point of view of technology education, Physics and Chemistry teaching in grades 5 – 9 gives the student the necessary material to form a picture of the world, and it helps them to understand the purpose of natural sciences and technology as part of the culture. In addition to the traditional areas of Physics and Chemistry, the curriculum in grades 7 – 9 underlines the role of environmental education, entrepreneurship education, the interaction of science technology and society and the utilization of ICT.

In the National curriculum for comprehensive schools in Estonia subjects have been divided into six subject fields, one of which is the subject field of Technology (in Estonian 'tehnoloogia ainevaldkond'), which includes the following subjects (syllabi): Handicraft (in Estonian 'tööõpetus'), Technology Education (TE) (in Estonian 'tehnoloogiaõpetus') and Handicraft and Home Economics (HHE) (in Estonian 'käsitöö ja kodundus') (NC, 2010). In the beginning, Handicraft is taught in grades 1 to 3 for girls and boys together. At the 2nd stage of studies, the students are divided into study groups based on their wishes and interests, selecting either HHE or TE. This allows students to study in greater detail the subject that they are interested in. The division into study groups is not gender-based. The aim is to give both boys and girls an opportunity to choose the subject suitable for them, either TE or HHE, which will be their main subject. With both subjects, there is a compulsory exchange of the subjects every year for about eight lessons. In addition, every year, project-based learning supervised by both teachers is conducted for about 25 % of the lesson time a year. The projects can be integrated with projects in other subjects or projects conducted between different classes as well as with school-wide and longer-term events between schools (SFT, 2010; NC, 2010).

Subjects taught in the subject field of Technology in Estonia enable students to acquire the mentality, ideals, and values inherent to the contemporary society. They learn to understand the options they have in solving tasks or creating new products; find and combine various environmentally sustainable techniques. In lessons, students study and analyze phenomena and situations, as well as use various sources of information, integrate creative thinking and manual activity. As a part of the study process, students generate ideas, plan, model, and prepare objects/products and learn how to present these. Students' initiative, entrepreneurial spirit, and creativity are supported and they learn to appreciate an economic and healthy life style. Learning takes place in a positive environment, where students' diligence and development are recognized in every way. Teaching develops their skills in working and cooperating, as well as their critical thinking and the ability to analyze and evaluate. (SFT, 2010).

The objectives of the syllabus of TE clearly distinguish the following areas of emphasis: cooperation skills, multicultural world, and globalization, analyzing the influences of technology, analyzing and synthesizing skills, completeness, technological literacy, and a healthy diet. We can say that the syllabus of TE approaches learning objectives more broadly and globally. An important role in the subject syllabus belongs to different forms of teachers' and students' cooperation and equal choices for girls and boys between the subjects of HHE or TE. In addition, in the organization of the subjects in the subject field of Technology there is an obligation for teachers to swap student groups and offer them different types of project work concerned soft and strong materials alike. The learning and educational objectives listed in the subject syllabus are more closely related to activities characteristic of TE than those in the earlier subject syllabi. By means of different subjects in the subject field of Technology young citizens of the world are shaped and raised. Skillful implementation of the subject syllabus allows teachers to develop students' attitudes, values and ethical face. The TE syllabus of Estonia with its objectives and approach to learning supports students' informed and creative participation in this process while aiming to follow the modern trends in the field of Technology.

Within the Finnish and Estonian curriculums, the aim of Craft and Technology is to facilitate students' technological reasoning, in order to prepare them for participation in modern society and working life. Students learn practical skills via the development and creation of prototypes and systems and learn about technology as a field of human activity, using various tools from different design contexts associated with the transformation of energy, information and materials (Framework Curriculum Guidelines, 2004; NC, 2010). The development of their practical handicraft skills provides students with the opportunity to learn about and utilize various technologies in their designs. Students put ideas in practice through practical projects and the knowledge and skills gained are applied not only to the creation of new products, but to the adaptation and maintenance of existing products, machines and other items.

The Merriam-Webster Online Dictionary (2014) defines reasoning as *the action of thinking about something in a logical, sensible way, in order to form a conclusion or judgement*. According to Sutopo and Waldrip (2013) the ability of technological reasoning is necessary in the development of improved technological and scientific explanation and student's ability to explain indicates their level of understanding. In science and technology, reasoning and argument are essential in identifying the strengths and weaknesses of a line of reasoning and in establishing the best explanation for a natural phenomenon (National Research Council, 2012).

Technology can be described by means of how humans modify the world around them in order to meet their needs and solve practical problems (Maryland Technology Literacy Consortium, 2014). It extends human possibilities and enables people to do things they could not otherwise do. Technological action focuses on fulfilling specific goals under the influence of a variety of factors, such as individual, group or societal needs and the development of components, devices and systems. Technological knowledge and understanding is important for students, in rationalizing the changing world of today. Furthermore, as active citizens, it enables them to play a part in the modification of their surroundings. Technological understanding and reasoning have been examined within the context of technology and science education and some scholars claim that, if students are to successfully learn about technology and science, they must be aware of the different concepts and processes and the relationships between them, in order to understand these within the context of technological knowledge (Hubber, Tytler & Haslam, 2010; Prain, Tytler & Peterson, 2009).

Autio and Hansen (2002) researched students' technological abilities in Finnish comprehensive schools and found differences between boys and girls. It was suggested that the reason for this was distinct lack of emphasis on technical thinking for girls within the curriculum and that there was a need for early emphasis on technological knowledge. The authors also claimed that the relationship between students' cognitive ability, motor development and emotional engagement needed to be recognised and developed with modern pedagogical methods. Their data suggested that boys and girls differ in interest and technological reasoning, which is consistent with some other researches (Johnsson & Murphy, 1986; Streumer, 1988). Furthermore, this has an impact on girls' motivation for learning about technology (Byrne 1987; Halperin 1992).

Within the context of Craft and Technology education, the link between activities and technological reasoning is important and helps students to understand technological principles through their own experience. Moreover, Waldrip and Prain (2006) ascertained that when students learn to implement materials and tools, using both new and old technologies, they increase their understanding (Cox, 1999; diSessa, 2004; Greeno & Hall, 1997; Waldrip & Prain, 2006). Kohl, Rosengrant and Finkelstein (2007) suggested that the ability to demonstrate is a key in studying physical science.

Methods

The research took place during the years 2014-2016. The model of the study was quantitative survey and the research participants were 11- and 13-year-old students. The Estonian part of the research was undertaken with 303 students in total and the Finnish part was undertaken with 317 participants. In more detail, the amount of student participants can be seen in Table 1.

Country	11-year-old boys	11-year-old girls	13-year-old boys	13-year-old girls	Total
Finland	90	58	94	75	317
Estonia	75	74	78	76	303

In Estonia participating schools were selected through convenience sampling in both urban and rural areas. However, most of the city schools came from Tallinn which is the capital of Estonia. Hence, it is obvious that the sample did not consider a selection that is representative of the entire population (Cohen, Manion & Morrison, 2007; Coopers & Schindler, 2006). In Finnish sample the schools were selected on the basis to ensure schools with different curriculums as well as rural and city schools. The Finnish sample related to earlier research projects in a larger context concerning technological abilities: technological will, technological skill and technological knowledge (Autio, 1997; Autio & Hansen, 2002, Autio, 2013). In Finland, no statistical differences were found within the schools of similar curriculum of Craft and Technology education. Even in the University training school the results were the same as in rural areas, even though the school is usually ranked one of the most successful in Finland. Thus, we can assume that the questionnaire measured technological reasoning, not just the context students learn in school.

To evaluate students' technical understanding and reasoning, a questionnaire was devised, concerning mechanical systems based on simple physical principles. Mechanical systems are systems commonly built for a single purpose and usually comprise a few parts or subsystems. Simple mechanical systems are prevalent in our daily lives and are built in such a way that their parts are in synchronisation with each other, working towards a shared goal. The Oxford Online Dictionary (2014) defines the adjective 'mechanical' as *skilled in the practical application of an art or science, of the nature of a machine or machines, and relating to or caused by movement, physical forces, properties or agents concerned with mechanics*. Similarly, the Merriam-Webster Dictionary (2014) defines the term as relating to machinery or tools. Power that flows through a mechanical system provides a way to understand the performance of devices ranging from levers and gear trains to automobiles and robotic systems. A mechanical system is assembled from components called machine elements: these elements provide structure for the system and control its movement (Uicker, Pennock & Shigley, 2003). Examples from mechanical contexts used in the questionnaire are presented in Figure 1.

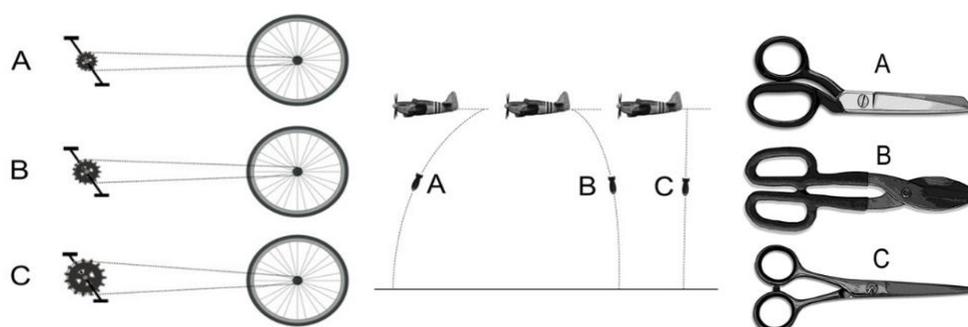


Figure 1. Example pictures from the questionnaire

The questionnaire originated in Finland and has been widely used in the choice of a vocational career by the ministry of labor in Finland. In an earlier research (1993-1996) it was used as a part of a larger context examining students' technical abilities. The questionnaire was based on 28 questions, with related figures. Each question included three possibilities, one of which was the correct answer. Structured and closed questions generate frequencies, making statistical treatment and analysis easier and enabling comparison across groups (Oppenheim, 1992). A questionnaire should be attractive and encouraging to respondents (Cohen, Manion and Morrison, 2007). Although the pictures were from the years 1993-1996, the layout and general impression of the

questionnaire was sufficient in getting good answers. The questions referred to students' technological knowledge and reasoning supported by their education and life experiences.

A numerical analysis was performed using the Statistical Package for Social Sciences software (SPSS), which provided total averages, the median, standard deviation and averages for different classes of questions. The relationship between variables was examined using Kendall's Tau test. As expected of the earlier research both Finnish and Icelandic samples approximately followed a normal curve. In earlier studies of the Finnish ministry of labor, the reliability was measured to be 0.85. In the research of students' technical abilities (1993-1996) reliability was 0.88.

Results

The Finnish part of the research project was conducted with 317 participants and the Estonian part with 303 participants. The main goal was to evaluate the present level of students' technological knowledge and reasoning. It was not the authors' main intention to generalize and compare the results between students and two countries. However, a statistical analysis was done and some interesting differences were found between countries and gender to analyze further in discussion. As expected, based on an earlier study the correct answers obey normal distribution. Figure 2 presents the number of Finnish and Estonian students' correct answers in the survey.

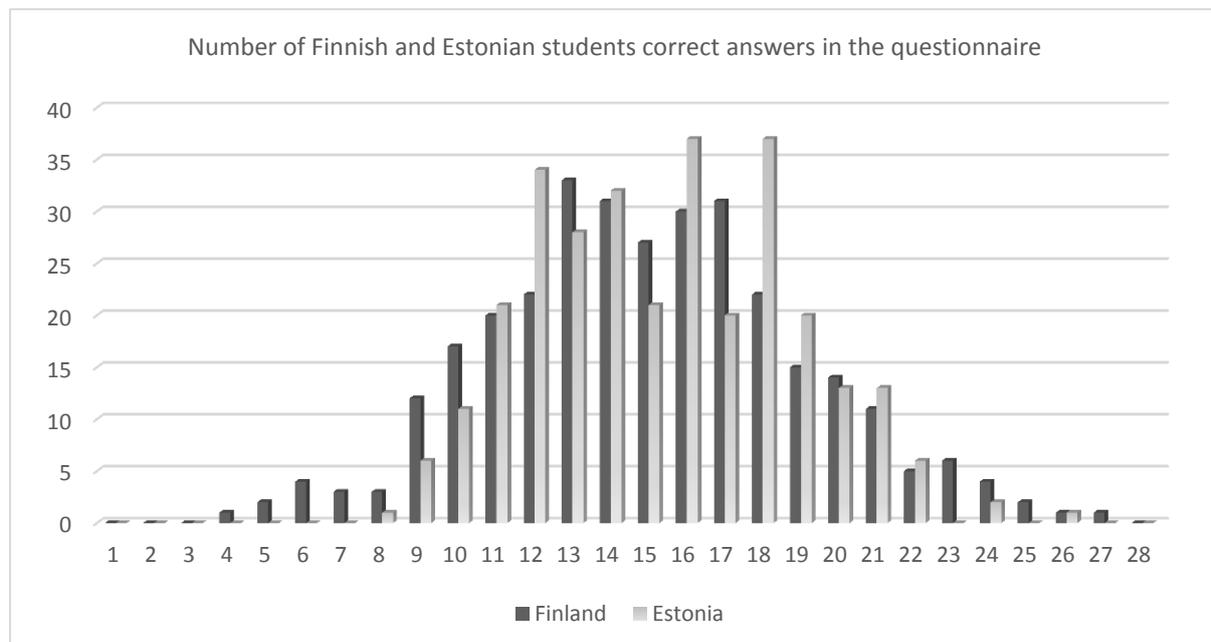


Figure 2. The number of Finnish and Estonian students' correct answers in the questionnaire

As we can see in Table 2 the total average of right answers to 28 questions was in Estonia 15.4 and in Finland 15.0. The biggest category in the Estonian sample was 16 and 18 right answers scored by 37 students. In the Finnish sample the biggest category was 13 right answers provided by 33 students. As expected, there were differences in the answers provided by the 11- and 13-year-old students. The average number of correct answers among 11-year-old students in the Estonian sample was 14.9 (standard deviation 3,2) and in Finnish sample 14.1 (st.dev 3.7). In the group of 13-year-old students, the small difference was almost disappeared as the average in Estonia was 15.8 (st.dev. 3,5) and in Finland 15.7 (st.dev 4.1). In all age groups the standard deviation was a little bit higher in the Finnish sample.

In addition, there were statistically significant differences between boys and girls in Estonia ($p=0.003$). In terms of the total answers provided by both sexes, the boys answered 16.0 of the questions correctly while the girls answered 14.7 of the questions correctly. In Finland, there were also statistically significant differences between boys and girls ($p<0.001$). Based on the total answers provided by both sexes, Finnish boys answered 15.7 of the questions correctly while the girls had 14.0 right answers. Interestingly, a difference was seen among most talented students as well, whereas there were eleven boys but just two girls who answered twenty-four or more questions correctly.

Table 2. The number of Finnish and Estonian students' correct answers in the survey

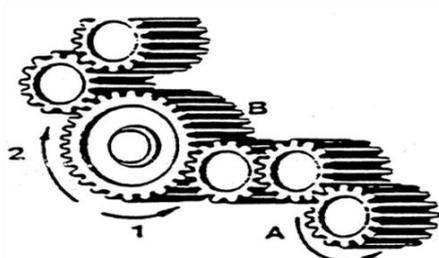
	All students	11-year-old students	13-year-old students	Boys	Girls
Finnish students	15.0	14.1	15.7	15.7	14.0
Estonian students	15.4	14.9	15.8	16.0	14.7

Later, the questionnaire was classified into eight categories based on their nature, as seen in Table 3. The number of questions in each category was different and some of the questions were more difficult than others. This was not considered as the questionnaire was originally designed to measure technological reasoning, but not to evaluate the contents of the curriculum in technology education directly. These categories, however, give interesting indications of students' knowledge in these areas. The highest average of correct answer in Finland was 68% right answers to 28 questions. It was found in the category for *balance and gravity*. The same category was scored the highest (65%) also in Estonia. Next one in Finland was 62% for *speed, acceleration and distances* followed by 58% for *speed of pulleys and gearwheels*. In Estonia, almost the same categories were highest in the list: 65% for *balance and gravity* and 63% for *direction of rotation* followed by *speed, acceleration and distances* 60%. The lowest averages of correct answers in Finland were 34% for *mechanisms* and 45% for *lift pulleys*. In Estonia, the lowest scores were also in *mechanisms* 29% and 48% for *lift pulleys*.

Table 3. The average % of correct answers to the main fundamentals in the questionnaire

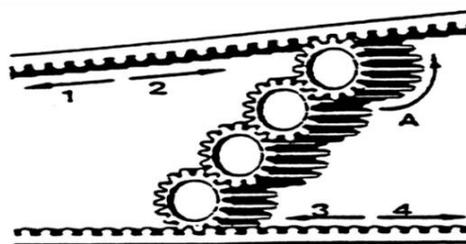
Categories	Numbers of questions	Correct answers FIN / EST
Direction of rotation	6	56 % / 63 %
Speed of pulleys and gears wheel	3	58 % / 56 %
Lift pulleys	2	45 % / 48 %
Speed, acceleration and distances	3	62 % / 60 %
Balance and gravity	4	68 % / 65 %
Thermodynamics and pressure	3	54 % / 59 %
Power and torque	4	51 % / 57 %
Mechanisms	3	34 % / 29 %
Total:	28	54 % / 55 %

Students' earlier experiences and simple physical knowledge should have helped them to answer most of the questions for example in the category of balance and gravity. As a matter of fact, the average of correct answer to this category was in Finland as high as 68%. The same category was scored the highest 65% also in Estonia. The lowest average of correct answers both in Finland and Estonia was for mechanisms (34% / 29%). As we can conclude from the example questions in Figure 3 it is obvious that in this category more technological understanding and reasoning is needed. It seems that this part from technological literacy cannot be learned directly from textbooks.



If cogwheel A rotates to the direction of the arrow, in what direction does cogwheel B rotate?

- a) direction 1
- b) direction 2
- c) cogwheels can not rotate



Cogwheel A turns to the direction of the arrow. In what direction do the cogwheels move?

- a) direction 1 and 3
- b) direction 2 and 4
- c) direction 1 and 4
- d) cogwheels can not move

Figure 3. Example questions from the questionnaire in the category of mechanisms

Conclusions

The main idea of this research was to evaluate the present level of Finnish and Estonian students' technological knowledge and reasoning. Furthermore, the study tried to find out if there is a relationship between students' Craft and Technology education studies and their technological reasoning? Anyway, it was not the authors' main intention to generalise and compare the results between students and two countries although these results give interesting information for example in gender issues. Based on the research results, the authors attempted to answer the research questions which were presented at the beginning of the study.

In answering the first research question: *What is the present level of students' technological understanding and reasoning in Finnish and Estonian schools?* Our statistical analysis shows that the total average of right answers to 28 questions was in Estonia 15.4 and in Finland 15.0. The researchers think that the students did not perform in the measurement of technical understanding and reasoning as well as expected. Although there is evidence about the lack of transfer (Cree & Macaulay, 2000), based on their studies in technology education students should have been more familiar with technological knowledge and reasoning. There are multiple reasons for this, thus the issue requires further examination. However, in too many schools Craft and technology lessons are based on reproducing artefacts according to given models without any creativity. Moreover, learning is too often focused on production skills with the aim of teaching students how to replicate demonstrated skill.

In Science education, a common problem is that many teachers use old fashioned pedagogical methods and teach the typical presentation-recitation way. In addition, students for example do routine practical work or just solve simple textbook problems. 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).

The second research question was: *What is the relationship between students' Craft and Technology education studies and their technological understanding and reasoning?* A remarkable part of the Finnish and Estonian national curriculum for Craft and technology is connected with technological knowledge and handicraft skills within a problem-solving context. Practical skills can improve both technological knowledge and reasoning (Prain, Tytler & Peterson, 2009). Craft and technology give students opportunities to learn about technology and to apply their skills in different settings.

However, the influence of the National Curriculum in Craft and Technology cannot be seen directly from the results of this survey; the students should have been more familiar with the content of the survey because of their craft and technology studies and the use of textbooks in other subjects, such as physics (Kohl, Rosengrant & Finkelstein, 2007). In Finland Craft and Technology education is nowadays officially named Handicraft and it is claimed that Technical craft and Textile craft should be compulsory for boys and girls in grades 3–9. Since 1996, because of this, boys have had much less technology education lessons than before. When comparing the results from an earlier research (1993-1996) with our current study held by the same research instrument, boys' technological knowledge and reasoning has diminished from 17.2 to current 15.7 correct answers in 28 questions. Especially, among 13-year-old boys the difference was statistically very significant ($p=0.001$) as the result has come down from 18.5 to 16.5 (Autio, 2013). In Estonia, Textile craft is a separate subject mostly included in Home economics while technological contents are taught in Technology Education lessons mainly for boys. Anyway, we can assume that there is a certain transfer effect between the content of curriculum and the results in technological knowledge and reasoning.

To answer the third research question: *Are there differences between students' technological understanding and reasoning in Finland and Estonia?* Our data shows that there were some differences between the two countries. The total average of right answers to 28 questions was in Estonia 15.4 and in Finland 15.0. The difference was clearly seen especially between Finnish and Estonian girls (The average number of correct answers to girls in the Estonian sample was 14.7 and in Finnish sample 14.0). Interestingly there was a difference between Finnish and Estonian 11-year-olds as well while the Estonian figure was 14.9 and 14.1 in Finland. For 13-year-old students, the difference was almost diminished while the average in Estonia was 15.8 and 15.7 in Finland.

The difference between Finnish and Estonian 11-year-old students is interesting issue and it needs to be further researched. Estonian curriculum gives common aims but leaves the teacher significant freedom in planning the content of lessons. Hence, it is possible that there is a greater emphasis on technological studies for younger students and more traditional activities in handicrafts and sustainable studies for older students. However, at least part of the difference can be explained by different results from Finnish and Estonian girls. As a matter of fact, the difference between Finnish and Estonian girls is even more surprising while in Finland half of the Craft

education lessons are reserved for Technical craft and the gender equality has been one of the main educational goals for decades.

Although, it was not the main goal of this research, we can't pass the differences between boys and girls. There were statistically significant differences between boys and girls in Estonia ($p=0.003$). The boys answered 16.0 of the questions correctly while the girls had 14.7 right answers. In Finland, the difference was even more significant ($p<0.001$) as Finnish boys answered 15.7 of the questions correctly and girls had 14.0 right answers. This result is usually emotionally charged although it is not a surprise that boys and girls differ in their interests. This is consistent with several other researches (Autio, 1997; Autio, 2013; Johnsson & Murphy, 1986; Streumer, 1988). In addition, the difference in technological knowledge, especially in spatial reasoning corroborates with some other researches (Linn & Petersen, 1985; Voyer, Voyer & Bryden, 1995). Hence, it is obvious that this has an impact on girls' motivation for learning about technology (Byrne 1987; Halperin 1992). However, we must take into account that spatial skills and technological reasoning consistently improve with a simple training course and they are mostly due to previous experience in design-related courses such as technical drawing, as well as play with construction toys such as Legos (Sorby & Baartmans, 2000).

There were differences in students' answers within the different categories of questions. To clarify this context, it would be beneficial to design a questionnaire with better-classified questions and with similar numbers of questions in each category. This would provide better information about the students' familiarity with the different categories. In any case, students' earlier experiences and simple physical knowledge without real technological reasoning should have helped them to answer some questions. We can assume that this has partly happened for example in the category of balance and gravity as average of correct answer in Finland was 68%. The same category was scored the highest 65% also in Estonia. The lowest average of correct answers in Finland was 34% for mechanisms. The same category scored the lowest also in Estonia with 29% of the right answers. It is obvious that in this category technological reasoning and ability to illustrate is needed to translate common physical knowledge into conclusions.

Discussion

Because of the prevalence of technology within modern society, learning about technology is becoming an important aspect of modern education. A large part of the Finnish and Estonian national curricula for Craft and Technology is associated with technological knowledge, handicraft skills and design principles within a problem-solving context. Gaining practical skills can accommodate both technological knowledge and understanding through technological reasoning (Prain, Tytler & Peterson, 2009). The school subject Craft and Technology aim to support students' technological knowledge and skills, with an emphasis on practical handicraft and innovative thinking. Students' practical handicraft skills provide them opportunities to learn about various technologies in their design work. It also helps students to use technology and creativity in experiments that increase their technological competence. In terms of technological literacy, students are required to demonstrate new skills and knowledge. Thus, within the Finnish and Estonian curriculum, the subject of Craft and Technology aims to develop advanced technological literacy in students. The purpose is to prepare them for participation in modern society and working life.

Practising handicraft within Craft and Technology provide students opportunities to learn about technology and to apply their skills in different settings. The subject of Craft and Technology supports technical literacy and technical skills within a workshop environment and thus should provide students with practical experience. It is also important for students to experiment and to train them in representing the solutions they use in their projects. Rosengrant, Heuvelen and Etkina (2009) identified that students who frequently used representations were successful in mechanic's tests. In addition, Ainsworth (2008) claimed that multiple illustrations played a large role in learning and constructing a deeper understanding in students, as they can integrate information from more than one source. Moreover, Malone (2008) stated that students with higher ability to demonstrate principles are better at solving difficult problems.

However, the influence of students' lessons in Craft and Technology on the research outcome was not clear from the results. It is possible that the students were unable to transfer the knowledge gained from their lessons at school to new circumstances. In addition, some old-fashioned pedagogical methods do not encourage students to construct scientific concepts or meanings. Nevertheless, the authors consider that all technological knowledge and experiences the students gained through their education were beneficial for the outcome. It would have been interesting to compare grades from individual subjects (such as Design, Craft and Physics) with the outcome of

the survey. It might also have been possible to formulate a new questionnaire based on students' technological studies on Craft and Technology education.

It was not the main goal of this research to compare two countries, not to mention the difference between boys and girls. According to the results, there were differences between Finland and Estonia. The main difference between the curriculums is that both Technical craft and Textile craft are compulsory for both boys and girls in Finland. In Estonia, students can choose the subject based on their wishes and interests. This allows students to study in greater detail the subject that they are really interested in.

Although, it is not a surprise that boys and girls differ in their interests, the difference is usually emotionally charged. However, based on earlier research we could expect that there were differences between boys and girls. Boys answered 56% of the questions correctly while the girls performed 51% of the correct answers. One possible reason for this might be the different social expectations for boys and girls. The 1998 Ofsted report, entitled 'Recent Research on Gender and Education Performance', stated that technology is rated as masculine by pupils and is thus preferred by boys (Arnot, Gray, James, Rudduck & Duveen, 1998). The media frequently depicts men as experts in technology, while the structure of learning tasks for boys and girls is sometimes different, as are the nature of feedback in classroom situations and the organization of classroom seating (Carter, 2011). However, because these factors are often subtle, they go unnoticed. Kiefer and Sekaquaptewa (2007), Byrne (1987) and Halperin (1992) suggested that boys and girls differ in their interests and that this has an impact on girls' motivation for learning about technology.

Every research has obvious limitations and due to several reasons, we cannot fully generalize the results. The questionnaire was not originally designed to evaluate the curriculum of technology education. Some of the questions were quite difficult especially for the younger students. However, this was necessary to ensure sufficient statistical dispersion for both 11 and 13-year-old students. Anyway, the questionnaire needs to be improved and the content needs to be updated with modern contents. Moreover, the sample did not consider a selection that is representative of the entire population. In any case, the research gave the authors new ideas how to develop students' technological knowledge and reasoning and some interesting data to analyze in more detail in the future.

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