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Technology Education and Technological Reasoning in Finland, Estonia, and Iceland

ABSTRACT

The research took place in Finland, Estonia, and Iceland. The researchers were interested in the present level of students' technological reasoning at the ages of eleven and thirteen. Students' technological reasoning was measured with a questionnaire regarding mechanical systems connected with simple physical phenomena. Data was collected using a questionnaire distributed to 317 students in Finland, 303 in Estonia and 277 in Iceland. The results highlighted general lack of understanding in technological reasoning. Some differences between Finland, Estonia and Iceland were found. This is explained by different curriculum settings. Furthermore, difference between boys and girls was found, which could be due to different interests in technological area.

KEYWORDS: Technology education, Technological reasoning, Technical literacy

1. *Introduction*

The goals of the Finnish, Estonian and Icelandic national curriculums for Technology education are basically quite similar and aim to equip students with the knowledge, skills and attitudes required to develop technological knowledge and reasoning[2]. Curriculums include technological knowledge and reasoning based on handicraft skills within a problem-solving context. Teaching aims to help students 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 on how to assess, un-

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[2] Framework Curriculum Guidelines, Helsinki, Opetushallitus, 2004; O. AUTIO & R. HANSEN, *Defining and Measuring Technical Thinking: Students' Technical Abilities in Finnish Comprehensive Schools*, in «Journal of Technology Education», 14 (1), 2002, pp. 5-19; NC, *Põhikooli riiklik õppekava [National curriculum for comprehensive schools]*, 2010.

derstand use and manage technology in a broad context, both at home and in the community.

Although the goals in the curriculums are quite similar, the main difference seems to be that Finnish 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. The

general aim of Finnish Technology education is to develop students' craft skills and support their self-esteem through practical craft activities; it also aims to increase students' understanding about the various craft tools, 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. In addition, gender issues are important throughout the whole curriculum[3].

Estonian curriculum has in practice two different craft/technology subjects – the technologically based Technology education (TE) and Handicraft/Home economics (HHE) separately. Students can choose the subject based on their wishes and interests. Subjects taught in the subject field of Technology in Estonia enable students to acquire the mentality and values inherent to the contemporary society. In lessons, students study and analyse 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 them. Teaching develops their skills in working and cooperating, as well as their critical thinking and the ability to analyze and evaluate[4].

In Iceland, artistically based Textile craft is included in Home economics while technological contents are taught in Technology education for both boys and girls. The present national curriculum for Technology education places an emphasis on individual-based learning. It also gives teachers the freedom to run an independent curriculum in school, which is based on the national curriculum. The subject is product based and students learn via traditional craft activities. Students' work is based on craft tradition rather than technology; however, innovation and idea generation are an important part of the Icelandic curriculum. There are also the aims of developing students' manual skills, instructing them in the manufacturing processes and training them to organise their own work. The national curriculum also incorporates outdoor education, working with green wood and sustainable design[5].

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[3] Framework Curriculum Guidelines, Helsinki, Opetushallitus, 2004.

[4] SFT, *Põhikooli riiklik õppekava. Ainevaldkond "Tehnoloogia" [National curriculum for comprehensive schools. Subject field Technology]*, 2010.

[5] B. Olafsson & G. Thorsteinsson, *Examining Design and Craft Education in Iceland: Curriculum Development and Present Situation*, in «FORMakadmisk», 3(2), 2010, pp. 39-50.

In practice, the researchers were interested at the present level of students' technological reasoning and the relation between the curriculum and students' achievements. To evaluate students' technological reasoning in Finland, Estonia and Iceland, a questionnaire was devised, concerning mechanical systems based on simple physical principles. The age of research participants 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 between these three countries. The research questions were:

1. What is students' practical level of technological understanding and reasoning in Finnish, Estonian and Icelandic schools?
2. What is the relationship between Technology education curriculums and students' technological knowledge and reasoning?
3. Are there differences between students' technological knowledge and reasoning in these three countries?

2. *Technological reasoning*

Within the Finnish, Estonian and Icelandic curriculums, the aim of Technology education is to facilitate students' technological reasoning, to prepare them for participation in modern society and working life. Students learn practical skills and learn about technology connected to whole environment and all human activity, using various tools from different design contexts associated with the transformation of energy, information, and materials.

The development of students' practical handicraft skills provides them the opportunity to learn about and utilise various technologies. Students put ideas into 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 different materials.

Technological knowledge and understanding are important for students, in rationalising the changing world of today. Furthermore, as active citizens, it enables them to play a part in the modification of the environment. Technology can be described by means of how humans modify the world around them to meet their needs and solve practical problems[6]. 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 reasoning was measured with a questionnaire regarding mechanical systems connected with simple physical phenomena. Mechanical sys-

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[6] Maryland Technology Literacy Consortium, *Maryland Technology Literacy Standards for Students. Professional Development and Technology Measures for Students, Teachers and School Administrators*, 2014.

tems 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. Their operations are obvious to us unless we examine them precisely. The Oxford Online Dictionary[7] introduced 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 such as is concerned with mechanics.

The Merriam-Webster Online Dictionary[8] defines reasoning as the action of thinking about something in a logical, sensible way, to form a conclusion or judgement. In science and technology, reasoning and argumentation are important in establishing the best explanation for a natural phenomenon[9]. The ability of technological reasoning is a necessary precondition in the development of improved technological and scientific explanation and in students' ability to improve the level of understanding[10].

Technological understanding and reasoning have been examined within the context of technology and science education Hubber, Tytler and Haslam[11] 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.

Autio[12] researched the technological knowledge of students aged eleven and thirteen in Finnish comprehensive schools and found statistical differences between boys and girls. The author assumed that boys and girls differ in their interests and spatial visualization. The performance on the visualization-in three-dimensions test is seen as an estimate of spatial skills thought to be related to science achievement and career selection and as an estimate of general analytical ability[13]. It is obvious that spatial visualization influences technological reasoning. This finding is consistent with some other researches[14]. It is as-

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[7] The Oxford English Dictionary Online, 2014.

[8] Merriam-Webster Dictionary, *Merriam-Webster Dictionary*, 2014.

[9] National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas*, The National Academies Press, Washington DC, 2012.

[10] P. Sutopo & B. Waldrip, *Impact of a representational approach on students' reasoning and conceptual understanding in learning mechanics*, in «International Journal of Science and Mathematics Education», 11(4), 2013, 1-24.

[11] P. Hubber, R. Tytler & F. Haslam, *Teaching and learning about force with a representational focus: pedagogy and teacher change*, in «Research in Science Education», 40, 2010, 5-28.

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

[13] M. Linn & A. Petersen, *Emergence and characterization of sex differences in spatial ability: A meta-*analysis, in «Child Development», 56(6), 1985, pp. 1479–1498.

[14] S. Johnson & P. Murphy, *Girls and physics: Reflections on APU survey findings*, London, Department of Education and Science, 1986; J.H. Streumer, *Evalueren van techniek.* Encshede, Univer-

sumed, that this has also an impact on girls' motivation for learning about technology[15].

Within the context of Technology education, the link between practical work and technological reasoning is important and helps students to understand technological principles through their own experience. Kohl, Rosengrant and Finkelstein[16] assume that the ability to demonstrate is a key in studying physical science. In addition, students with higher ability to demonstrate principles are better at solving problems[17]. Rosengrant, Heuvelen and Etkina[18] supposed that students who frequently used representations were successful in technological reasoning. Ainsworth[19] claimed that illustrations are important in learning and constructing a deeper understanding. Furthermore, several researchers have suggested that when students learn to implement materials and tools, they improve their understanding about technological learn to implement materials and tools, they improve their understanding about technological phenomena[20].

3. *Methods*

The research was undertaken during the years 2015-2016 in Finland, Estonia, and Iceland. The participants were 11- and 13-year-old students. The Finnish sample was 317 participants. The Estonian part of the research was undertaken with 303 students and in Iceland 277 students took part in the study. Approximately the same number of boys and girls and correspondingly younger and older students took part in the research. However, in the Icelandic sample there was more emphasis in 13-year-old students' age group. In more detail, the amount of research participants can be seen in Table 1.

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siteit van Twente, 1998.

[15] M. BYRNE, *Techniques for Classroom Interaction*, Longman, Harlow, 1987; D.F. HALPERIN, *Sex Differences in Cognitive Abilities*, Erlbaum, Hillsdale, NJ, 1992.

[16] P.B. KOHL, D. ROSENGRANT & N.D. FINKELSTEIN, *Strongly and weakly directed approaches to teaching multiple representation use in physics*, in «Physics Review Special Topics - Physics Education Research», 3, 2007, pp. 1-10.

[17] K.L. MALONE, *Correlations among knowledge structures, force concept inventory and problem-solving behaviors*, in «Physics Review Special Topics-Physics Education Research», 4, 2008, pp. 1-15.

[18] D. ROSENGRANT, A.V. HEUVELEN & E. ETKINA, *Do students use and understand freebody diagrams?*, in «Physics Review Special Topics - Physics Education Research», 5, 2009, pp. 1-8.

[19] S.AINSWORTH, *The educational value of multiple representations when learning complex scientific concepts*, in J. K. GILBERT, M. REINER & M. NAKHLEL (Eds.), *Visualisation: Theory and Practice in Science Education*, Springer, New York, 2008, pp. 191-208.

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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
Iceland	30	31	116	100	277

Table 1: *The number of Finnish and Estonian research participants.*

In the 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[21]. 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. In Iceland both rural and city schools were included in the sample. However, the whole sample did not consider a selection that is representative of the entire population in Finland, Estonia, and Iceland[22].

To evaluate students' technological knowledge and reasoning, a questionnaire was devised, concerning simple mechanical systems and physical principles used and seen in daily life. The questionnaire was developed by the ministry of labour in Finland and has been widely used for students to see if they have competence to a technological career. The questions referred to students' technological knowledge and reasoning supported by their education and life experiences. The questionnaire consists of 28 questions, with related figures. Each question included three possibilities, one of which was the correct answer. Examples from simple mechanical contexts used in the questionnaire are presented in Figure 1.

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[21] AUTIO & HANSEN, *Defining and Measuring Technical Thinking: Students' Technical Abilities in Finnish Comprehensive Schools*, *op. cit.*; AUTIO, *Oppilaiden teknologiset valmiudet – vertailu vuoteen 1993 [Students' technical abilities – a comparison to year 1993]*, *op. cit.*

[22] L. COHEN, L. MANION & K. MORRISON, *Research Methods in Education*, Routledge, New York, 2007; D.R. COOPER & P.S. SCHINDLER, *Marketing Research*, McGraw–Hill, New York, 2006.

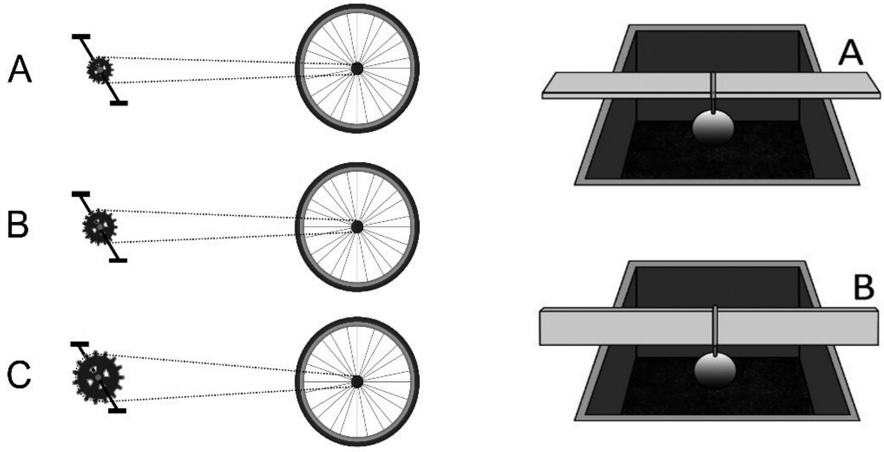

Figure 1. *Example pictures from the questionnaire*

This kind structured and closed questions make statistical treatment and analysis easier and enabling comparison across groups[23]. Moreover, a questionnaire should be attractive and encouraging to respondents[24]. It must be considered that 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, but this was necessary to ensure sufficient statistical dispersion for both 11- and 13-year-old students.

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. As expected from the earlier researches, Finnish, Estonian, and Icelandic samples approximately followed a normal curve. In earlier studies of the Finnish ministry of labour reliability was measured to be 0.85 and in a research of students' technical abilities (1993-1996) reliability was 0.88.

4. *Results*

The main idea of this research was to evaluate the present level of students' technological knowledge and reasoning. In addition, the study tried to find out: is there a relationship between students' Technology education lessons and the results of the questionnaire in technological knowledge and reasoning?

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[23] A.N. OPPENHEIM, *Questionnaire Design, Interviewing and Attitude Measurement*, Pinter, London, 1992.

[24] COHEN, MANION & MORRISON, *Research Methods in Education*, *op. cit.*

As expected, based on an earlier study the correct answers obey normal distribution. Figure 2 presents the number of Finnish, Estonian and Icelandic students' correct answers in the survey.

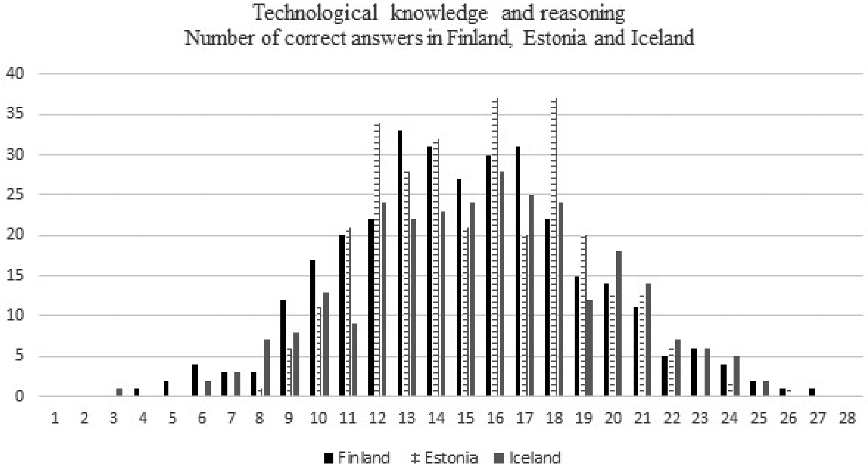


Figure 2. *The number of Finnish, Estonian and Icelandic students' correct answers in the questionnaire.*

The total average of right answers to 28 questions was in Finland 15.0, in Estonia 15.4 and in Iceland 15.5. 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 correct answers provided by 33 students. In Iceland 16 correct answers were scored by 28 students. As expected, there were differences in the answers provided by the 11- and 13-year-old students. The average number of correct answers to 11-year-old students in Finnish sample was 14.1. In the Estonian sample the figure was 14.9 and in Iceland 14.7. In the group of 13-year-old students, the small difference was almost disappeared as the average in Finland was 15.7, in Estonia 15.8 and in Iceland 15.8.

In Finland, there was statistically significant difference 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. 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 had 14.7 correct answers. The difference between boys and girls was the smallest in Iceland ($p=0.025$). The boys answered 16.0 of the questions correctly while the girls had 14.9 of correct answers.

	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
Icelandic students	15.5	14.7	15.8	16.0 14.9

Table 2. *Finnish, Estonian, and Icelandic students' correct answers in the survey.*

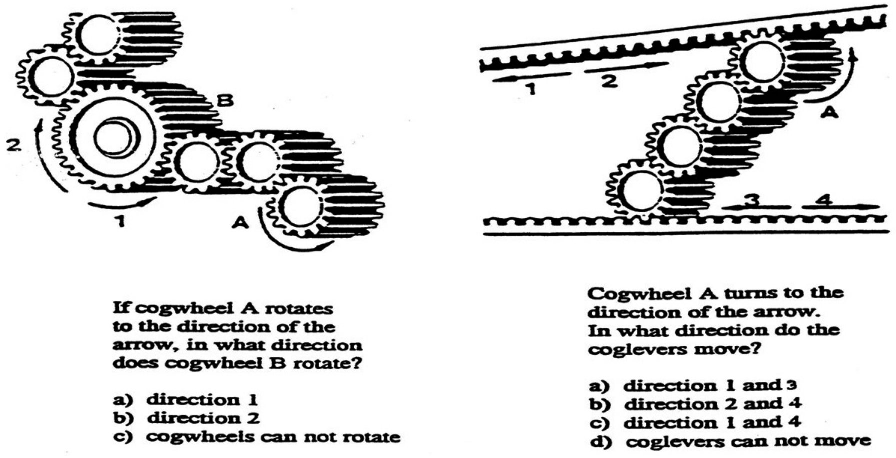
In Finland, no statistical differences were found within the schools of similar curriculum of Technology education. Even in the University training school the results were the same as in rural areas, even though the school is usually ranked one of the most successful in Finland. Thus, we can assume that the questionnaire measured technological reasoning, not just the context students learn in school. In Estonia, the study participants were students in both urban and rural areas. Although the difference between schools was not measured, we can assume that in Tallinn city schools the students' knowledge level was somewhat higher than in the country schools. In Iceland, large part of the students came from the capital of Iceland – Reykjavik. However, it is the only city in Iceland and most of the whole population in Iceland live in that city.

Later, the questionnaire was classified into eight categories based on their technological 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. Next one in Finland was 62 % for speed, acceleration and distances followed by 58 % for speed of pulleys and gearwheels. In Estonia and Iceland, almost the same categories were highest in the list: 65 % in Estonia and 70 % in Iceland for balance and gravity. Correspondingly, 63 % and 54 % for direction of rotation followed by speed, acceleration and distances 60 % in both Estonia and Iceland. 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. In Iceland, the most difficult category was mechanisms 40 %.

Categories	Numbers of questions	Correct answers FIN / EST / ICE
Direction of rotation	6	56 % / 63 % / 54%
Speed of pulleys and gears wheel	3	58 % / 56 % / 65 %
Lift pulleys	2	45 % / 48 % / 50 %
Speed, acceleration, and distances	3	62 % / 60 % / 60 %
Balance and gravity	4	68 % / 65 % / 70 %
Thermodynamics and pressure	3	54 % / 59 % / 51 %
Power and torque	4	51 % / 57 % / 51 %
Mechanisms	3	34 % / 29 % / 40 %
Total:	28	Average:54 % / 55 %/ 56 %

Table 3. *The average of correct answers for the main fundamentals in the questionnaire*

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 also in Estonia (65 %) and Iceland (70 %). The lowest average of correct answers in Finland, Estonia and Iceland was for mechanisms (34 % / 29 % / 40 %). As we can conclude from the example questions in Figure 3 it is obvious that in the category of mechanisms 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 coglevers move?

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

Figure 3. *Example questions in the category of direction of rotation and mechanisms*

5. *Discussion*

The first research question was: What is students' practical level of technological understanding and reasoning in Finnish, Estonian and Icelandic schools? Our research data shows that Icelandic students gave 15.5 right answers to 28 questions. Among Estonian students the figure was 15.4 and in Finland 15.0. The students did not perform in the measurement of technical knowledge and reasoning as well as expected. There are multiple reasons for this. In Science education, a common problem is that many teachers teach the typical presentation-recitation way while students 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[25]. In addition, learning is too often focused on production skills and in too many schools technology lessons are still based on reproducing artefacts according to given models without a connection with technological reasoning. Technology education lessons are more practical rather than theoretic and the optimal solution between theory and practice has not yet been found.

The second question of our research was: What is the relationship between Technology education curriculums and students' technological knowledge and reasoning?

A remarkable part of the Finnish, Estonian and Icelandic national curriculum for Technology education is associated with handicraft skills and design principles within a problem-solving context. Practising handicraft within Technology education lessons give students plenty of opportunities to learn about technology. Practical work with tools, machines and different materials is expected to accommodate both technological practice and knowledge[26].

Based on students Technology education studies and the use of textbooks in other subjects, such as physics, the students should have been more familiar with the content of the survey[27]. The goal of transfer is the ability to use the knowledge learned in lessons in practical reasoning used outside the school[28]. Although there is evidence about the problems in transferring[29], the results in technological knowledge and reasoning were not as good as we could have expected.

We can assume that there is a certain relation between the content of cur-

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[25] A. ARONS, *Teaching Introductory Physics*, John Wiley and Sons, New York, 1997.

[26] V. PRAIN, R. TYTLER & S, PETERSON, *Multiple representation in learning about evaporation*, in «International Journal of Science Education», 31(6), 2009, pp. 787–808.

[27] KOHL, ROSENGRANT & FINKELSTEIN, *Strongly and weakly directed approaches to teaching multiple representation use in physics*, *op. cit*.

[28] J. BRASNSFORD, A. BROWN & R. COCKING, *How people learn: Brain, mind, experience, and school*, National Academy Press, Washington D.C., 2000.

[29] V.E. CREE & C. MACAULAY, *Transfer of learning in professional and vocational education*, Routledge, London, Psychology Press, 2000; K.J. PUGH & D.A. BERGIN, *Motivational influences on transfer*, in «Educational Psychologist», 41(3), 2006, pp. 147-160.

riculum and the results in technological knowledge and reasoning. During last twenty years 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[30].

The third research question was: Are there differences between students' technological knowledge and reasoning in these three countries?

Although, the difference between the three countries was relatively small, the difference was seen between Finnish, Estonian and Icelandic girls. As a matter of fact, the difference in technological knowledge and reasoning between Finnish (14.0) and Icelandic/Estonian girls (14.9 / 14.7) was not expected while in Finland the gender equality has been one of the main educational goals for decades. It seems that, at least in technological knowledge and reasoning, the Finnish compulsory system is not working as it has been planned. It seems that there are simply not enough lessons in technology education as just one subject is divided into two different contents.

It was not the main goal of this research, but we cannot pass the differences between boys and girls. Although it is not a surprise, that boys and girls differ in their interests, this result usually is emotionally charged. In any case, statistically significant differences between boys and girls in Estonia (p=0.003) were found. 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 correct answers. In Iceland, the difference was not as significant (p=0.025) while boys had 16.0 and girls 14.9 correct answers. This difference in technological knowledge, especially in spatial reasoning corroborates with several other researches[31]. However, we must consider that spatial skills and technological reasoning consistently improve with training and they are mostly due to previous experience in design-related activities, as well as play with construction toys such as Legos[32]. Anyway, it is obvious that this has an impact on girls' motivation for learning about technology[33].

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[30] AUTIO, *Oppilaiden teknologiset valmiudet – vertailu vuoteen 1993 [Students' technical abilities – a comparison to year 1993], op. cit.*

[31] O. AUTIO, *Oppilaiden teknisten valmiuksien kehittyminen peruskoulussa [Student's development in technical abilities in Finnish comprehensive school]*, Helsinki, The University of Helsinki, Department of Teacher Education, 1997; JOHNSON & MURPHY, *Girls and physics: Reflections on APU survey findings, op. cit.*; LINN & PETERSEN, *Emergence and characterization of sex differences in spatial ability: A meta-analysis. op. cit.*; STREUMER, *Evalueren van techniek, op cit.*; D. VOYER, S. VOYER & M. BRYDEN, *Magnitude of sex differences in spatial abilities: A meta-analysis and consideration of critical variables.* Psychological Bulletin, 117(2), 1995, 250-270.

[32] S. SORBY & B. BAARTMANS, *The development and assessment of a course for enhancing the 3-D spatial visualization skills of first year engineering students*, in «Journal of Engineering Education», 89(3), 2000, pp. 301-07.

[33] BYRNE, *Techniques for Classroom Interaction*, *op. cit.*; HALPERIN, *Sex Differences in Cognitive Abilities*, *op. cit.*

6. *Conclusions*

The school subject Technology education is an important aspect of modern education. It aims to support students' technological knowledge and skills. Developing students' practical handicraft skills helps them to learn about and utilise various technologies in their work. It also helps students to use technology within broader contexts outside the school. Finnish, Estonian and Icelandic Technology education curriculum is associated with technological knowledge, handicraft skills and design principles within a problem-solving context. Practical skills are supposed to accommodate both technological knowledge and understanding[34]. Practising handicraft within technology lessons should help students to learn about technology and develop their skills further in many different learning environments. However, in technology education lessons the optimal solution between theory and practice has not yet been found.

According to the results, there were differences between Finland, Estonia, and Iceland. This might be due to different curriculum settings. All curriculums provide students technological knowledge based on handicraft skills within a problem-solving context. However, the main difference seems to be 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 detail the subject that they are really interested in. In Iceland two different subjects: art-based Textile education and innovation-based Technology education, compulsory for both sexes, seem to be relatively good setup for gender equity as the difference in attitudes and technological reasoning was the smallest in Iceland. In Estonia, Textile craft is a separate subject mostly included in Home economics while technological contents are taught in Technical craft/Technology education lessons. Both boys and girls can choose these lessons based on their interest area. We can assume that this is a relatively good setup for both boys and girls compared with the Finnish compulsory system.

The difference in results between boys and girls was not a surprise. Gender-based segregation and falling recruitment for scientific and technological studies is a common phenomenon. However, it is a paradox that the inequity is still noticeable in Finland, where for decade's gender equality has been a prime educational goal. One possible reason for this might be the different social expectations for boys and girls. Furthermore, the feeling of autonomy is especially important for older students who want and need more autonomy in their decisions and perhaps want to concentrate more on their real interest area. Some research in other life contexts such as education in general has also shown that high levels of autonomous motivation toward education lead to high academic performance[35].

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[34] PRAIN, TYTLER & PETERSON, *Multiple representation in learning about evaporation*, *op. cit.*

[35] K. BURTON, J. LYDON, D. D'ALESSANDRO & R. KOESTNER, *The differential effects of intrinsic and*

However, the most obvious reason for gender differences is different interest areas for boys and girls. In the future, it is a challenge for the curriculum development. How can 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[36]. In addition, motivation in technology education can be significantly improved by developing special programs[37], where teachers are aware of the differing interests of both genders and consider ways of making the environment and the subject attractive to all[38].

Due to several reasons, we cannot fully generalise the results. Although the schools were selected on the basis to ensure schools with different curriculums as well as rural and city schools; the sample did not consider a selection that is representative of the entire population. In the future, also the questionnaire needs to be improved and the content needs to be updated. In any case, the study provided the authors new ideas to develop students' technological knowledge and reasoning. It will be the basis for a new research with a reconstructed survey.

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