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Development of Students' Technical Abilities between 1993-2022 in Finnish Comprehensive Schools

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Abstract
The aim of this study was to find out if there have been any changes in technical abilities among Finnish school children during the last 30 years. Technical abilities were first measured in the affective, psychomotor, and cognitive areas in the year 1993 and these results were later compared with the results from 2012 and 2022. The number of test participants was 267 in the year 1993, 317 in 2012 and 282 in 2022. The age of the student respondents was 11–13 years. The measurements were done with exactly the same research instruments in all three years. Some positive changes were found in affective area among girls' test groups. Unfortunately, in all research groups the development was negative in the psychomotor and cognitive area. The reason for the decline could be in the reduction of craft and technology education lessons available, especially for boys. From a broader point of view, the changes can be due to the changes in society as a whole. It seems that the curriculum changes during last 30 years have not worked as they have been planned. Especially, boys underachievement is explained by the fact that, even if students work with systematic planning models and use their creativity, aesthetical design usually overshadows technological issues. It is assumed that progressive teaching and assessment favour girls and traditional methods are more congenial to boys.

Keywords
Technology education, Craft education, Curriculum, Technological abilities, Affective ability, Psychomotor ability, Cognitive ability.

Introduction
Between the years 1993 and 2022, there have been several changes in the national curriculum concerning technology education. The Framework Curriculum Guidelines (National Board of Education, 1994) for compulsory education states in its general section that the technical development of society makes it necessary for all citizens to have a new readiness to use technical adaptations and be able to exert an influence on the direction of technical development. Furthermore, students of any sex or gender must have the opportunity to acquaint themselves with technology and to learn to understand and avail themselves of technology. The curriculum also emphasizes that extensive knowledge is necessary when participating in technology-related discussions and problem solving. Moreover, in the general part of the curriculum, it is said that the ability to use different forms of technology, especially information and communication technology (ICT), gives students the chance to use the tools of modern society and, in general, offers a versatile environment for the understanding and the development of different forms of technology.

During 2001, there was an active discussion about the role of technology education in Finnish compulsory education. Spokespersons from industry were active in organizing national seminars for developing technology education in Finnish schools, especially the goals and content of technology education in the curriculum. Moreover, several projects aimed at developing the curriculum and technology education were started (Järvinen et al., 2000; Lavonen et al., 1998; Parikka, 1998; Santakallio, 1998.

The results obtained from the various development projects in the field of technology and from international discussion about the role of modern technology had an effect on the formulation of the goals and contents of technology education in the national curriculum framework for compulsory school (National Board of Education, 2004). Hence, 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. Students should be familiar with new technology, including ICT, 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. Although technology education was introduced for the first time in the framework curriculum, a separate technology education subject has not been established.

Since the national curriculum's (National Board of Education, 2004) emphasis on technology, the demand for technology as a school subject has increased considerably. However, in Finland the process proceeds with great difficulty, and it may take years before technology is taught to all pupils. The curriculum states that technical craft and textile craft should be compulsory for boys and girls in Grades 3–7. However, because of practical reasons such as timetabling and the number of teachers employed in many schools, students had to select just one of the craft subjects in 1993. As a consequence of this, most of the boys selected technical craft classes and girls joined textile education.

The latest Framework Curriculum Guidelines 2014 (National Board of Education, 2014) specified that in grades 1–9 technical craft and textile craft should be taught to both boys and girls throughout their entire compulsory schooling. The name for the subject was to be Handicraft and at a practical level, it is expected to create many changes. There are no separate subjects, just one multi material craft for both sexes. This means that there will be a minor emphasis on technology - art and design will be emphasized over technology education. Instead, the development of students' personalities, the growth of self-esteem and gender issues will be more important throughout the whole curriculum. There are expected to be many problems, as competence in different craft areas requires very different knowledge and skills; technological reasoning is based on very different scientific elements than aesthetical design.

What is more, during last year's there have been radical changes in craft teacher education. Based on gender equality there are no separate programs for technical craft teachers and textile craft teachers. The craft teachers have to master different contents and techniques in both technical and textile area. Unfortunately, the amount of ECTS credits is still the same as earlier although the students should master two different expertise areas. According to Kokko, Kouhia and Kangas (2020) confusion has occurred both in terms of the organization of the "new" subject that brings together the practices of textile and technical crafts, and the means and methods of craft education. Especially the new concept, multi-materiality, as well as the concept technology education, have been regarded problematic. Moreover, the changes and reduction in the distribution of the lesson hours have made the situation even more problematic. The main problem in Finland is that even though, now a days, there is more technology-related content that our children should be familiar with, the number of craft and technology lessons is still the same as 30 years ago, or even less and as a consequence of the latest curriculum girls have more technologically based lessons than 30 years ago. Unfortunately, boys have much less technologically based lessons than they had in 1993.

The main goal of this study was to find out if fundamental changes in students' technological abilities can be seen during the last 30 years. In order to evaluate students' technological abilities, research instruments were devised to measure cognitive, psychomotor, and affective areas of technology education. The main intention of the research was to compare the development between years 1993-2022. However, the comparison between boys and girls resulted in some new and interesting data.

The research questions were:

Are there differences in students' technological abilities in Finland between the years 1993 and 2022?

- in affective area
- in psychomotor area
- in cognitive area

Is there a difference between boys and girls in technological abilities?

Research Methodology

In the study, students' technological abilities were assessed with three different tests in: affective, psychomotor and cognitive areas. The main problem from the conception stage of the study was: how is technological 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 (cognitive, affective and psychomotor) of human personality, which are considered to be the outcomes of technology 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.

To find out whether there were any differences between the measurements in 1993, 2012, and 2022 the researcher employed a two-tailed *t*-test with the same variance because there was no hypothesis of the development in technological abilities based on the previous research. Instead, boys and girls were compared with a one-tailed *t*-test in affective and cognitive areas because there is plenty of research evidence available about the difference. The number of test participants in the first measurement was 267 in year 1993, in the next measurement 317 in year 2012 and 282 in the final measurement in 2022. The age of the student respondents was 11–13 years. Approximately the same number of boys and girls as well as 11- and 13-year-old students took part in the study. In all samples (1993, 2012 and 2022), the schools were the same. Those schools were originally selected to ensure that schools with different curricula as well as rural and city schools were represented.

The first sample from 1993 was based on a research design in which different solutions for the practical implementation of technology education were tested. At that time, only a few schools were using a curriculum in which textile and technical craft was introduced to both boys and girls. These schools were selected for the sample from 1993, and the same schools were selected in 2012 and 2022. To ensure that different curriculum solutions and schools from rural and city areas were represented, some country schools were selected. These country schools used a traditional curriculum. In practice, this curriculum included traditional wood and metal work as well as engineering projects with electronics, mostly for boys, and textile education, mostly for girls. In 2012 and 2022, all schools with 11-year-old students had moved to a new curriculum that provided textile and technical craft for both boys and girls.

Despite the fact that skilled behaviour underlies nearly every human activity, our understanding about the factors that contribute to the attainment of expertise in technology education is far from complete. However, some attempts to define technological competence have been made. For example Dyrenfurth's (1990) and Layton's (1994) presented technological literacy as a relationship between technological will, technological skill and technological knowledge. Later on, for example Kimbell and Stables (2007) have developed the definition of technological capability with modern contents. For this research, Autio and Hansen (2002) defined technological competence as an interrelationship between technical abilities in affective, psychomotor and cognitive areas (*Figure 1*).

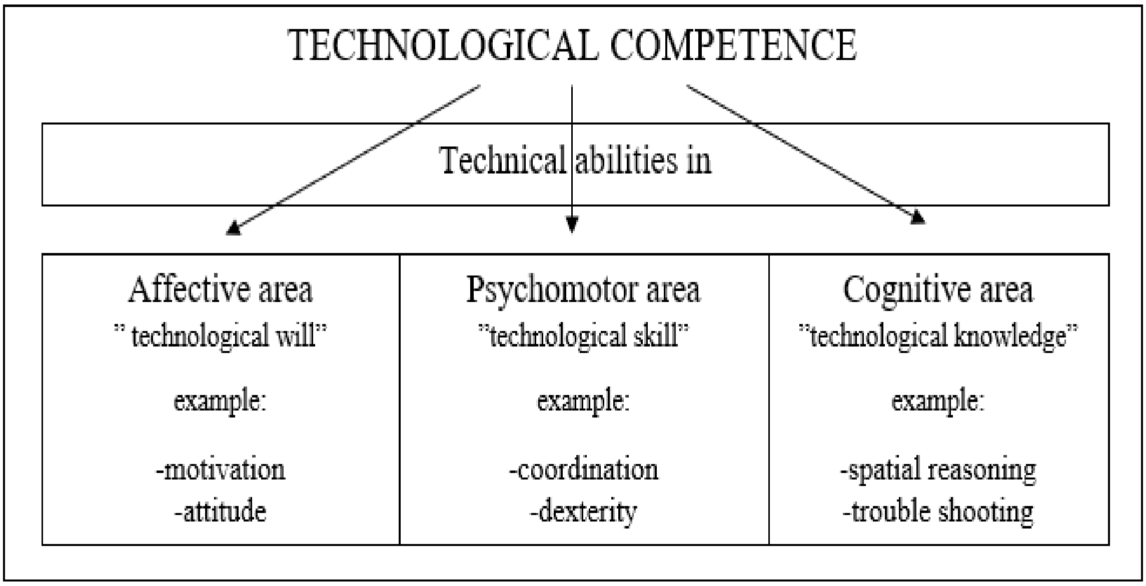


Figure 1. Technological competence

In order to evaluate students' *affective area*, a questionnaire was devised that consisted of 14 statements. For each Likert-type item, there were five options, from strongly disagree (1) to strongly agree (5). The questionnaire was based on the most common PATT (Pupils Attitudes Towards Technology) instrument, which was designed and validated by Raat and de Vries (1986) and van der Velde (1992). The original instrument, which consisted of 78 items, turned out to be too complicated and time consuming for 11- to 13-year-old students. Hence, for this study, a shorter version of attitude questionnaire was developed. The researcher removed many items that had small item-rest correlation (i.e., correlations between item score and total score of the rest of the scale). Finally, the questionnaire consisted of the following six factors: interest in technology, consequences of technology, difficulty of technology, role pattern, technological career, and technology as school subject. According to the researcher's observations, it was easy to use and not time consuming. In addition, the students could fully concentrate on answering of all items. Reliability of the questionnaire was 0.85 in 1993.

Instead of just comparing boys' and girls' attitudes, the underrepresentation of girls and women in science, technology, engineering, and mathematics (STEM) is a much more common research area (Burke & Mattis, 2007; Ceci, Williams & Barnett, 2009; Ceci & Williams, 2011; Cheryan et al., 2017). Hence, more attention should be paid to girls' subjective task value ranking for math and science relative to their ranking of other subjects such as reading and language skills (Klein et al., 2007). Even if women are more interested in other fields, it does not mean that they could not be equally interested in engineering (Cheryan et al., 2017).

There has been much interest in constructing theoretical conceptions of the dynamic's psychomotor performance. However, the analysis of motor abilities suggests that any process description is more complex than has yet been explicitly admitted. First, such descriptions must be more complex because of the large number and the wide range of dimensions that are needed in order to fully characterize individual difference in the motor domain. According to Powell et al. (1978) there are several compatible ways of describing the varied structural components of the motor system. From the standpoint of factor analysis, they represent hierarchically organized dimensions of individual differences; from the viewpoint of information processing theory, they represent decomposable classes of general motor programs or classes of parameters entailed by those programs, and from the perspective of general systems theory, they can be construed as hierarchically decomposable systems and subsystems (*Figure 2*.)

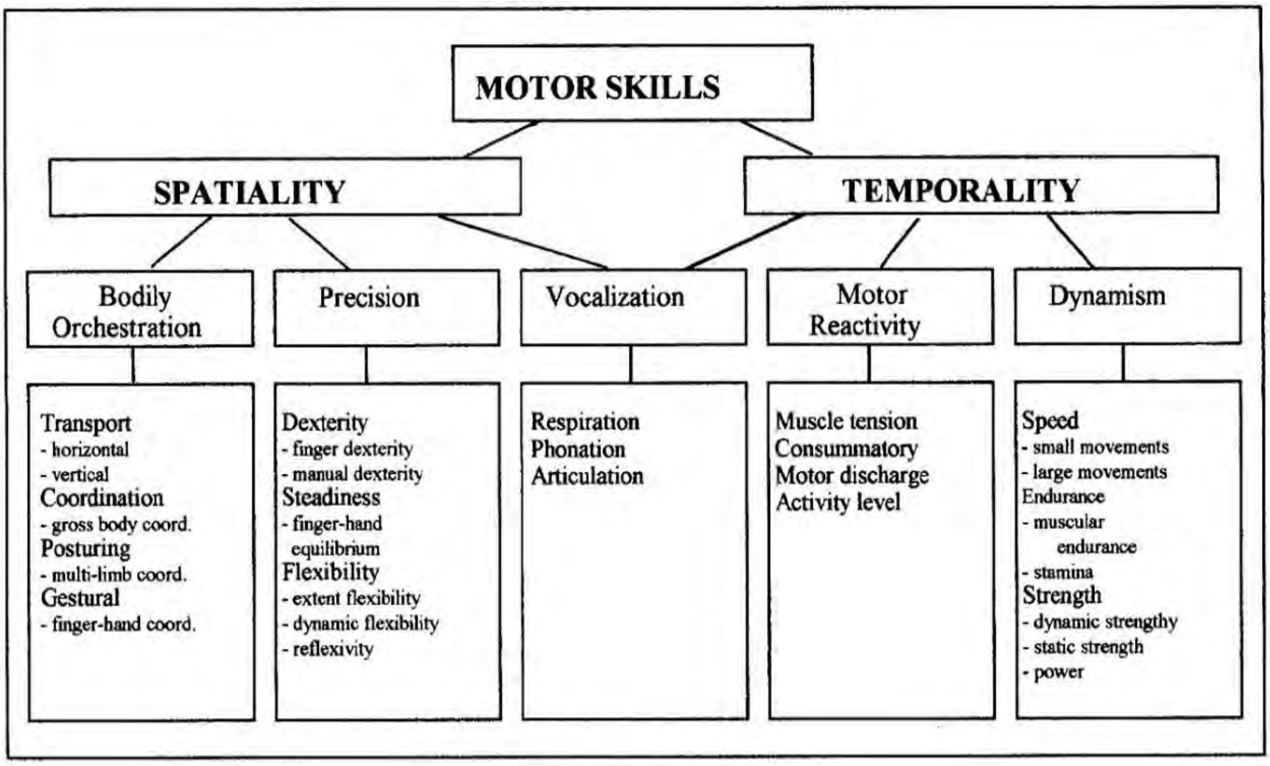


Figure 2. The hierarchical factor system of motor skills modified from (Powell & al. 1978).

In the *psychomotor area* the test was called X-boxes and it was based on the theory of Powell et al. (1978). In this test of motor skills all the elements of bodily orchestration, precision, motor reactivity and dynamism are involved. The task in the measurement was to build up as many x-box (*Figure 3*.) as possible in five minutes. The reliability of this test was 0.819 as measured with the Cronbach Alpha.

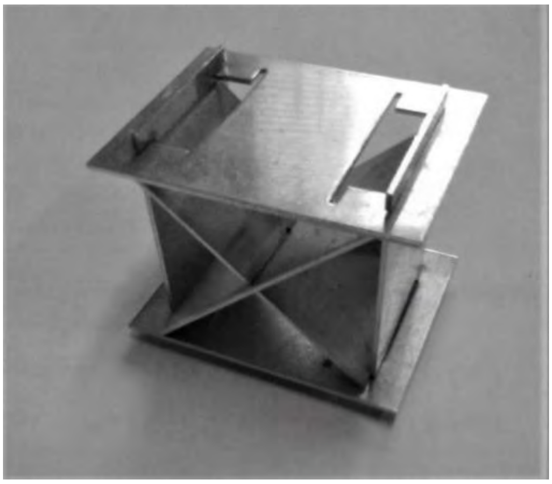


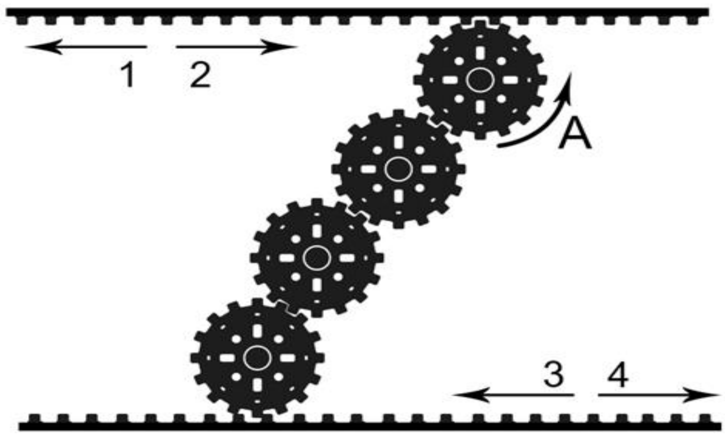
Figure 3. X-box

Technological knowledge is 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 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 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 science and technology, they must be aware of the different concepts and processes. To understand the relationship between these, they need to have technological knowledge, which is based on technological reasoning (Hubber et al., 2010; Prain et al., 2009).

Kohl et al. (2007) suggested that the ability to demonstrate is a key in studying physical science. Mental rotation involves the ability to look at a picture of an object and visualize what it might look like when rotated in three-dimensional space. This skill relates to the ability on how mentally transform images. This is useful in a variety of tasks, such as carpentry, architecture, map reading, engineering, and sports.

In the *cognitive area*, the test instrument was called 'a test of technological 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 in 1993, measured with the Cronbach Alpha, was 0.881. An example question can be seen in *Figure 4.*



If cogwheel A turns to the direction of arrow, in what direction do the cog levers move?
1) Direction 1 and 3
2) Direction 1 and 4
3) Cog levers cannot move

Figure 4. Example questions in cognitive area – technological reasoning

Results

Affective area

In the affective area a statistically very significant ($p<0.001$) difference was found between years 1993-2022 among 11-year-old girls as the result was 2.88 in the year 1993 and 3.37 in 2012 and 3,41 in 2022. Similarly, but a smaller development was found in 13-year-old girls test group. The difference between years 1993 (2.90), 2012 (3.14), and 2022 (3.21) was also statistically very significant ($p<0.001$). Among the boys' test groups, the results followed the same pattern as those of the girls during years 1993-2012. However, noticeable decline was found between years 2012-2022. The figures were (3,59 / 3,78 / 3,60) among 11-year-old boys and (3,51 / 3,72 / 3,51) among 13-year-old boys. Standard deviation remained quite stable in all test groups. However, in the year 1993 it was usually higher than in 2012 and 2022. In addition, there was a noticeable difference between younger (0.75) and older (0.46) girls in the year 1993. Average values and standard deviation in 1993, 2012, and 2022 among boys and girls test groups in the measurement of affective area is presented in *Table 1*.

Attitudes are assumed to be rather stable during the school years (Arffman & Brunell, 1983; Bjerrum Nielsen & Rudberg, 1989; Autio, 2013). This was expected to be the case in this research as well and in the measurement of 1993 the result of 11-year-old girls was 2,88 and 13-year-old girls 2,90. However, in years 2012 and 2022 the result was better among 11-year-old girls (3,37/3,41), as 13-year-old girls had 3,14/3,21. Among younger and older boys' similar difference was not noticed.

Table 1. Average values and standard deviation in 1993, 2012, and 2022 in the measurement of affective area

Group	1993		2012		2022		1993-2022
	M	***SD***	***M***	***SD***	**M**	**SD**	***p*-value**
11-year-old girls	2,88	0,75	3,37	0,56	3,41	0,55	p<0.001***
11-year-old boys	3,59	0,69	3,78	0,48	3,60	0,54	p = 0.49
13-year-old girls	2,90	0,46	3,14	0,52	3,21	0,52	p< 0.001***
13-year-old boys	3,51	0,69	3,72	0,56	3,51	0,55	p = 0.46

Although the difference between boys and girls in the affective area was smaller in 2022 than 1993, statistically very significant difference (p<0.001) was found. The difference between boys' and girls' attitudes was not surprising because similar results have been reported already 30 years ago in several studies (Allsop 1986; Autio, 1997; Autio & Soobik, 2013; de Klerk Wolters, 1989; Grant & Harding, 1987; Johnson & Murphy, 1986; Streumer, 1988). Nowadays, the difference between boys and girls has been accepted and more attention has been paid to the underrepresentation of girls and women in science, technology, engineering, and mathematics (Burke & Mattis, 2007; Ceci et al., 2009; Ceci & Williams, 2011; Cheryan et al., 2017; Stoet & Geary, 2018). The difference in research groups between the years 1993, 2012 and 2022 in the measurement of affective area is presented in *Figure 5.*

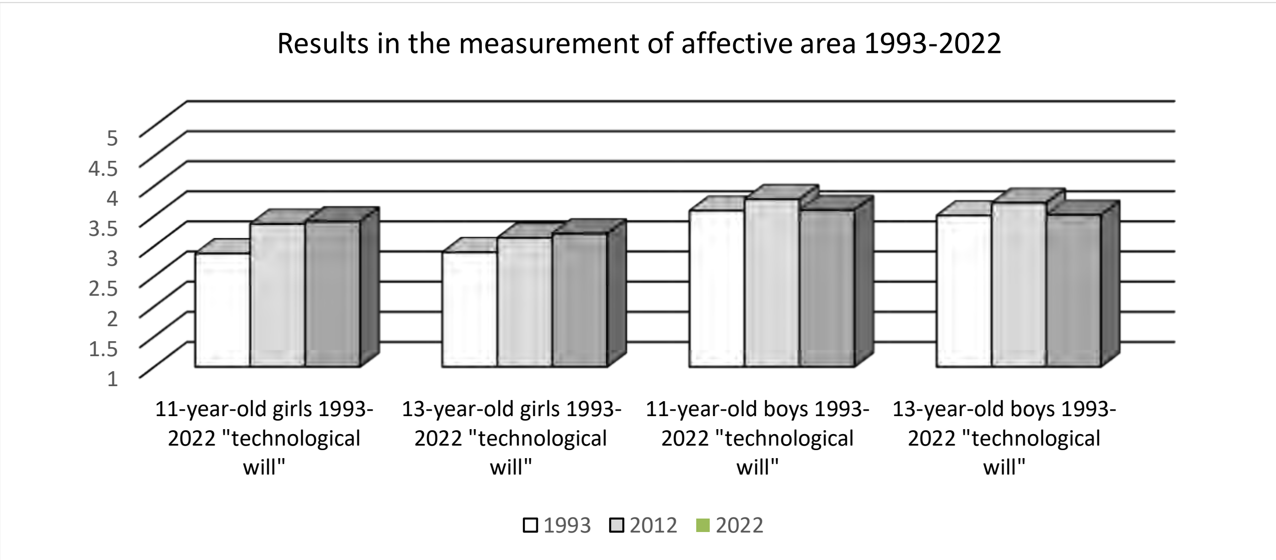


Figure 5. Difference in research groups between the years 1993, 2012 and 2022 in the measurement of affective area

The highest correlation (0.76, p<0.001***) to the average of all other statements was found in statement 1: I am interested in technology and the phenomena related to it. In the factor analysis, this statement explained 57.7 % of the total variance. Very significant statistical difference was found in 11-year-old girls test group as the result was 2,53 in year 1993, 3,43 in year 2012 and 3,64 in 2022. Unfortunately, in 13-year-old girls test group the development was diminished, as the result was 3,00 in year 1993, 2,97 in year 2012 and 2,95 in 2022. Among 11 and 13-year-old boys just small changes was found between years 1993-2022, as 11-year-old boys had 4,01 in year 1993, 4,34 in year 2012 and 4,16 in 2022. In 13-year-old boys test group the small development was diminished, as the result was 3,95 in year 1993, 4,07 in year 2012 and 3,88 in 2022. The average values for statement 1: I am interested in technology and the phenomena related to it are presented in *Figure 6.*

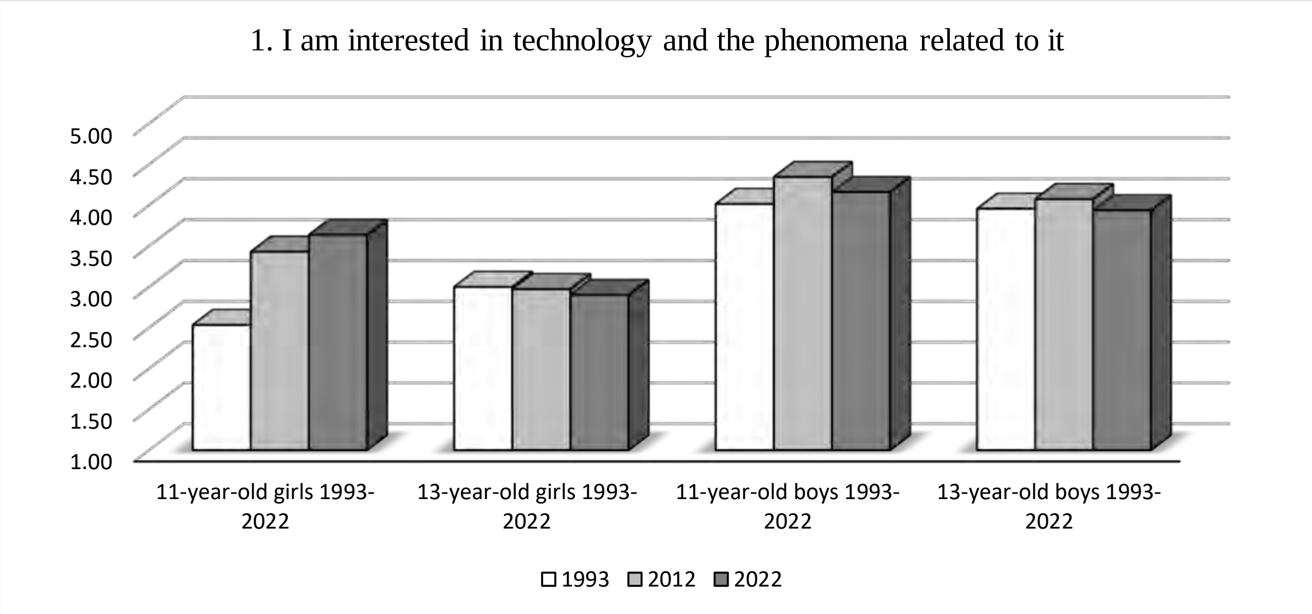


Figure 6. Difference in research groups between the years 1993, 2012 and 2022 in the statement: I am interested in technology and the phenomena related to it

Psychomotor area

In the psychomotor area a statistically significant difference was found among all test groups between years 1993-2022. Among 13-year-old boys the result dropped down from 4,52 in the year 1993 to 4,02 in 2012 and finally 3,25 in the measurement of 2022. The result was quite similar among 13-year-old girls. In the year 1993 the result was 4.50, 4,06 in the year 2012 and 3,17 in 2022. The results followed the same pattern among 11-year-old boys. In the year 1993 the result was 3,41, 3,12 in 2012, and 2,16 in 2022. Among 11-year-old girls' test groups similar decline was found between years 1993-2012 as the result was 2,84 in the year 1993 and 2,36 in 2012. Instead, a small positive change was found between years 2012-2022 as the result was 2,40 in the year 2022. Standard deviation was quite stable in all test groups. However, it was a bit lower in the 2012 and 2022 measurements. Average values and standard deviation in 1993, 2012, and 2022 among boys and girls test groups in the measurement of psychomotor area are presented in *Table* 2.

Table 2. Average values and standard deviation in 1993, 2012, and 2022 in the measurement of psychomotor area

Group	1993		2012		2022		
	M	*SD*	*M*	*SD*	M	SD	*p*-value
11-year-old girls	2,84	1,87	2,36	1,56	2,40	1,48	$p = 0.09$**
11-year-old boys	3,41	1,86	3,12	1,68	2,16	1,63	$p < 0.001$***
13-year-old girls	4,50	2,11	4,06	1,91	3,17	2,01	$p < 0.001$***
13-year-old boys	4,52	1,96	4,02	1,93	3,25	1,69	$p<0.001$***

It was quite obvious that there was a difference between younger (11-year-old) and older (13-year-old) students. This is most probably due to normal maturation and transfer from hobbies. In practice there was no difference between boys and girls in the psychomotor area. It seems that both textile – and technical craft place equal emphasis on psychomotor skills. However, the difference between 11-year-old boys and girls in the measurement of 2022 needs to be researched further, because it is possible that the lower level of technological reasoning among girls' test group may have had an impact on the performance in psychomotor test during years 1993-2012. Maybe, the direction changed between years 2012-2022 due to boys decline in technological reasoning. It is obvious that in every psychomotor action some elements of cognitive area are needed. In this case 3-dimensional perceptive skills may be the distinctive factor. Difference in research groups between the years 1993, 2012 and 2022 in the measurement of psychomotor area is presented in *Figure 7.*

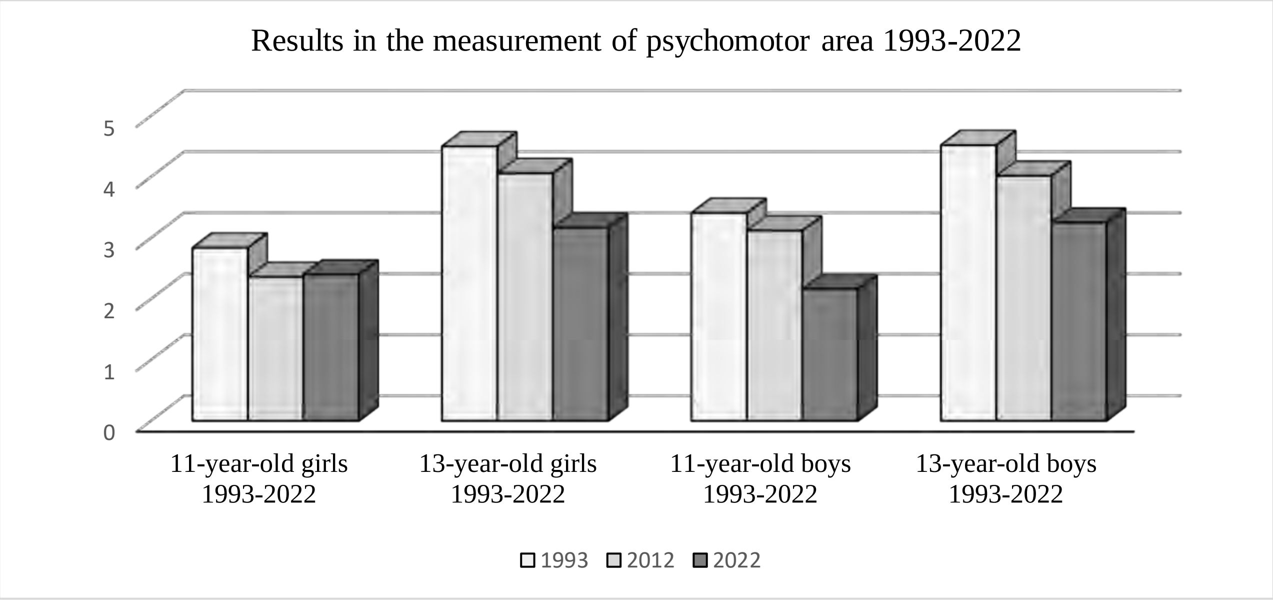


Figure 7. Difference in research groups between the years 1993, 2012 and 2022 in the measurement of psychomotor area

Cognitive area

In the cognitive area a statistically very significant (p<0.001) difference was found between years 1993-2022 among all test groups, except 11-year-old girls. The average number of correct answers to 28 questions among 13-year-old boys dropped down from 18.5 in the year 1993 to 16.5 in 2012 and finally 14,4 in the measurement of 2022. The difference was quite similar among 11-year-old boys. In the year 1993 the number of correct answers was 15.8, 14.9 in 2012, and 12,8 in 2022. Among 11-year-old girls' test groups in practice no difference was found as the result was 12.9 in the year 1993, 12.6 in 2012 and 12,5 in 2022. Similarly, no difference was found among the older girls between years 1993-2012 as the result was 15.3 in the year 1993 and 15.2 in 2012. However, noticeable decline was found between years 2012-2022 as the result was only 13,5 in the year 2022. Standard deviation was a bit lower among younger girls in 1993 (2,87) than in 2022 (3,59). Among older girls the figure was in 3,9 in 1993 and 3,08 in 2022. Among boys' test groups standard deviation was quite stable during years 1993-2022. Average values and standard deviation in 1993, 2012, and 2022 among boys and girls test groups in the measurement of cognitive area are presented in *Table* 3.

Table 3. Average values and standard deviation in 1993, 2012, and 2022 in the measurement of cognitive area

Group	1993		2012		2022		1993-2022
	M	*SD*	*M*	*SD*	M	SD	*p*-value
11-year-old girls	12,9	2,87	12,6	3,47	12,5	3,59	*p* = 0.24
11-year-old boys	15,8	4,59	14,9	3,96	12,8	3,8	*p*<0.001***
13-year-old girls	15,3	3,9	15,2	4,14	13,5	3,08	*p*<0.001***
13-year-old boys	18,5	3,56	16,5	3,83	14,4	3,81	*p*<0.001***

As expected, it was quite obvious that there was a difference between younger (11-year-old) and older (13-year-old) students. This is most probably due to normal maturation caused by the number of lessons in two years concerning technology education. Transfer from hobbies and the use of technology related textbooks in other subjects is assumed to be another reason.

It is not a surprise that boys and girls differ in their interests and hobbies. This maybe the reason for the male advantage in mental rotation performance that represents one of the most robust gender differences in adult cognition. The developmental trajectory of this male advantage remains a topic of considerable debate (Lauer et al., 2019). In any case, statistically significant differences (p<0.001) between boys and girls were found. This difference in technological knowledge, especially in spatial reasoning corroborates with several other research (Autio, 1997; Autio & Soobik, 2013; Johnsson & Murphy, 1986; Lauer et al., 2019; Linn & Petersen, 1985; Streumer, 1988; Tzuriel & Egozi, 2010; Voyer et al., 1995; Yang, & Chen, 2010). However, we must consider 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, as well as play with construction toys such as Legos (Sorby &

Baartmans, 2000; Tzuriel & Egozi, 2010; Yang, & Chen, 2010). Difference in research groups between the years 1993, 2012 and 2022 in the measurement of cognitive area is presented in *Figure 8.*

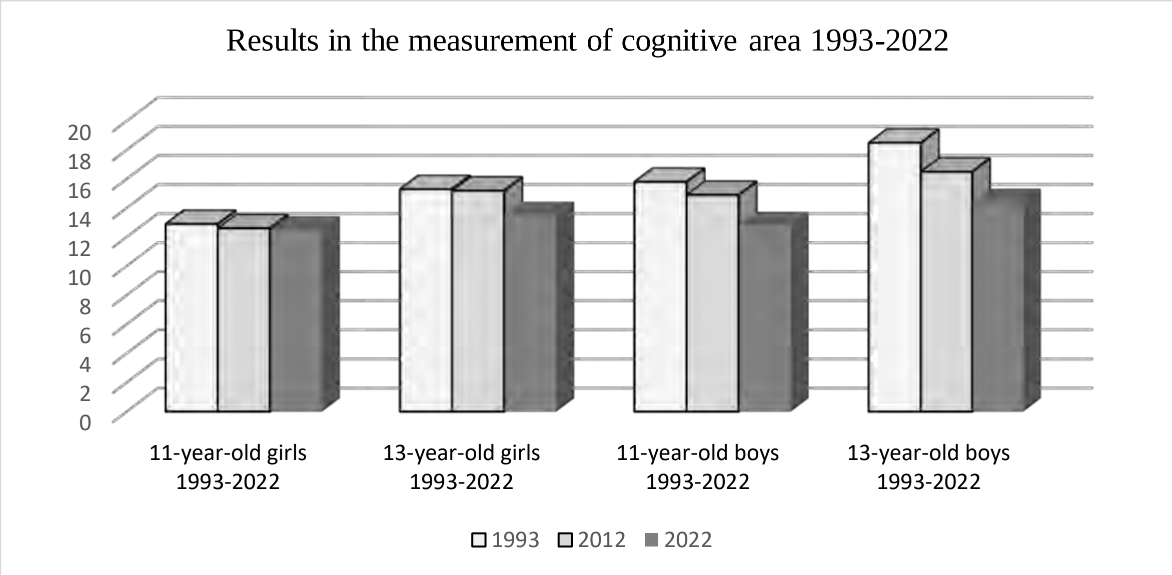


Figure 8. Difference in research groups between the years 1993, 2012 and 2022 in the measurement of cognitive area

Discussion

The critical side from the conception stage of this study was: how is technological 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? Moreover, to achieve a relevant comparison, the measurements were made with exactly the same test instruments in 1993, 2012 and in 2022. Because the test instruments should be the same during all measurements, they could not be updated during the last 30 years. Hence, it is possible that in the test of technological knowledge and reasoning some of the questions may have been old-fashioned for students in the year 2022. In addition, we must consider that the whole technological landscape has changed over time and today includes technology that did not exist 30 years *ago.* In the future, the questionnaire needs to be improved and the content needs to be updated with modern contents. In addition, some criticism could be raised because the selection of the schools was made already in 1993 and the sample was discretionary rather than incidental. However, the difference between schools in Finland is very small, as reported in the 2012 PISA results (Kupari et al., 2013).

The most alarming result in this research was that students did not perform in the measurement of technical knowledge and reasoning (cognitive area) as well as expected. Among 13-year old boys the average number of correct answers to 28 questions dropped down from 18.5 to 14.4 during years 1993-2022. The difference was quite similar among 11-year-old boys. In the year 1993 the number of correct answers was 15.8 and 12.8 in 2022. Among younger girls' test group in practice no difference was found, as 11-year-old girls scored 12.9 in the year 1993 and 12.5 in 2022. However, statistically very significant difference was found among the older girls, as they had 15.3 correct answers in the year 1993 and 13.5 in 2022.

Another fact was that results in psychomotor area among 13-year-old boys dropped down from 4,52 in the year 1993 to 3,25 in the measurement of 2022. The results followed the same pattern among 11-year-old boys. In the year 1993 the result was 3,41, and only 2,16 in 2022. The result was quite similar among 13-year-old girls. In the year 1993 the result was 4.50, and 3,17 in 2022. Among 11-year-old girls' test groups similar decline was found between years 1993-2012 as the result was 2,84 in the year 1993 and 2,36 in 2012. Instead, a small positive change was found between years 2012-2022 as the result was 2,40 in the year 2022.

Reasons for the decline could be in the reduction of technology education lessons available especially for boys. Instead, girls have more technology related lessons than they had 30 years ago. Unfortunately, this is not directly seen in this research. Maybe because, in combined craft education (as much textile and technical craft) learning is focused on production skills and lessons are mainly based on reproducing artefacts without a connection with technological knowledge and reasoning. Other researchers state that the real problem for boys' underachievement is the radical shift in teaching methods and in the content of the school curriculum that progressive education has wrought. It is assumed that progressive teaching and assessment favour girls and traditional methods are more congenial to boys (Attarian, 2000; Ward, 2000).

The most promising result was that girls' attitudes towards technology were definitely more positive in 2022 than in 1993. The average response in our Likert-style (1–5) questionnaire to all 14 items among 11-year-old girls was 2.88 in 1993 and 3.41 in 2022. Among 13-year-old girls' direction was the same, as the result was 2,90 in 1993 and 3,21 in 2022. However, the development between years 2012 and 2022 was much smaller. Although the development in boys test groups remained quite stable during years 1993-2022, it can be concluded that the positive development was because of changes in the technological environment in general. There are plenty of different technological solutions (e.g., mobile phones, games consoles, tablets, interestingly themed construction kits) available for all children nowadays that did not exist 30 years ago. This will be a challenge for the curriculum development in the future. 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 studies (Eccles, 2009; Mitts, 2008; Weber & Custer, 2005; Wender, 2004).

According to several international studies measuring proficiency in natural sciences and mathematics, Finnish girls have been outperforming boys both in mathematics and natural sciences since 2015 (Leino et al., 2018; Stoet & Geary, 2018). On the other hand, Finnish girls are still far less interested in engineering and technology than boys. Current intervention efforts and projects in Finland assume that enhancing girls' interest in natural sciences and mathematics will also lead to an increasing interest in technology and engineering. However, these efforts have not had a significant impact on the underrepresentation of women in engineering/technology. Paradoxically, countries with high levels of gender equality have some of the largest STEM gaps in secondary and tertiary education. For example, Finland excels in gender equality (World Economic Forum, 2015).

Therefore, instead of to encouraging more girls to study science and technology it is also necessary to help girls to better understand what engineering and development of technology are about. However, this is not primarily a question of giving young people information but rather a question of creating a wider disciplinary self-understanding. This requires a cultural change and critical contemplation of values as suggested by Ulriksen et al. (2010). Engineering has several subdisciplines that attract women more than others. Design and human technology are central aspects in any field of engineering. Thus, these areas should be considered consistently throughout the field instead of using them to create "female-friendly" subdisciplines, which easily become devalued as softer or "imaginary" engineering (Naukkarinen & Bairoh, 2020)

Nevertheless, from an intra-individual perspective, boys and girls have different patterns in how they prioritize math and science in relation to other subjects, which indeed exhibit the power of person-cantered approaches. Even if boys and girls have started to place similar values on math and science, the two gender groups still vary in how they rank math and science in relation to other school subjects. Hence, more attention should be paid to girls' Subjective task value (STV) ranking for math and science relative to their ranking of other subjects, if the problem of the gender imbalance in the physical science fields is to be remedied (Klein et al., 2007).

During last thirty years there has been an active discussion about the role of technology education in Finnish compulsory education. However, the optimal solution on 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 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, contents and the relationship between craft and technology are not clear for all parties.

Conclusions

The Finnish curriculum has put large emphasis on gender equity since 1970. Hence, it is confusing that the development in attitudes towards technology proceeds with great difficulty. Finnish girls seemed to be aware of the gender equity and they highly agree that both boys and girls may understand engineering-related phenomena. However, only a few girls are willing to challenge stereotypes about non-traditional careers for women (Autio, Soobik, Thorsteinsson & Olafsson, 2015). It can be concluded that an ideal solution in Finnish technology education has not been found. NBE (2014) states that even the name for the subject is changed to Handicraft, which means that there is a minor emphasis on technology. Instead, the development of students' personalities, the growth of self-esteem and gender issues are considered to be more important in the curriculum. Unfortunately, we cannot measure our students' development in these areas with reliable methods. However, in Pisa studies a serious decline has been noticed in several areas. In natural sciences, Finnish result was 563 in 2006 and 531 in 2016 (Leino et. al, 2018)

Several development projects are made to promote interest in technology. According to Mammes (2004) attitudes towards technology can be significantly improved by developing special courses just for girls. "Because technology education has traditionally been such a male-oriented subject, teachers need to be aware of the differing interests of girls and consider ways of making the environment and the subject attractive to them "(Silverman & Pritchard, 1996). Furthermore, some researchers believe that "in school situations where only females are present, the gender-related segment becomes relatively inactive, and interests could develop independently. So, if girls' interests should be turned to technology (against the gender stereotype), gender separate teaching is advisable" (Wender, 2004). In addition, several preconditions are recommended such as support from female role models and an atmosphere that encourages confidence and inclusion of technical problems in everyday situations that have a relationship with people (Häussler & Hoffmann, 1998). For example, teaching math, chemistry, and physics using more biologically based metaphors and a more real-world problem-oriented approach have been shown to increase female students' interest in physics (Klein et al., 2007

As we try to develop technology education in the future, it would be advisable that in the beginning, every student should be given the basic skills required in everyday life situations in both traditional craft and technology education but later on 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 considered 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 more emphasis on mechanics than just soft materials.

During last 30 years, hundreds of different development projects have been made all over the world and in Finland gender equity in technology education has been one main theme since 1970. The results of this research show some positive signs in girls' attitudes towards technology. However, the results in other areas are not as promising and it can be concluded that an ideal solution in Finnish technology education has not been found. The problem of the inequality in the field of technology seems to be far more complicated than we used to think. It is not just technology education that is responsible for solving such a complex problem but society as a whole.

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