Physical Learning Environment and its Suitability to the Objectives of Technology Education

In Estonian educational reform, the National Curriculum for Basic Schools, adopted in 2011, plays an important role and, among other subjects, sets new directions for technology education. The school bears the responsibility for creating a learning environment that is based on modern skills and knowledge and facilitates students' understanding of the world of technology. In Estonian general education schools, the subject of Technology Education is first introduced in Grade 4, when students are 10 to 11 years old. Before that period (in Grades 1–3) the main focus is on Handicraft and producing various objects, whereby Handicraft skills are valued and students learn about Estonian culture and traditions.

For the first time the new curriculum describes the study environment of Technology Education, which is seen as a community of intellectual, social, and physical environment:

> Learning environment is regarded as the ensemble of the intellectual, social, and physical environments where students develop and learn. The learning environment supports the student's development into an independent and active learner, carries the basic values of basic education and the school's mental attitude, and preserves and refines the traditions of the region and the school community. (Põhikooli riiklik õppekava, 2011)

Thus, the learning environment creates prerequisites and conditions for acquiring a subject as well as for the development of the student's personality. Technology Education is established on performing various practical tasks mostly in a material-spatial environment. The material basis of teaching carries an important role, comprising both the aids for teaching (literature, didactic teaching materials, tools etc., technical teaching aids, and their software) as well as the material-spatial conditions where the teaching is carried out (classrooms, workshops, labs, and the equipment). The curriculum for Technology Education establishes the standards of the physical learning environment the school is required to provide. The school predominantly teaches Technology Education in classrooms, which are equipped according to the practical work selected by the school, and the schools provide the materials necessary for teaching Technology Education (Ainevaldkond "Tehnoloogia," 2011). In this article terms *physical learning environment* and *material-technical basis* are used as synonyms.

The curriculum establishes minimal requirements for the physical learning environment of Technology Education. The school is free to upgrade the list of rooms and equipment according to the work plan developed by the teacher,

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which includes both the learning tasks to be carried out during the lessons as well as practical work. In addition to the national curriculum, the regulations "Health-protection requirements for schools" (Tervisekaitsenõuded koolidele, 2012) drawn up by the Ministry of Social Affairs prescribe specific (including technical) requirements for Technology Education.

The requirements and suggestions regarding the physical environment of teaching Technology Education are not always realised in practical teaching. This may be due to a variety of reasons; for example, the lack of financial means for creating a modern physical learning environment, teachers' insufficient knowledge of the objectives of modern Technology Education, the importance of the subject not being sufficiently emphasised in school, etc.

The purpose of the present article is to explain the disagreement between the requirements established in the National Curriculum for Basic Schools for the physical environment of teaching Technology Education and the actual state in the schools today. The article gives an answer to the following questions:

1. To what extent are teachers satisfied with the material-technical basis of Technology Education?
2. What methods and conditions of material-technical basis would guarantee the expected standards for Technology Education?

The objective of the present article is to examine and compare the opinions of teachers in Estonian basic schools on the material-technical basis in light of both the present (since 2011—Technology Education) and the previous (from 2002 to 2011—Craft and Technology Education) curriculum.

Theoretical Background

Changes in the Objectives and Content of the Subject

Over the years the objectives and the content of the subject have changed considerably. The changes are not merely connected with Estonia, but are due to global changes in the development of technology in the world as a whole. Vries (2011) argues that the concept of Technology Education widened; we began to understand that technology has a social embedding, a human dimension, and it has gone through a certain history. Parikka, Rasinen, and Ojala (2011) give their view of contemporary technology education:

> During technology classes understanding of the relation between technology and culture, technology and society, technology and nature and the effects of technology on these should be discussed and understood. This means a conscious, critical and reflective attitude towards technology. Education becomes more meaningful and diverse when an open analysis is conducted about the values and lifestyles - the concept of humanity and the world - that the technological way of life is based on, and where the choices will lead to…. This in turn will challenge the pupils to consider

development trends offered by future technology and to take more responsibility for their own curriculum and work. (p. 136–137)

Teaching Technology Education at school should be planned and organised in a way that would stem from the vision of different possibilities in future life (Parikka 2003). It would be a future-oriented education, the goal of which would be technological readiness, which helps today's students and future adults to make ethically sustainable choices on technological commodities, use these resourcefully, and develop technological solutions that are more practicable and less harmful to the environment (Parikka, 1998).

Technology Education tries to explain the structure and the principles of operation of the human-shaped technological world to students (Parikka & Rasinen, 2009). Alamäki (2000) stresses that it is very important for technological invention that students are able to identify and notice problems that can be solved with the help of technological solutions; in this process, they need to be able to reason if the problem is in the connection with the technological world and what kind of technologies they could use in solving certain problems. Järvinen, Karsikas, & Hintikka (2007) advocate that children's understanding of technology can be achieved by enabling them to work in the same spirit that real technologists do. In addition to the perspective above, children should be given opportunities to act according to the technological processes required to solve the problems they face (Twyford & Järvinen, 2000). As part of general education, engaging pupils in designing and making products of worth in ways that develop creativity, problem-solving skills, and the ability to collaborate is a demanding task (Barlex, 2007).

Engineering and Technology Education provide an outstanding environment for activating these clearing processes in the classroom for several reasons. Learning, engineering, and technology take place in a rich and sophisticated learning environment, consisting of materials, tools, machines, and computers (Barak, 2011). Children need to be given opportunities for creative and innovative action. In addition to tools, materials, and other physical resources, other people's ideas are an additional resource to inform individual learning (Banks, 2009). Ritz and Moye (2011) write that:

> Teachers of Engineering and Technology Education need to provide environments where appropriate content is taught and experiences allow students to apply and test the knowledge gained. After positive experiences with the new knowledge, learners gain ownership of the knowledge and can then use it to solve problems and answer questions. This type of mastery experience is the basis for the design experiences that occur in engineering and Technology Education laboratories – learn it – apply it – master the experience – transfer the knowledge to new situations. (p. 132)

The Importance of Practical Activities in Technology Education

In Technology Education, learning is mostly achieved through different practical tasks. Rasinen (2011) stresses that Technology Education should be studied, whenever possible, through practical, hands-on activities. To make this happen, learning should take place in a modern learning environment, in which modern learning methods are applied, with teachers who interpret handicraft education in a modern and future-oriented manner (Rasinen, 2011). All students need a basic understanding of how physical materials and processes are produced and applied, and many learn best when they are given frequent opportunities to make the abstract concrete (Hill, 2006). Learning through experimentation and practice is important for motivating students' will to learn and developing students' problem-solving abilities. Effective teaching materials have to help the student to identify these problems, get the new resources needed in order to progress, and integrate them into a new problem-solving strategy (Ginestie, 2009). Technological Education should enable pupils to develop their technological ability through opportunities to take part in activities of an extended nature, which take advantage of knowledge, understanding, and skills from many areas of the curriculum (Layton, 1993).

Regarding the practical activity of Technology Education, Parikka et al. (2011) say that

> In Technology Education on one hand machines and equipment (equipment technology) and on the other hand use of tools (manufacturing technology) are studied. Knowledge of the quality of production materials connects these technologies to knowledge of technology. This definition is related to both material and mental aspects. (p. 135)

The importance of the physical environment in Technology Education and its purpose is vividly expressed by Parikka (1998), who notes that in the school learning environments, it is essential that the classrooms expressively present and introduce different everyday technical structures, as it is the understanding of their operation, in particular, that arouses students' interest and inspires various mathematical, scientific, and technological interpretations. Parikka (2003) observes that such practical everyday problems that the students themselves consider relevant provide the most attractive grounds for natural scientific interpretations as well as for joint projects in the field.

In the analysis of a study of five countries in the European Union (Austria, Estonia, Finland, France, and Germany) that concentrated on describing Technology Education for 6 to 12-year-old school children (primary and junior secondary), Rasinen (2011) points out that Technology Education requires better facilities for studying technology—laboratories, workshops, tools and equipment, computers, and various other materials. Writing about the importance of learning environment, Parikka and Rasinen (2009) point out that

> learning environment is the main factor of physical requirements for teaching technology and in many ways it also works as a "quiet" objective

in behalf of the students. The expediency and spaciousness, salubrity (ventilation, light and heating), equipments (machines, devices, and tools) make up the principal part of the learning environment. Additionally, providing students with materials and tools, computers and computer software and textbooks is dependent on the economic situation of the school. (p. 35)

Baldwin and Barlex (2007) write that in order to successively teach technology and design, an important condition is that the teacher needs to facilitate pupil capability by organising and maintaining an appropriate environment; this means that pupils will have open access to materials, components, tools, and equipment. An authentic learning environment allows students to construct knowledge using real-world contexts and examples (Lee, 2011). Baldwin and Barlex (2007) stress the need of Technology Education for various resources; it is important to have access to a significant consumable expenditure budget and to provide pupils with the materials and components they need to model and make their design ideas.

Alamäki (1999) brings out in his study that in Finland, the respondents indicated that the three most significant obstacles, in order, were: lack of financial resources, insufficient material on how to teach technology education, and lack of other accompanying resources. The learning environment must become more modern and new technologies need to be utilized so that this innovative and future-oriented subject could give students the readiness to follow safety aspects and adopt important safety attitudes (Inki, Lindfors, & Sohlo, 2012). Work safety plays an important role in Technology Education. Various machines, devices, and materials may, if used incorrectly, be dangerous, which is why the goal of basic schools should be to guarantee a healthy and safe environment that supports learning (Kantola, 1997). In planning classes for Technology Education, newer approaches to learning that lean on humanity and social constructivism should be considered, as these stress self-direction, explaining things independently, team work, creativity, innovative approaches, and holism as well as project work that would flexibly integrate subjects.

Method

Aims of the Research

The present article focuses on Technology Education teachers' opinions on the physical learning environment of Technology Education. The study compares and analyses the changes in the physical learning environment of Technology Education.

Participants and Procedures

Two questionnaire surveys (Study I and Study II) were carried out among teachers of Technology Education in Estonian general education schools. In Study I, which was carried out in 2004, 157 teachers participated (women N =

8). In Study II, which was conducted in 2011, 109 teachers participated (women $N = 6$). The statistical data processing software SPSS 18.0 was used to process the survey data; descriptive statistics and *t*-tests were applied.

Measures

The questionnaire is based on a survey used by Rasinen (2000), which was translated into Estonian with certain modifications added. In the present article, I focus on the comparison and analysis of the *physical learning environment* of Technology Education. The physical learning environment block contains 27 questions, which were assessed on the 6-point scale (0 = *cannot answer, I don't know*; 1 = *does not meet the needs*; 2 = *slightly meets the needs*; 3 = *meets the needs partly*; 4 = *meets the needs more or less*; 5 = *meets the needs adequately*). The value "0" was not taken into account when analysing the results.

First, I elicited a general interpretation of the physical learning environment in schoolwork. I asked the teachers of technical subjects to assess the situation of the material technical basis at schools in light of the National Curriculum for Basic Schools, mainly the effective curriculum for Technology Education. As a whole, the questionnaire covered the following topics:

1. *Workrooms.* Including their size, expediency of the location and the arrangement, sanitary situation, etc.
2. *Supply of tools and materials.* The supply of different materials and tools (electro-technical and electronic tools) as well as personal protective equipment, including availability of ergonomic tools in classrooms, etc.
3. *Computers and computer software.* Computers and computer-run workbenches, Internet connection, computer software for planning and designing objects, etc.
4. *Teaching aids.* Including up-to-date textbooks, online teaching materials, video materials, visual aids, etc.
5. *Technical conditions of workrooms.* The correspondence of classrooms to the technical conditions, including electricity supply, ventilation, including the suction system of wood flakes and dust, etc.
6. *Metal processing machines.* Metal processing devices, including thermo-treatment devices, etc.

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Results

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Table 1 demonstrates the results of the mean of environmental aspects between the years 2004 and 2011. The results revealed that the change toward higher satisfaction was the most apparent in the case of several characteristics. The most significant statistical differences in assessing the physical environment during the two periods were manifested in assessing woodwork machines and resources needed for electro-technical and electronic tools (in both cases $p < 0.001$) as well as resources needed for online teaching materials, computer-run

workbenches, and Internet connection (in each $p < 0.001$). An important difference was also apparent in the availability of technical drawing software and size of rooms and workspace ratio (in both cases $p < 0.001$) as well as in the availability of thermo-treating equipments for metals and in using video materials in introducing different types of work (in both cases $p < 0.005$). A considerable difference can also be seen in size of workrooms and in the electricity supply (in both cases $p < 0.01$). There are a number of statements that have a considerable, yet not very strong, statistical difference ($p < 0.05$): availability of various necessary rooms, the sanitary state of the rooms, ventilation, availability of tools, availability of ergonomic tools, digital devices, and availability of computers.

In the case of the following statements, there were no statistically significant differences during the two periods in question: expediency of the location (question 2, $p = .157$), arrangement of rooms (question 3, $p = .100$), availability of personal protective equipment (question 8, $p = .791$) and different materials (question 9, $p = .257$), availability of metalwork machines (question 13, $p = .319$), availability of up-to-date textbooks (question 16, $p = .089$) and visual aids (question 19, $p = .989$), computer software for planning and designing products (question 25, $p = .082$), and means needed for teaching the topics established in the syllabus (question 27, $p = .430$).

Table 1

Comparison of the Satisfaction Scores of Environmental Aspects Between the Years 2004 (Study I) and 2011 (Study II)

Question	*M* (2004)	*M* (2011)	*t*-test	*p*
1. Size of workrooms (e.g. the wood processing room too small)	3.09	3.54	t(258) = -2.88, *p* < 0.01	
4. Availability of necessary rooms (e.g. painting room and a room for thermo-treating metals)	1.64	1.95	t(253) = -2.22, *p* < 0.05	
5. Sanitary state of classrooms (e.g. the state of walls and floors)	3.37	3.77	t(257) = -2.53, *p* < 0.05	
6. Ventilation (e.g. aspiration system for removing wood dust and wood chips)	2.00	2.45	t(253) = -2.59, *p* < 0.05	
7. Electricity supply (e.g. the availability of an adequate number of sockets)	3.52	3.95	t(291) = -2.91, *p* < 0.01	
10. Supply of tools (e.g. pliers, plane, etc.)	2.93	3.24	t(295) = -2.37, *p* < 0.05	
11. Availability of ergonomic tools (e.g. work benches with adjustable height, etc.)	2.02	2.39	t(253) = -2.48, *p* < 0.05	
12. Wood processing machines (e.g. wood thickness machine etc.)	2.69	3.49	t(257) = -4.91, *p* < 0.001	
14. Equipment for thermo-treating metals, (e.g. welding equipments, forge furnace)	1.39	1.66	t(245) = -2.12, *p* < 0.005	
15. Electro-technical and electronic tools (e.g. soldering iron, etching bath)	2.71	2.20	t(254) = -3.55, *p* < 0.001	
17. Online teaching materials (incl. also CDs)	1.53	2.46	t(241) = -7.53, *p* < 0.001	
18. Video materials (e.g. for treating different types of work)	1.53	1.85	t(243) = -2.70, *p* < 0.005	
20. Digital devices (e.g. digital camera)	1.44	1.74	t(245) = -2.17, *p* < 0.05	
21. Computer-run work benches (e.g. CNC mini milling machines)	1.08	1.72	t(234) = -5.04, *p* < 0.001	
22. Computers	1.66	2.03	t(244) = -2.26, *p* < 0.05	
23. Internet connection	2.33	3.32	t(255) = -4.56, *p* < 0.001	
24. Technical drawing software (e.g. Vertex G4)	1.26	1.82	t(238) = -4.38, *p* < 0.001	
26. Size of rooms and work space ratio (e.g. more than 16 students in one lesson)	2.68	3.28	(257) = -3.58, *p* < 0.001	

Note: N 2004 = 159; N 2011 = 109. All differences between groups are significant *p* < 0.05.

Comparing teachers' assessments on the physical environment of teaching Technology Education during the two different periods, we can conclude that in 2011, teachers' assessments on most of the statements were considerably more positive. The development is especially evident in a more extensive utilisation of

Internet connection and online learning possibilities. Another important improvement compared to the results of 2004 is the utilisation of woodwork machines, computer-run workbenches (e.g. CNC mini milling machines), and computer-based programs for technical drawing. Based on the questionnaire of 2004, the availability of computer-run workbenches met the schools' needs the least in teachers' opinion because, at the time, such devices were available only in a small number of schools. Also, the availability of technical drawing software did not meet the needs; the same tendency can also be seen in case of software for planning and designing products in 2004. At the same time, assessments on two questions from the questionnaire of 2011 have not been increased compared to the questionnaire of 2004. These were questions about electro-technical and electronic tools and supply of personal protective equipment. These last results show that due to nationwide public procurement concerning this equipment in 2004, the schools have not acquired more of this equipment in the interim. There were no differences in assessing such statements that do not expect larger technological innovations, such as the expediency of the location, the arrangement of rooms, and the availability of textbooks and simpler teaching aids.

Discussion and Conclusions

The objective of the present article was to examine and compare the opinions of teachers in Estonian basic schools on the physical learning environment in light of both the present (since 2011—Technology Education) and the previous (from 2002 to 2011—Craft and Technology Education) curriculum. The present study reveals major changes in the conditions of the physical environment of teaching Technology Education in Estonian basic schools.

The data collected in 2011 reveals significant changes in the conditions of the physical environment of teaching Technology Education. We can say that a statistically significant difference was present in 18 statements out of 27 referring to the physical learning environment. Based on the responses in both phases of the study, we may conclude that most Estonian schools have classrooms for teaching craft and technology education where general teaching can be carried out, which have satisfactory sanitary conditions. Although the improvement has not been striking, it is nevertheless noticeable.

Workroom

From the standpoint of workrooms, it is important to have enough space and work places for students to carry out the learning process. In recent years, many Technology Education workrooms have been renovated and modernized in Estonia. The problem is that in workrooms in older schools, it is not possible to gain more space for Technology Education. It is very important for schools to have workrooms corresponding to the norms that are equipped with the

necessary tools and materials (Baldawin & Barlex, 2007; Rasinen, 2011; Parikka & Rasinen, 2009).

Supply of Tools and Materials

Supply of tools and materials varies significantly from school to school. There are schools managing well in the field, and there are those that are considerably lacking. It depends greatly on the financing of the school, and many schools and teachers awaited an increase in material resources. Alamäki (1999) points out the same tendency in his study.

Computers and Computer Software

The most notable changes were seen in the possibilities of using computers and computer software, which is connected with technical drawing software, computer-run work benches, and software for planning and designing products; an equally important improvement was witnessed in using the possibilities offered by the Internet. Although the number of computers in school has increased, it does yet not meet the needs of Technology Education. With the aim of applying information technology in schoolwork, the Tiger Leap Foundation, which helps schools to acquire computer-run workbenches (CNC milling machines) and various computer software (including computer software for technical drawings—e.g., Solid Edge), was founded. For that purpose, the school and the teacher must show initiative and take part in projects, training, and student competitions. The availability of newer study materials (including information technology) in school has considerably improved over the years. Parikka (1998) has stressed the need for introducing different everyday technical structures in Technology Education.

Teaching Aids

The results carried out in two different school years vividly point out that many schools still lack up-to-date teaching aids needed in modern teaching, i.e. video materials and online teaching materials, visual aids, digital devices, and up-to-date textbooks. Over the years we have witnessed considerable improvement in the availability of teaching aids in schools, but nevertheless it is not enough. This is a weak spot in activities supporting the curriculum, namely, there is a lack of teaching aids for Technology Education. Yet, the good news is that the publication *Technology and Creativity* (Soobik, 2011) was issued.

Workrooms and Technical Conditions of Workrooms

Schools maintained by a capable local government generally have better technical conditions in the workrooms used in technology education. Although sanitary repairs are gradually carried out in technology education classes in schools, the need for more frequent repairs is significant. Parikka and Rasinen (2009) point out that the technical conditions of workrooms are an essential

aspect of the physical learning environment. Many schools in Estonia do not have adequate ventilation, and the aspiration system for removing wood dust and wood chips can only be found in a small number of schools.

Metal Processing Machines

In recent years there has been a little improvement in using equipment for thermo-treating metals in Technology Education (welding equipment, forage furnace), although in teachers' assessments this aspect has rather been modest. It is possible that teachers lack the necessary means and conditions, or that in their opinion teaching metal processing is not necessary.

The study shows that during the observed period, the physical learning environment of Technology Education has slightly improved in Estonia; a steady progress towards improvement can be seen. Modern study aids are increasingly used in schools, including computer-run workbenches and corresponding programs, etc. However, modernising and developing the physical environment of Technology Education should be an ongoing objective, and means should be found to improve the physical environment of Technology Education in order to teach students using modern technology.

In brief, the following steps can be pointed out to further develop the physical environment of Technology Education:

1. Training courses need to be organised for Technology Education teachers, showing them how to use up-to-date teaching methods and tools in the classroom and how to relate the teaching with actual technological needs, thus making teaching more effective and productive.
2. Teaching materials on Technology Education should be published, and the experience of the specialists in the field on teaching and shaping a better physical environment should be brought out.
3. In planning the learning environment, it should be guaranteed that in addition to rooms and equipment for teaching Technology Education, there would also be possibilities for planning, research, and experimenting, including using a computer and pertinent computer software.
4. Various means, including tools and devices and materials necessary for teaching, should be requested from the financiers of the school.
5. Besides handling tools and processing materials, students should also have knowledge on work safety. The teacher and the school must create a learning environment that enables students to work safely.

The physical environment of Technology Education is equally as important as the content of the subject and the study results, teaching methods, and a professional teacher. Together, these elements form an integrated whole in teaching. Thus, on-going research on the physical environment is vital.

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