Report on Case Studies of Overseas Information Technology Usage

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National Institute for Educational Policy Research

Ministry of Education, Culture, Sports, Science and Technology

Introduction

This case study report investigates and summarizes the institutional aspects and lesson usage of Information and Communication Technology (ICT) in education in some Scandinavian countries, based on the results of the OECD Programme for International Student Assessment Survey (PISA 2015 Survey), as part of measures to improve reading comprehension.

Looking at the reading comprehension scores from the 2015 survey, the progress of Scandinavian countries such as Denmark, Norway, and Estonia, etc. was conspicuous (Fig. 1). One of the features of the 2015 survey was the fact that it marked a complete transition from the conventional written form of survey to a computer-based survey.

Looking at the results of the ICT survey conducted at the same time, Denmark, Estonia, and Finland had ICT utilization rates for school learning and ICT utilization rates for school study outside of school that were higher than those of Japan (Fig. 2), and Denmark in particular had the highest utilization rate of PISA 2009 participating countries in the Digital Reading Comprehension Survey for computer utilization situations in Danish language lessons[1] (Fig. 3).

Fig. 1 Comparison of Reading Comprehension Rankings over Time from the PISA Survey (2012, 2015)

Country	PISA 2012 Survey Results → PISA 2015 Survey Results (Reading Comprehension)
Denmark	25th (496 points) → 18th (500 points)
Estonia	11th (516 points) → 6th (519 points)
Finland	6th (524 points) → 4th (526 points)
Norway	22nd (504 points) → 9th (513 points)

Source: National Institute for Educational Policy Research “Knowledge and Skills for Life 6 – OECD Programme for International Student Assessment Survey (PISA) – 2015 International Survey Reults Report”, 2016

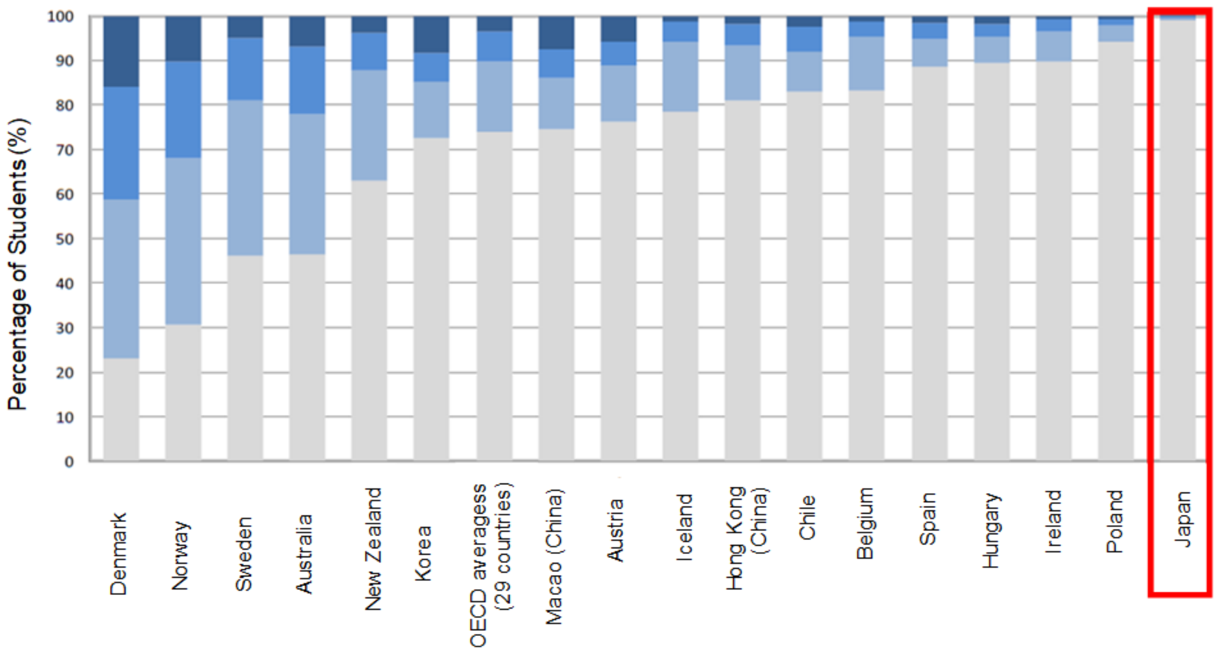
1 Estonia did not participate in the PISA 2009 Digital Reading Comprehension Survey.

Fig. 2　ICT Utilization situation in Each Country from the PISA Survey (2015)

Country	How lomg do you use the internet at school on school days? (Responded “Use it at least 1 minute per day”)	Look at the internet for school studies. (Responded “Look 1-2 times or more a week”)	Use a computer to do homework. (Responded “Use 1-2 times or more a week”)
Denmark	91.66%	89.18%	90.02%
Estonia	85.47%	45.43%	53.36%
Finland	90.28%	51.47%	23.34%
Norway	(Did not participate in ICT Utilization Survey)		
Japan	49.18%	15.58%	8.90%

Source: Created by the National Institute for Educational Policy Research based on the OECD PISA 2015 Database

Fig. 3　State of Computer Use in National Language Classes (PISA Digital Reading Comprehension Survey Participant Countries[2])



Notes:
1. The percentages of students that have used a computer even a little in Japanese class are arranged in descending order fro the left.
2. Of countries that participated in the digital reading comprehension test, results are not available for France and Columbiaso they were excluded from this table.
3. The OECD average is the average of the 29 OECD member countries, excluding France, UK,USA, Luxembourg and Mexico.

Source: National Institute for Educational Policy Research “OECD Student Learning Achievement Survey - PISA 2009 Digital Reading Comprehension Survey– Summary of International Results -”, 2011

It can be inferred that, in addition to use in daily lessons at school, ICT equipment is

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[2] Participants in the Digital Reading Comprehension Survey: Iceland, Ireland, Denmark, Norway, Sweden, Austria, Hungary, Belgium, France, Spain, Poland, Australia, New Zealand, Chile, Columbia, Hong Kong, Macau, South Korea, Japan.

also used in learning outside of school, such as for homework, etc.

Given these circumstances, a study was made on ICT utilization in education in Scandinavian countries in an attempt to find helpful information to promote ICT utilization in schools in Japan.

The basic structure of this case report is as follows. Chapter 1 summarizes the literature on the utilization of ICT in education in the four Scandinavian countries of Denmark, Estonia, Finland, and Norway. Chapters 2 and 3 summarize the study visits to Denmark in 2017 and Estonia and Norway in 2018 from among the countries discussed in Chapter 1. Finally, Chapter 4 summarizes the literature from previous studies in other countries about the results of ICT utilization.

Lastly, we would like to thank everyone in Japan as well as in Denmark, Estonia, and Norway who cooperated in the survey despite their busy schedules in the process of compiling this case report.

Contents

Chapter 1　Status of ICT Use in Education in Each Country

This chapter will examine information from the literature on ICT utilization in the four countries of Denmark, Estonia, Finland, and Norway that showed a significant increase in reading comprehension in the 2015 survey over the previous survey, from the perspectives of curriculum, computer-based testing, the development and management of digital teaching materials and contents, as well as teacher training and in-service training.

1.1. Denmark

1.1.1. Overview of Education System

The Danish school system (See Fig. 1.1) includes primary (Grundskole 1.–6. klasse) for Grades 1 to 6, and lower secondary (Grundskole 7.–9. klasse and Grundskole 10. klasse) for the four years of Grades 7 through 10. Compulsory education begins in the year of turning 6 with a year of preschool education (Børnehaveklasse) (Grade 0), followed by 6 years of primary education and 3 years of lower secondary education (Grades 7–9), for a total of 10 years, and this is carried out in free public schools (Folkeskole) or private autonomous educational institutions.[3] School grades are determined by age for compulsory education stages, with no streams to distribute students by ability, and there are almost no children or students who have to repeat a year.

After compulsory education, students can choose from a variety of upper secondary education programs, including General education (Gymnasiale uddannelser) and Vocational education (Erhvervsuddannelse). Also, after completing Grades 7 through 9 of compulsory lower secondary education, there is an optional Grade 10 (Grundskole 10. klasse) for the purpose of searching career paths and improving performance. About 50% of students completing Grade 9 move on to Folkeskole, Grade 10 at a private independent school, or continuing school (Efterskole)[4] (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016, UNESCO 2018,

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[3] Autonomous educational institutions that comply with public school standards. These can be large Privatskoler in cities or smaller Friskoler in regional areas.
[4] Private residential schools emphasizing social learning with subjects including sports, music, natural environment, ecology, etc.

Undervisningsministeriet (Date of publication unknown)).

1.1.2. Curriculum

In 2003, the “Common Objectives” (Fælles Mål) were introduced with the aim of presenting the objectives of each subject as national goals. The initial Common Objectives set out the main objectives, intermediate objectives, and final objectives of each subject, but this was in the form of recommendations to local governments and did not specify specific contents or teaching materials, with the actual educational activities carried out at schools varying depending on the school.

From 2013 to 2015, the Common Objectives were revised into competence objectives and skill and knowledge objectives, shifting their emphasis from educational contents to learning effectiveness. The new Common Objectives were introduced on an optional basis in August 2014 and were officially implemented in April 2015.

School boards were established in each school, consisting of representatives of the parents, teachers, and children/students, and these school boards would make recommendations on curriculum to the school, based on the Common Objectives. The curriculum then has a binding effect in each school, upon final approval from the Board of Education of the local government. Many municipalities have developed common plans for the schools under their jurisdiction (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016, UNESCO-IBE 2012).

Guidelines for handling ICT in each subject are provided as supplements to the Common Objectives of primary, lower secondary, and upper secondary education. The competencies of children/students are summarized by the four positions of “critical investigator,” “analyzing receiver,” “focused and creative producer,” and “responsible participant,” and they are required to utilize a variety of digital skills throughout the learning process (European Schoolnet 2017a).

1.1.3. Computer-Based Testing

Children/students in primary and lower secondary education are required to participate in national testing (national scholastic ability tests) that are specified for each subject by grade. More specifically, testing is carried out 10 times for the six subjects of Danish (Grades 2, 4, 6, and 8), Mathematics (Grades 3 and 6), English (Grade 7), Geography (Grade 8), Physics and Chemistry (Grade 8), and Biology (Grade 8), with the option of Danish for children/students whose native language is not Danish (Grades 5 and 7). The testing has the following features.

- Tests are IT-based, with each student logging on to a website to take the test.
- Responses are scored automatically, and teachers are able to give scores to children/students the following day.
- The tests are adaptive, with questions changed in real time in response to the answers of individual children/students.

This national testing also aims to function as the following types of tools.

- Education tools for teachers
- Tools for assessing continuous learning by children
- Promotion of the evaluation culture in school
- Strengthen dialog and cooperation between schools and parents
- Measurement and recording of student performance

For upper secondary education, “the Net tests” are implemented, digitizing the testing process. The scoring of descriptive questions from these tests is carried out by people (European Schoolnet 2017a).

1.1.4. Development and Management of Digital Teaching Materials and Contents

Under the e-Government Strategy 2011–2015, with the three purposes of “reducing printed matter,” “new digital welfare,” and “digital solutions for closer cooperation within the public sector,” Denmark increased funding for the development of digital learning materials, funding for the purchase of digital learning materials by local governments, the measurement of digital material effectiveness, and the improvement of school digital infrastructure (European Schoolnet 2017a).

In addition, the Ministry of Education (Undervisningsministeriet)[5] has launched EMU and Materialeplatformen to supply and share Open Educational resources (OER).

EMU[6] is a knowledge and learning portal that offers free resources for school teachers.

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5 Known as the Ministry of Children and Education (Ministeriet for Børn og Undervisning) between 2011 and 2013 under the 1st Thorning-Schmidt Cabinet, and the Ministry of Children, Education and Gender Equality (Ministeriet for Børn, Undervisning og Ligestilling) between 2015 and 2016 under the 2nd L.L. Rasmissen Cabinet. The name was returned to the Ministry of Education as of March 2018.

6 https://www.emu.dk/

Many of these resources are produced by professional organizations in each subject area and have been verified on an evidentiary and quality basis. These open education resources are often not used directly in classes for children or students but rather are used to provide inspiration and guidance. Some, such as video materials, can be used as is in classes.

Materialeplatformen[7] is an online educational repository that has the function of cataloging all learning resources for schools issued by private businesses, museums, etc. It also functions as a site for sharing open education resources created by teachers (European Schoolnet 2017a).

1.1.5. Teacher Training and In-service Training

(1) Teacher Training

To become a teacher in Denmark, it is necessary have completed the equivalent of 240 units under the European Credit Transfer and Accumulation System (ECTS) by receiving a 4-year bachelor’s degree in humanities.

As part of the teacher training program, students select three subjects of specialization, including one subject out of Danish, Mathematics, and English, and two subjects out of German, Music, Biology, Physical Education, English, History, Geography, Physics/Chemistry, Art, Science and Technology, Social Science, Craft Design, and Religion (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al. 2016).

Teacher training for primary and lower secondary education specifies that “students (participating in training) have a knowledge of ICT and media, and utilize ICT and media to support the capacities of children as critical investigators, analyzing receivers, focused and creative producers, and responsible participants, and are able to plan, implement and develop ICT and media for education.” ICT is not specifically covered in teacher training for upper secondary education (European Schoolnet 2017a).

(2) In-service Training

In August 2014, an educational policy measure was implemented to introduce new common objectives that focus on learning effects with the aim of improving the education at the folkeskole. At that time, the following three objectives were advocated, with the aim of maintaining and developing the strengths and academic standards of the folkeskole.

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[7] http://materialeplatform.emu.dk/materialer/

- The folkeskole must work to maximize the potential of all students.
- The folkeskole must reduce the impact of social background on academic performance.
- The folkeskole must enhance trust in schools and the well-being of children, by respecting expertise and best practice.

.The following three areas of improvement were indicated toward the achievement of the three objectives.

- Improved teaching and learning throughout a longer and more diverse school life.
- Enhanced professional development of teachers and other educational staff, and principals.
- Careful selection of objective, clarification, and simplification of rules.

Despite the needs for such school reforms, the reality was that there is no system in place to obligate teachers to undertake professional development, and initiatives need to be put in place to organize opportunities for teachers and principals to undertake professional development.

Various levels of education and various courses are offered in colleges (Professionshøjskole). For example, you can register for a Diploma Program, which is the equivalent of 15 credits under ECTS, with an emphasis on educational instruction and evaluation in a specific subject. You can also obtain a Master's Degree in Education that is the equivalent of 60 credits under ECTS at university level (Universitet) (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016).

In addition to these courses at universities and colleges, other short-term courses are available for professional development in the areas of Folkeskole subjects and learning environments, the roles of teachers, the evaluation of digital learning tools, etc.

Various efforts, such as the following, are being made for public school leaders to utilize ICT.

EMU also has a page for public school leaders, which provides support from Ministry of Education learning consultants, including on the utilization of ICT (European Schoolnet

- The Demonstrations School Projects (2013–15)
- Use and adoption of digital learning platforms and resources (2016–17)
- IT competencies development through capacity building schools and profession schools (2017–18)

2017a).

1.2. Estonia

1.2.1. Overview of Education System

In the Estonian school education system (see Fig. 1.2), primary education is for 6 years, Grades 1 through 6, and lower secondary education is for 3 years, Grades 7 through 9. Primary education is carried out at 6-year primary schools (algkool) or in primary education courses (6 years) at 9-year basic schools (põhikool).

Compulsory education begins from the year turning the age of 7, and basic education (Põhiharidus), which includes primary education and lower secondary education, is considered compulsory.

Upper secondary education consists of general education (Üldkeskharidus) and vocational education (Kutsekeskharidus), with general education consisting of a 3-year course and vocational education of a 3- or 4-year course (UNESCO 2018, Haridus- ja Teadusministeerium (Date of publication unknown)).

1.2.2. Curriculum

A national curriculum has been established in Estonia for both basic school and upper secondary education. The 2014 edition of the national curriculum for basic school has national language, foreign language, mathematics, natural science, society, art, technology, and physical education as required subjects, and religion, information, career education, and entrepreneurial education as electives. The Grades are broken up into Stage 1, consisting of Grades 1 through 3, Stage 2, consisting of Grades 4 through 6, and Stage 3, consisting of Grades 7 through 9, with learning hours and goals set out for each subject in each Stage.

There are 8 cross-subject topics presented: “lifelong learning and career planning,” “the environment and sustainable development,” “citizen initiative and companies,” “cultural identity,” “the information environment,” technology and innovation,” “health and safety,” and “values and morals.”

The core of the national curriculum consists of the 8 key competencies of “culture and value,” “society and citizens,” “self-management,” “learning to learn,” “communication,” “mathematics, natural sciences, and technology,” “entrepreneurship,” and “digital” (Haridus- ja Teadusministeerium (Date of publication unknown)), and one of the features of this core curriculum is the inclusion of ICT and related digital competencies in the key competencies.

Each school formulates a curriculum for each Grade based on the national curriculum, specifying aims and learning plans. In formulating the curriculum at each school, not only teachers and other school staff, but also students, parents, and other interest groups are involved (Haridus- ja Teadusministeerium (Date of publication unknown)).

1.2.3. Computer-based Testing

Primary and secondary school testing in Estonia that utilize ICT include Standard-Determining Tests, Basic School Final Examinations, and State Examinations, all of which have been implemented online (e-testing) since 2014 (Republic of Estonia Ministry of Education and Research, 2018b). Of these, Standard-Determining Tests and Basic School Final Examinations are to be abolished in 2019.

The State Examinations are mandatory final examinations for upper secondary education schools (Republic of Estonia Ministry of Education and Research, 2014), and the exam subjects were changed from fiscal 2019 (European Commission, 2018a). The preparation and coordination of these three tests are carried out by Innove[8] (ibid.).

1.2.4. Development and Management of Digital Teaching Materials and Contents

In Estonia, efforts have been made to support the development of digital learning materials such as requiring textbook publishers to make textbooks available in digital formats, etc. Currently, new programs have been prepared for the purpose of developing digital contents for general and vocational education.

Also, as online repositories contents sharing, there are Koolielu[9] for preschool and general education, and e-ope.ee[10] for vocational and higher education (European Schoolnet 2015a).

1.2.5. Teacher Training and In-service Training

(1) Teacher Training

Teacher training in Estonia is basically carried out through a 5-year Bacehlor’s degree and Master’s degree program. Moreover, the social status and wage levels of teachers in Estonia are not high, and intensive programs to obtain teacher qualifications in 2 months are in place for degree holders to teach in non-specialty subjects to increase the number of teaching candidates. The contents of the teacher training programs include education theory, knowledge of specific subjects, and specialty contents (educational science, psychology, teaching methods, teaching practice (NCEE, 2018)).

8 https://www.innove.ee/en/examinations-and-tests/standard-determining-tests/
9 https://www.koolielu.ee/
10 http://www.e-ope.ee/repositoorium

In terms of ICT, teacher training at Tartu University and Tallinn University includes ICT capabilities as part of their curriculum, integrating modules and subjects (European Schoolnet 2015a).

(2) In-service Training

Teachers are required to complete at least 160 hours of in-service training every 5-year period, with promotion proving difficult if not completed. This training can be self-led or can be taken at national and local government agencies or at private schools that are licensed to provide training.

The Ministry of Education and Research is developing self-diagnostic tools for professional development to allow teachers to use these tools to determine what is necessary for self improvement by evaluating themselves against common standards. One of the aims of the evaluation methods using these tools is also for it to be used in classes as part of school education (NCEE, 2018).

HITSA (Hariduse Infotehnoloogia Sihtasutus[11]), a joint venture non-profit organization of the Estonian government, Tartu University, Tallinn University, etc., provides the following specialized ICT training.

- Preparation of teaching materials using digital resources
- Learning processes in the digital age
- Digital learning environments and resources
- Teacher professional development
- Technical education
- Management of educational facilities in the digital age

[11] “The Information Technology Foundation for Education” in Estonian.

HITSA has also developed the "Educational Leader in a Digital Age" program with the following goals, targeting school leaders.

- Understanding trends in learning processes in the digital age, and overseeing the establishment of modern learning environments in educational institutions
- Understanding how to incorporate appropriate methods of supporting digital devices and resources in the learning environment
- Understanding how to implement required changes within organizations
- Planning practical steps to change learning processes in the digital age
- Systematic development and effective utilization of ICT devices and resources within educational institutions based on the needs of learners
- Understanding the need to develop a vision for the digital age as teams
- Formulating action plans to implement team visions within organizations
- Understanding how to configure digital domains within organizations
- Evaluating the digital infrastructure and development needs based on organizational needs

The purpose of this program is for each educational institution to purposefully lead the digital learning process, and to support them in the creation of visions and action plans for ICT (European Schoolnet 2015a).

1.3. Finland

1.3.1. Overview of Education System

The school education system in Finland (see Fig. 1.3) consists of 6 years of primary education, Grades 1 through 6, and 3 years of lower secondary education, Grades 7 through 9.

Compulsory education begins from the year turning the age of 7, initiating 9 years of free compulsory education that combines 6 years of primary education and 3 years of lower secondary education defined as basic education (Perusopetus), completed by many children at general schools (Peruskoulun).

Upper secondary education consists of general education (Lukiokoulutus) and vocational education (Ammatillinen perustutkinto), both of which are 3-year courses (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016, UNESCO 2018).

1.3.2. Curriculum

The National Board of Education, operating under the Ministry of Education and Culture (Opetus- ja kulttuuriministeriö), formulates the national core curriculum that includes the educational purpose, contents, and subject time allocations for basic education.

Local governments organize local curricula based on the national core curriculum. In recent years, core competencies have been emphasized in education policy, defining achievement standards for major subjects (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016).

ICT is not an independent subject as part of the national core curriculum but is positioned as one of 7 cross-discipline competencies that are included in all subjects, with local governments required to specify targets for ICT skills in all subjects as part of their curriculum.

The development of ICT capabilities as part of the national core curriculum can be classified into the following four areas.

- Development of ICT skills to produce individual output, with an understanding of the main principles/concepts/logic of ICT
- Safe and responsible use of ICT and ergonomically sound work methods
- Utilization of ICT for the management of information and explorative and creative work methods
- ICT usage experience for interaction and networking

In all 4 of these areas, it is important that students learn actively, work creatively, and find their own learning paths and styles. Students learn about various ICT applications and usage purposes, and are instructed on the importance of ICT in daily life and with an awareness of the use of ICT in communication. As part of basic education, students are taught the impact of ICT in a globalized world, and to understand the opportunities and risks of ICT (European Schoolnet 2017b).

1.3.3. Computer-based Testing

Under the Digabi Project of the University Admissions Examination Committee (Ylioppilastutkintolautakunta), computer-based testing has been adopted for university entrance examinations (Ylioppilastutkinto) at upper secondary education level (Ylioppilastutkinto) and has been implemented in stages. Tests were initially carried out for philosophy, geography, and German in the fall of 2016, and the number of target subjects has been increased gradually, with all subjects scheduled to have implemented computer-based testing by spring 2019 (European Schoolnet 2017b).

1.3.4. Development and Management of Digital Teaching Materials and Contents

Digital teaching materials are being developed by commercial publishers. Some major publishers are creating both conventional paper textbooks and digital teaching materials, with some new smaller publishers specializing in digital teaching materials. The share of digital learning materials is gradually expanding, even at compulsory education level, but development has progressed more at upper secondary education level.

Moreover, the online service Finna,[12] which is operated by the National Library (Kansalliskirjasto), functions as a public platform for open education resources and a GIS-based platform for user-created contents.

The Finnish National Agency for Education (Opetushallitus Utbildningsstyrelsen) also operates Linkkiapaja,[13] a portal for sharing learning resources created by teachers. Teachers are also able to share contents that they create on the private commercial digital learning resource trading and distribution channel Edustore[14] (European Schoolnet 2017b).

1.3.5. Teacher Training and In-service Training

(1) Teacher Training

In Finland, universities have teacher training programs for both classroom teachers and subject teachers, with a Master’s degree being the prerequisite for teachers. The outlines of the teacher training programs are defined by the government, with each university having discretion for the specific contents.

In grades 1 through 6 of general school, a classroom teacher system is adopted, and the classroom teacher teaches almost all subjects. Students aiming to become classroom teachers must generally complete the equivalent of a Master’s degree with the equivalent of 300 credits under the ECTS within 5 years.

A subject teacher system is adopted from Grade 7 of general education. Subject teacher training is carried out at undergraduate level with subjects on subject-specific contents, with educational contents provided by the teacher training faculty, etc., carried out in collaboration between various university faculties and departments. Teaching practice is also included in the educational contents, held at university teacher training schools and associated schools. The training period for subject teachers is generally 5 or 6 years (Finnish National Board of Education (2016), TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al. 2016).

Finland is currently working on teacher training reforms, and according to the guidelines provided by the Ministry of Education and Culture, teachers are being asked

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12 https://finna.fi/
13 http://linkkiapaja.edu.fi/oph/search.html
14 http://www.edustore.fi/

to play a role as experts in new educational innovation, one example being digital learning environments (Opetus- ja kulttuuriministeriö 2016).

(2) In-service Training

Under collective agreement, it is an obligatory working condition for teachers to participate in in-service training 3 days each fiscal year. Employers such as local governments are responsible for in-service training and bear the cost.

The National Board of Education is responsible for financial assistance, supervision, promotion, etc. for teacher in-service education related to national educational policy. Every year, each educational institution can apply for financial assistance from the National Board of Education. Various efforts have been made by the Ministry of Education and Culture, including starting a new in-service education program in 2014 targeting 50,000 teachers in two years (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al. 2016).

It is not required for ICT to be included in in-service training, but local governments and universities provide ICT-related training. The National Agency for Education launched a national level tutor teacher program in 2016, with the expectation that tutor teachers will support other teachers in the utilization of ICT at school education sites (European Schoolnet 2017b).

1.4. Norway

1.4.1. Overview of Education System

The school education system in Norway (see Fig. 1.4) consists of 7 years of primary education (Barnetrinnet), Grades 1 through 7, while lower secondary education (Ungdomstrinnet) consists of 3 years, Grades 8 through 10.

Basic education (Grunnskole) consists of 10 years of primary education and lower secondary education, which are considered free compulsory education. Basic schools do not conduct any streaming to divide students by ability under a political agreement for equality in education, and there are virtually no alternative programs.

Upper secondary education level schools (Videregående Skole) consist of 3 years, Grades 11 through 13, and while this period is not compulsory it is recognized as a right and is provided free of charge. There are a variety of elective programs prepared for higher education and vocational training in addition to common basic subjects for all students (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016, UNESCO 2018, Regjeringen.no, (Date of publication unknown)).

1.4.2. Curriculum

The Ministry of Education and Research (Kunnskapsdepartementet) develops the national curriculum (hereinafter "Curriculum") together with expert groups, and this is approved by Congress (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016).

The Curriculum has legally binding force on local governments, schools, and teachers, but schools have certain discretion such as in the setting of learning objectives and annual class hours for each subject based on local circumstances (European Schoolnet 2015b).

The National Curriculum for Knowledge Promotion, a comprehensive curriculum for the entire school system, was introduced in stages from 2006, being fully implemented in 2008. Competencies to be achieved by the end of Grades 2, 4, 7, 10, 11, 12, and 13 are also defined as curriculum objectives (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016).

This curriculum positions the five skills of "oral," "reading," "writing," "numeracy," and "digital" as basic skills across all subjects. Under the framework created as reference for the development and revision of the national curriculum of each subject, digital skills are required to be integrated into the learning activities of all subjects across primary, lower secondary, and upper secondary education, divided into the four subcategories of "searching and processing," "producing," "communicating," and "digital judgement." Various ICT solutions are recommended for use in various subjects, and in many cases learning objectives are set for the digital skills themselves in each subject (European Schoolnet 2015b).

1.4.3. Computer-based Testing

Since 2014, the Norwegian Directorate for Education and Training (Utdanningsdirektoratet – direktoratet for barnehage, grunnopplæring og IKT), a subordinate institution of the Ministry of Education and Research that aims to develop curriculum and national testing, etc., has been making rapid progress in the dissemination of computer-based testing in secondary education. In computer-based testing, evaluators are able to access all responses simultaneously, and the realization of an effective and safe means of evaluation is one of the objectives of its introduction.

Computer-based testing is currently offered as optional for lower and upper secondary education, and tests are conducted in two parts depending on the subject, with Part 1 for subjects that do not require computer tools (apps, etc.) and Part 2 for those that require such tools. For example, Part 2 of lower secondary education mathematics requires the mastery of spreadsheets and formula processing systems, etc. Computer-based testing has also been implemented for national Norwegian, English, and Mathematics tests, which are held in Grades 5 and 8 (European Schoolnet 2015b).

1.4.4. Development and Management of Digital Teaching Materials and Contents

Digital learning resources are developed for subjects such as mathematics, natural science, Norwegian, and foreign languages by the Ministry of Education and research ICT Center (Senter for IKT i utdanningen), operating the portal Iktipraksis.no[15] for the use and sharing of digital contents.

The National Center for Natural Science established at the University of Oslo (Naturfagsenteret) also operates naturfag.no,[16] which provides teaching materials to teachers with a focus on natural science, and sites such as viten.no[17] that provide online learning materials for students.

NDLA (Nasjonal digital læringsarena)[18] also provides digital teaching materials for free for teachers and students at upper secondary education level, and is operated in collaboration with 18 of the 19 counties, excluding Oslo (European Schoolnet 2015b).

Norwegian school education also makes use of various digital contents such as apps, etc. Normally, user IDs and passwords need to be set up for all apps used, and authentication is required each time they are used, but in order to avoid such inconveniences, the Norwegian government has provided the Feide[19] single-sign-in platform. By using Feide, it is possible to acces multiple apps, web services, and cloud services with a single ID and password authentication (Feide, Year of Publication unknown).

1.4.5. Teacher Training and In-service Training

(1) Teacher Training

Basic school teachers are employed by local governments, and upper secondary school teachers are employed by counties. According to the employment regulations in force since 2008, primary education teachers require at least 30 credits under the European Credit Transfer and Accumulation System (ECTS) for either Norwegian, Mathematics, or English, while lower secondary education teachers require 30 to 60 credits in specialty subjects (the number varies depending on the subject) to qualify as

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15 https://iktipraksis.iktsenteret.no/
16 https://www.naturfag.no/
17 https://www.viten.no/nob/
18 https://ndla.no/
19 https://www.feide.no/introducing-feide

teachers. However, once employed as a teacher, teachers can teach subjects for which they have not earned the credits. Upper secondary education teachers require mastery in all subjects in which they teach, with at least 60 credits. In 2010. there was a reform to basic school teacher training, and whereas previously teachers of Grades 1 through 10 in basic schools had been able to obtain a qualification to teach all subjects to all grades upon graduation from college (Høgskolen) teacher training course, the reforms divided these into two courses, to obtain qualifications to teach all subjects to students from Grades 1 through 7 and to obtain qualifications to teach specialized subjects to Grades 5 through 10. Each course is 4 years, including 100 days of practice teaching.

Qualifications to teach specialized subjects for lower and upper secondary education level are obtained at universities (universitet) (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016).

（2）In-service Trainig

According to the survey conducted by NIFU (Nordisk institutt for studier av innovasjon, forskning og utdanning), in 2013, ICT is not emphasized in teacher training. This led to complaints from not only in local governments but also schools, noting the issue of new teacher ICT skills being insufficient for those required at schools (European Schoolnet 2015b).

Professional development for in-service teachers is the responsibility of local and county governments that are the school administrators, and is supported with a lot of government funding.

The revision of relevant laws and regulations in 2014 has significantly impacted the skills of teachers, making it mandatory for primary education teachers to acquire at least 30 credits in subjects that they teach by the end of 2025, and for lower secondary education teachers to master necessary credits for each subject that they teach. Universities and colleges are offering professional development courses to this end (TIMSS & PIRLS INTERNATIONAL STUDY CENTER et al., 2016).

Under the national program for the "Promotion of the status and quality of teachers – a joint effort for a modern school of knowledge" in the fall of 2015, the government invested 1.2 billion Norwegian kroner (about 110 million euros) to make ICT training for educational use available, and about 5,000 teachers participated (European Schoolnet 2015b).

References

・European Commission (2018a) Eurydice: Estonia National Reforms in School Education <https://eacea.ec.europa.eu/national-policies/eurydice/content/national-reforms-school-education-20_en> Last access June 21, 2019

・European Schoolnet (2015a) *Country Report on ICT in Education: Estonia*

・European Schoolnet (2015b) *Country Report on ICT in Education: Norway*

・European Schoolnet (2017a) *Country Report on ICT in Education: Denmark*

・European Schoolnet (2017b) *Country Report on ICT in Education: Finland*

・Feide (Date of publication unknown) Introducing Feide <https://www.feide.no/introducing-feide> Accessed June 25, 2019

・Finnish National Board of Education (2016) *Compulsory education in Finland* <http://www.oph.fi/download/180148_Compulsory_education_in_Finland.pdf> Accessed March 22, 2018

・Haridus- ja Teadusministeerium (Date of publication unknown) *Alus-, põhi- ja keskharidus* <https://www.hm.ee/et/tegevused/alus-pohi-ja-keskharidus> Accessed March 15, 2018

・Innove (Date of publication unknown) *Innove* <http://haridusinfo.innove.ee> Accessed March 15, 2018

・MEXT (2017) *World School Systems (Europe)* (in Japanese) <http://www.mext.go.jp/b_menu/shuppan/sonota/attach/1396864.htm> Accessed February 20, 2019

・NCEE (2018) *Estonia: Teacher and Principal Quality* <http://ncee.org/what-we-do/center-on-international-education-benchmarking/top-performing-countries/estonia-overview/estonia-teacher-and-principal-quality/> Accessed March 15, 2018

・Opetus- ja kulttuuriministeriö (2016) *TEACHER EDUCATION DEVELOPMENT PROGRAMME* <http://minedu.fi/documents/1410845/4183002/Teacher+Education+Development+Programme+2016> Accessed March 16, 2018

・Republic of Estonia Ministry of Education and Research (2014) The first trial of electronic national standardized tests in fifty schools was conducted successfully <https://www.hm.ee/en/news/first-trial-electronic-national-standardized-tests-fifty-schools-was-conducted-successfully> Accessed May 23, 2019

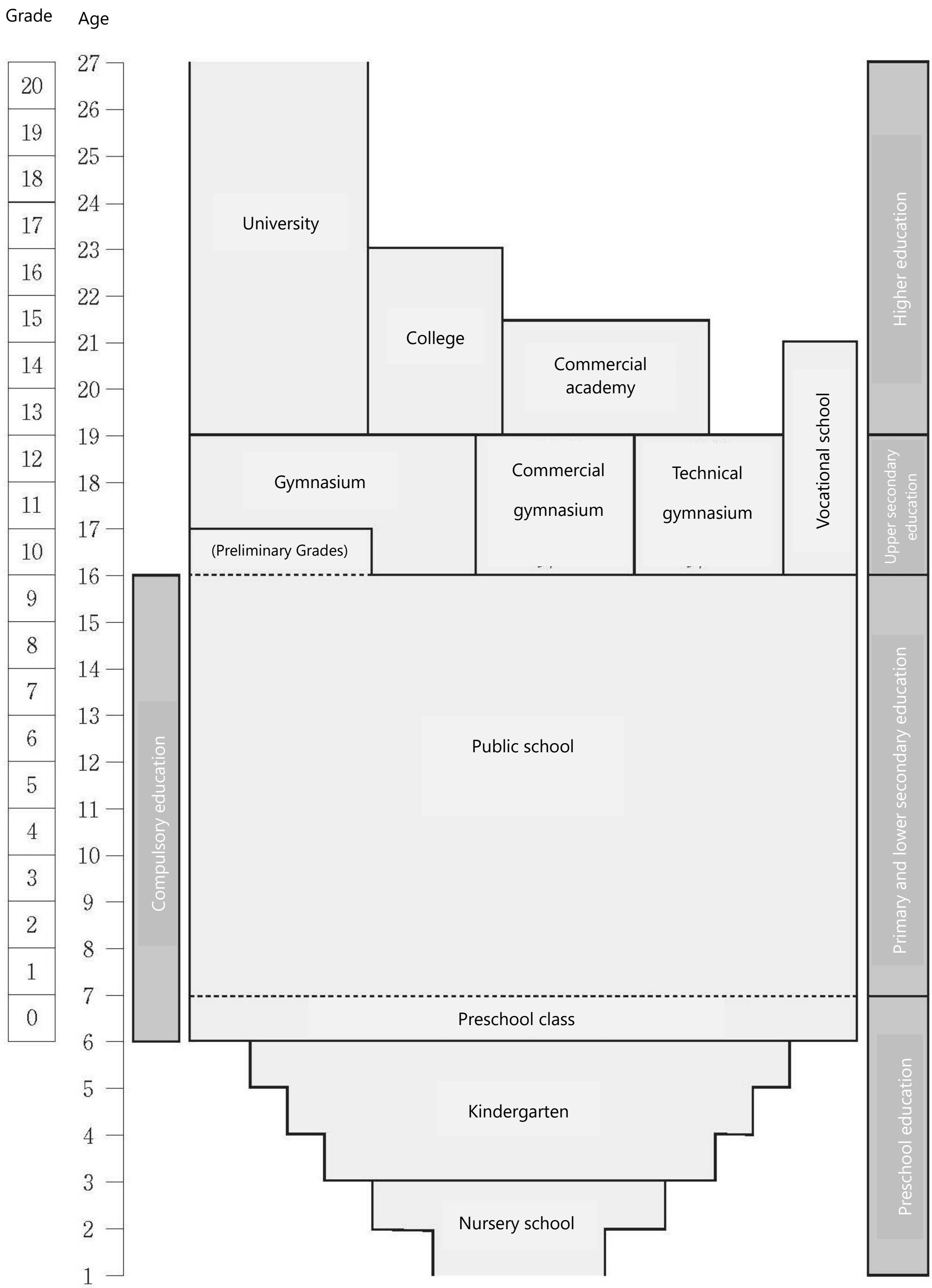
・Republic of Estonia Ministry of Education and Research (2018b) DIGITAL FOCUS <https://is.gd/L26Tj9> Last access June 24, 2019

・Regjeringen.no (Date of publication unknown) *Kunnskapsdepartementet*

<https://www.regjeringen.no/no/dep/kd/id586/> Accessed March 16, 2018

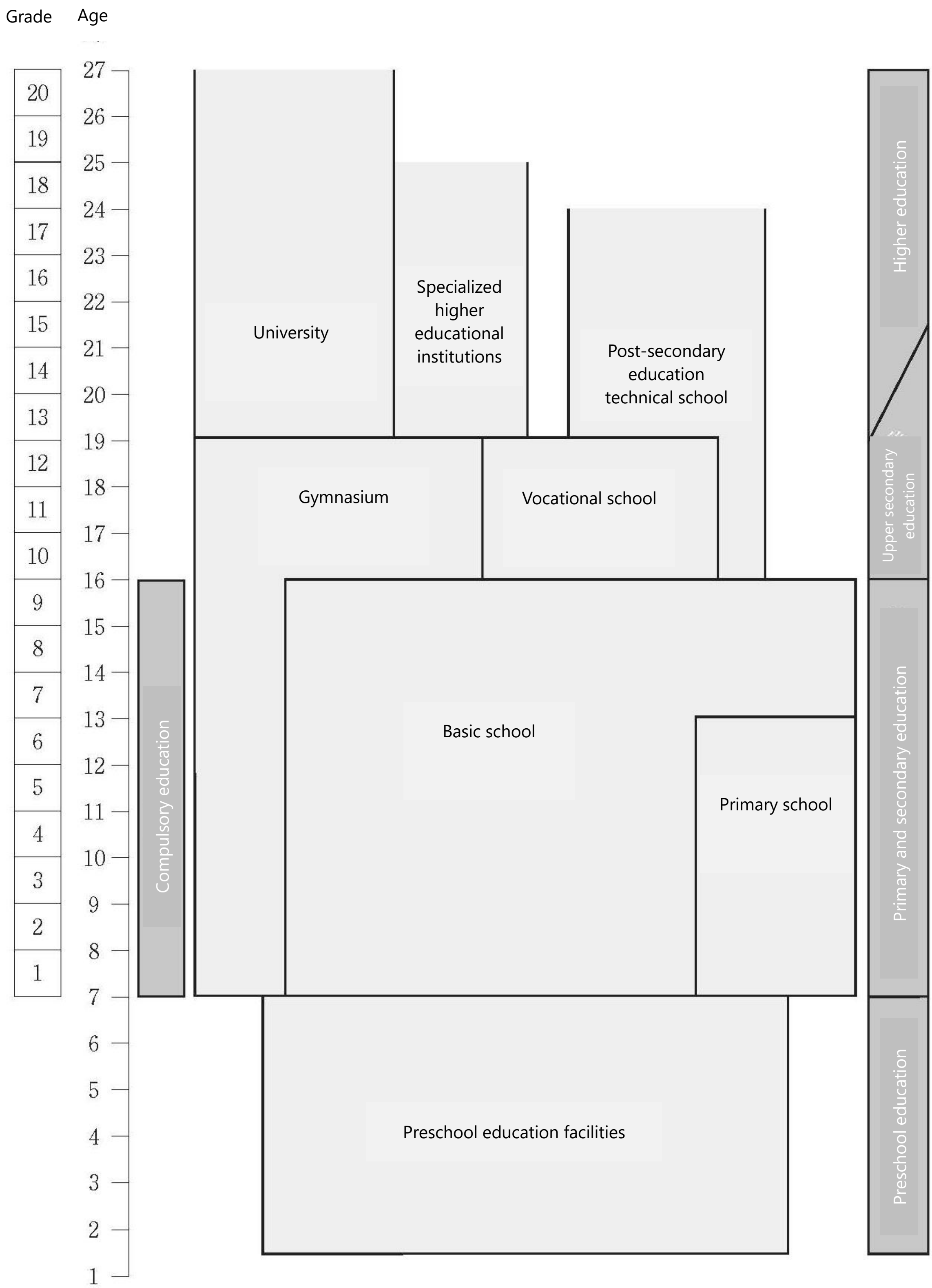
- TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College, and International Association for the Evaluation of Educational Achievement (2016) *TIMSS 2015 Encyclopedia*, <http://timssandpirls.bc.edu/timss2015/encyclopedia/> Accessed March 15, 2018
- Undervisningsministeriet (Date of publication unknown) *Undervisningsministeriet* <https://www.uvm.dk/> Accessed March 16, 2018
- UNESCO (2018), *ISCED Mappings*, <http://uis.unesco.org/en/isced-mappings> Accessed March 15, 2018
- UNESCO-IBE (2012) *World Data on Education. 7th edition, 2010/11* <http://www.ibe.unesco.org/fileadmin/user_upload/Publications/WDE/2010/pdf-versions/Denmark.pdf> Accessed March 21, 2018

Fig. 1.1 School System in Denmark



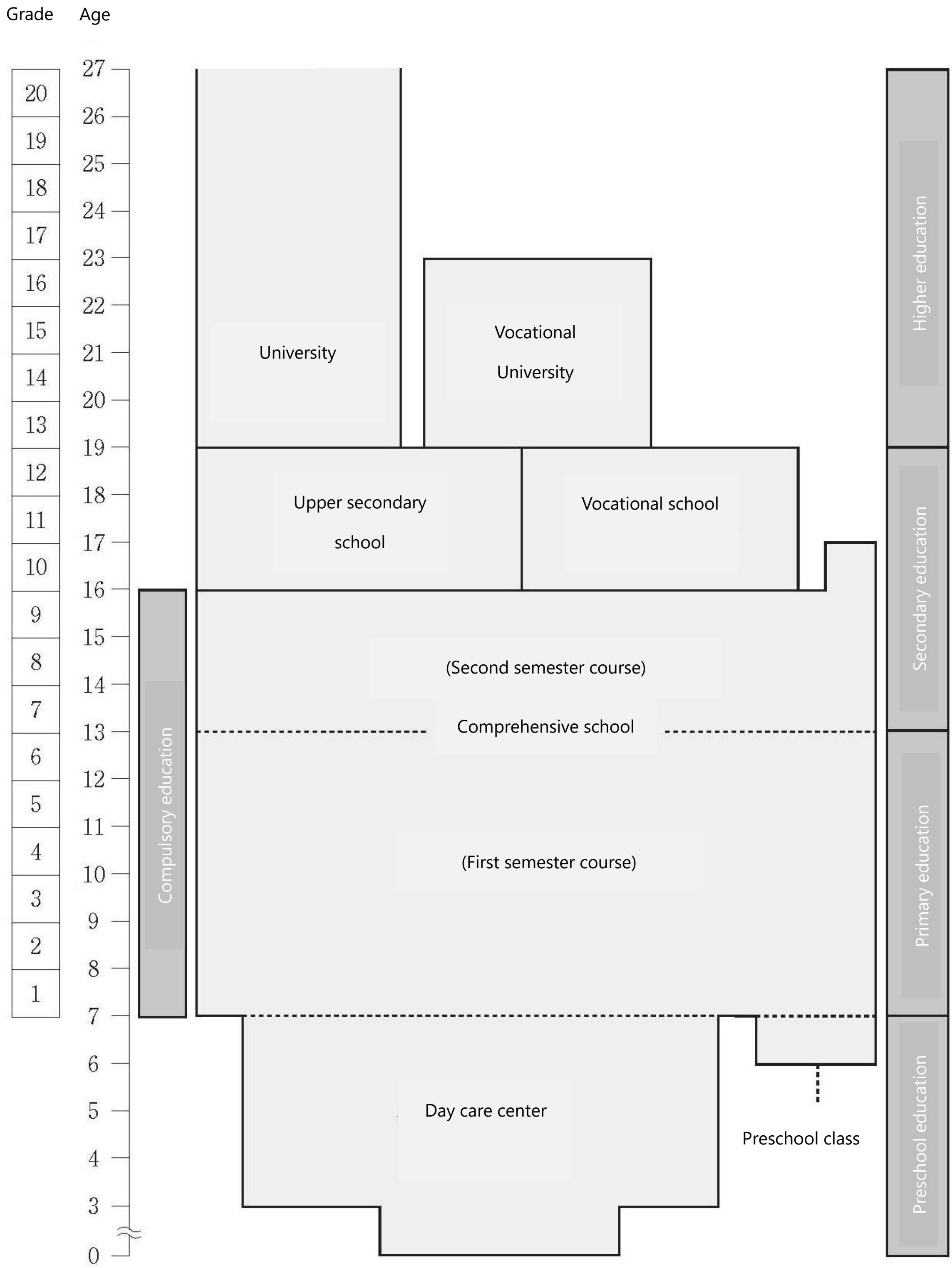
Source: Ministry of Education, Culture, Sports, Science, and Technology (2017)

Fig. 1.2 School System in Estonia



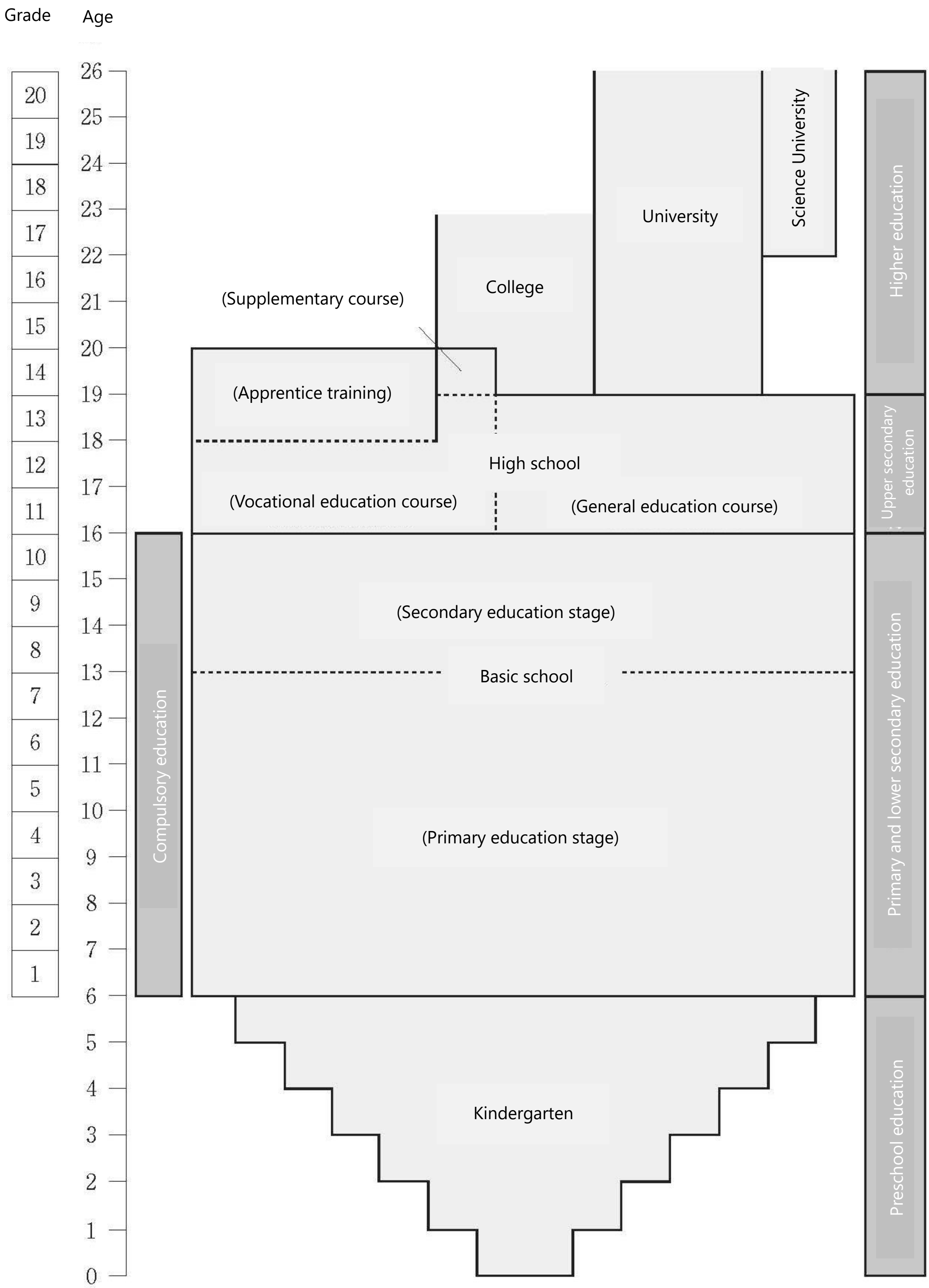
Source: Ministry of Education, Culture, Sports, Science, and Technology (2017)

Fig. 1.3 School System in Finland



Source: Ministry of Education, Culture, Sports, Science, and Technology (2017)

Fig. 1.4 School System in Norway



Source: Ministry of Education, Culture, Sports, Science, and Technology (2017)

Chapter 2　2017 Field Study Results

In this Chapter, we will summarize and organize the results of a study conducted in Denmark in fiscal 2017, as part of the collection of reference information for the promotion of ICT use in schools in Japan.

2.1. Study Overview

2.1.1. Targets

For this study, a total of three schools were visited in Denmark (1 primary school, 1 lower secondary school, and 1 integrated primary/lower secondary school) to see the state of ICT usage in primary and secondary education. In Denmark, local governments have a lot of discretion with respect to school education, and because the approaches to education differ depending on the municipality, in addition to a school in Copenhagen, we also visited schools in Helsingør where a special emphasis is being placed on ICT education.

Fig. 2.1 School Study Visits

Date of Visit	School Visited	School Type
Monday, October 30, 2017	Tibberupskolen Grydemoseskolen	Lower Secondary School Primary School
Tuesday, October 31, 2017	Øster Farimagsgades Skole	Integrated Primary/Lower Secondary School

2.1.2. Study Items

The following study items were sent to the 3 schools prior to the visit, and interviews were conducted during the visit.

Fig. 2.2 Visit Checklist

Study Items	1. Learning methods and contents	2. System maintenance and management	3. Training contents and support
Study Perspectives	1. Specific examples of ICT use in lessons and learning assignments 2. Frequency of ICT use in learning 3. Assignment submission methods and progress management methods 4. Specific examples of learning	1. Digital teaching materials database 2. Learning management systems 3. System	1. Teacher training for ICT use 2. School support for participation in training

	assignments at home 5. Computer tool usage (Microsoft Word, Excel, PowerPoint)	maintenance and management, and budget	

2.2. Study Results

2.2.1. Tibberupskolen (Lower Secondary School)

Tibberupskolen is a lower secondary school located in the suburban area of Espergærde. Espergærde is is part of the Kommune[20] of Helsingør, which is about 50 minutes north of Copenhagen by train.

Tibberupskolen website (Danish): http://espergaerdeskole.dk/tibberupskolen/

(1) State of ICT Equipment Introduction

Two-storied School Building

The introduction of ICT equipment at schools in Denmark is largely up to the discretion of each Kommune. The introduction of ICT equipment in schools in Helsingør is particularly progressive, with laptop computers having been introduced to primary and lower secondary schools in the city all at once in 2010, and with students each being provided with a computer (in some primary schools this has been in the form of BYOD[21]). At the time of introduction in 2010, all teachers were provided with 40 hours of training on ICT utilization, and training was held again for all teachers in 2015. No particular mandatory training has been held for teachers since this, but teachers are learning through teaching each other how to use digital teaching materials, and sharing information on good teaching materials, etc.

(2) Network Environment

All classrooms have wireless LAN routers installed at the center of the ceiling so that students can use computers in the classroom. These routers have a connection limit of about 20 people, and tend to freeze as the number of people accessing it increases, but even when there are problems with the equipment, the lessons still move forward without much trouble, as students stay put, doing other work until it recovers or sharing screens with other students, etc.

(3) Examples of ICT Use in Learning

In the Grade 7 (13–14-year-olds) mathematics classes that we visited, all of the teachers were teaching by projecting digital teaching materials onto electronic blackboards instead of writing on a blackboard. The same 4 word problems were shown

20 Local government equivalent to municipalities in Japan. Kommune.

21 Brining your own devices to use at school. Stands for “Bring Your Own Device”.

on the students' laptop computers and the electronic blackboard installed at the front of the classroom. The teacher explained each sentence one at a time with a touch panel and shared the contents throughout the classroom. The students then separated into groups of 4–5 students for a group discussion on mistakes hidden in the text and why those mistakes are likely to occur, in an exploratory style of learning.

After the group discussion, the teacher prompted the students to share their opinions and the students actively expressed their opinions.


Teacher explaining using an electronic blackboard

During the group discussion, one or two of the children could be seen taking out a notebook and pencil to make simple calculations. The teacher explained that the use of paper and pencils was not restricted, but that "some students think better when they are writing. Students are free to choose for themselves the best way for them to learn."

On the other hand, very few students took notes on the content of group discussions or their own opinions.

The teacher in charge of this class was a young teacher in their 4th year, and they actively made use of ICT lessons, saying that they were not using paper teaching materials at all in classes. The teacher noted that the advantages of using digital teaching materials was that they were easy for students to understand and were easy to learn from, and that the use of ICT equipment was a good way of keeping students focused.


Discussion while looking at the computer screen


Student using a notebook to calculate

(4) Digital Teaching Materials

This school mainly used Uni-Login digital teaching materials. Uni-Login is an authentication management service operated by UNI-C, an ICT promotion organization of the Ministry of Education, which offers a variety of educational services to students, parents, teachers, and educational institutions. Using Uni-Login, students can take national tests, receive messages from their school, check grades, etc. Teachers can use materials provided by Uni-Login to give homework such as drills, etc., and can obtain various digital teaching materials to be used in class. They can also access the educational portal site EMU[22] (https://www.emu.dk/modul/about-emu) to obtain materials created by the state and teachers, and paid materials provided by materials companies, etc.


Unit Test Summary Screen

Uni-Login also offers unit tests that teachers can download. For

[22] A digital educational platform developed by UNI-C. It can be accessed by students as well as teachers, providing digital teaching materials including math games.

tests, students use their laptop computers to answer online, and since scoring and counting are done automatically, the teacher can instantly check the rates of correct responses and mistakes for each student. Teachers don’t need to spend long time scoring tests and can immediately understand the level of understanding of the students, making it possible to provide quick feedback and follow-up learning to students as well as to give highly efficient guidance without oversight.

Grade 9 (15–16-year-olds) students do most of their Danish and Mathematics homework on laptops. For example, for Danish reading homework, books to read that can be browsed with Uni-Login are specified, and students can select the books that they want to read and read them on their laptops.

(5) Other

We asked the School Leader (Curriculum Coordinator) whether teachers were confused with the introduction of ICT equipment, and there was a small number of veteran teachers who were not comfortable with using ICT and who did not use it in their classes because their teaching methods were already well-established. Support is provided by teachers that are good at using ICT and younger teachers for those teachers who are not as active in using ICT equipment, but teachers are not pressured by the school to use ICT equipment in their classes.

2.2.2. Grydemoseskolen (Primary School)

One-storied school building

Grydemoseskolen was originally integrated with the above-mentioned Tibberupskolen (Lower Secondary School), but the primary school and secondary school were divided into separate schools in June 2017. The school is located in Helsingør, about a 20-minute walk from Tibberup-skolen.

Grydemoseskolen website (Danish): http://espergaerdeskole.dk/grydemoseskolen/

(1) State of ICT Equipment Introduction

As noted in the Tibberupskolen section, Helsingør has provided one laptop computer per student in primary and secondary schools since 2010. Therefore, children use laptop computers from Grade 0.

(2) Network Environment

As at Tibberupskolen, wireless LAN is installed in the ceiling of each classroom. We visited various classes using ICT equipment, and saw no particular issues with the internet connection.

(3) Examples of ICT Use in Learning

Classes were using electronic blackboards and laptop computers in every subject.

Rather than trying to force the use of ICT equipment into the learning process, most teachers noted that they “use ICT equipment because it is convenient and easy for students to understand, and because it helps maintain student focus.”

① Danish Language Classes (Grade 3 (9–10-Year-Olds))

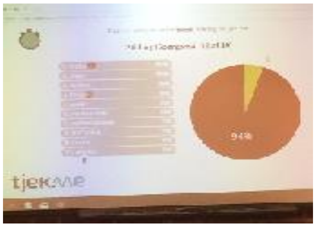
We watched a lesson that summarized how to give a presentation and how to use the library. The contents from previous lessons was shown on the electronic blackboard at the front of the classroom in a quiz style, and this was also shown on the screens of the children’s laptop computers for them to respond. The teacher read out the problems from the electronic blackboard, while the children clicked on one of the 4 responses shown on the screens of their laptops. The answers from the entire class were aggregated instantly, and the accuracy rate was shown in a pie graph on the electronic blackboard at the front of the class. The names of the 3 children with the highest accuracy were also displayed.

The children were learning in a fun and focused way, as they looked at the aggregated results and checked each other’s accuracy rates.

Once the quiz was over, a list of the accuracy rates for each problem could be seen. For problems with low accuracy rates, the children looked at why there were so few correct answers and shared their opinions. The children seemed very comfortable with reading text on the screen and operating their laptops.

The quiz and choices projected onto a smart board

Child answering with their laptop computer



Aggregated accuracy rates

② Programming Classes (Grade 5 (11–12-Year-Olds))

A class was held to make final adjustments to a robot to participate in the World Robot Olympiad. This programming class was an elective class taught by a mathematics teacher, with about 10 children. The teaching materials were programming materials (LEGO Education) created by LEGO and purchased by the school with a city subsidy. The children had made a wheeled robot with LEGO, which was connected to a laptop to program its motions. Programming can be done easily using software. In terms of how to use the teaching materials, LEGO provided small-scale training for teachers, but according to the teacher, the LEGO materials had been created for easy use by anyone (just like an iPhone, it was intuitive and easy to understand), and could be used without any problems even without teacher training. The teacher had studied the digital teaching materials by self-study and learning between teachers.

The students were having a lot of fun but were also very serious about their final adjustments to the robot. They were making the robot move on a field, and when it didn’t work, they would connect it to their computer, refine the programming, and finetune the robot assembly.

This learning unit takes 8 weeks, and includes learning about marketing and science such as solar power generation, etc. According to the mathematics teacher that led the class, this programming class included classmates from both lower and upper grades who not only learned about programming but also cultivated communication and a cooperative attitude through their discussions with classmates.

Programming lessons are held in many schools in Denmark, but the state has not yet decided whether to introduce this as part of the national curriculum. Apparently, some schools have paid parents and graduates that are good at programming to provide temporary support for lessons. Also, each class must have one child that is good at IT (called Student IT Patrol), not only in programming classes, and these students apparently teach other students and teachers how to use ICT and provide day-to-day support.


Children making final adjustments while watching the robot move


Children modifying programs


Programming software screen

③ Homework Time (Grade 2 (8–9-Year-Olds))

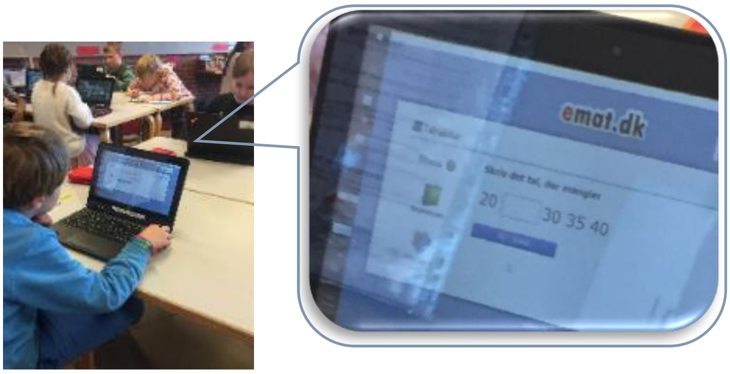

Using printouts to practice writing numbers

In Grade 2 classes, an hour of "homework time" is set each week. In lower grades, children are encouraged to finish their homework at school, and children who have already finished their homework can use this time to choose their own learning activities. Some children were using worksheets made by the teacher (practicing writing numbers or coloring in shapes), while others were doing math drills with digital materials on their laptops. Another child was writing a long story in Microsoft Word. When we asked about the children typing, the teacher said "They learn how to type from about Grade 2. Some teachers teach keyboard fingering, but the children learn it naturally themselves without being taught." "In lower grades, rather than teaching typing or correcting their mistakes, it is important that the children are able to express their good ideas as much as possible. So even if they make spelling mistakes with their typing, I don't really point it out much. Also, if the children use UpWriter (a sentence reading software), they will notice the spelling mistakes themselves and fix them. In terms of learning to spell, basic words are posted around such as on the floor in the hallway, etc., and we try to make it natural for the children to learn spelling while they play." We saw that by using ICT children were able to learn by themselves rather than having to be corrected each time by the teacher.

④ Other Classes

In addition to the above classes, we visited a Grade 4 (10–11-year-olds) music class and a Grade 5 (11–12-year-olds) mathematics class.

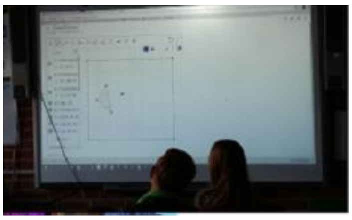
Learning to color in shapes



Digital teaching materials for math drills

In the music class, a PowerPoint presentation had been created and the children were divided into groups and worked with their laptops inside and outside of the classroom.

In the mathematics class, we observed students drawing triangles with computer software and rotating them to make patterns. Instead of learning from the teacher, they were using a video to learn about shapes. Because the video included audio with very simple instructions, the teacher didn't need to explain anything, just run the video on the electronic blackboard. Just watching the video, rotating the triangle with the mouse, and copy-and-pasting new triangles, the students were really motivated and were calling out "I want to try it!" This was a testimony to the many teachers who had said that "introducing ICT into classes raised the interest and focus of the children." Also, because of the quality of the digital teaching materials, children were able to advance the learning experience by themselves just by listening to the audio instructions. Many of these learning videos were taken from GeoGebra[23] and Youtube.



Mathematics lessons with video

Children listening seriously to voice guidance

[23] GeoGebra: Mathematics software operated by an Austrian company and NPO for learning geometry, algebra, and statistics. GeoGebra Japan website: https://sites.google.com/site/geogebrajp/

(4) Digital Materials

Digital teaching materials for almost all subjects (Educational Material Company Poster)

In addition to materials from Uni-Login and EMU, this school also used digital teaching materials created by textbook companies. The purchase of digital teaching materials is determined after the city or school evaluate the contents of the materials. The textbook company Gyldendal, which is used by this school, provides digital teaching materials for various subjects for Grades 0 through 10.

(5) Other


Children sharing their opinions by looking at photos

The week after out visit to the school was a week with no regular classes to hold a school-wide event on the theme of “Attractive Kommune – How to Change this City for the Better,” an event where the children were encouraged to come up with various ideas about what needs to be done and what kinds of activities are needed to make the city more loveable. ICT was also to be used in this event, with children creating videos and images to express their ideas and presenting them. According to the story of School Leader (Curriculum Coordinator), “The fundamental idea that children have full of good ideas is in Denmark. This event is an opportunity for children to express their own ideas.” Various photos were shown on the monitor installed in the corridor in front of the library for weeks prior to the event. Photos were shown one after another without any common threads or themes, and were meant to serve as inspiration and stimulation for the children. We saw some children in Grades 2–3 (8–10-year-olds) stop and look at these images and share their opinions about them.

2.2.3. Øster Farimagsgades Skole (Integrated Primary and Secondary School)


Three-story school building

Øster Farimagsgades Skole is located about 20 minutes by train and bus from Copenhagen Central Station and is an urban school in a neighborhood that includes the Copenhagen National Museum, etc. According to Principal Elisabeth Jensen, there are many wealthy students, and while the current number of students is 750, there are plans to add an additional 50 next year.

Øster Farimagsgades Skole website (Danish): http://oef.skoleporten.dk/sp/5976/foreside?pageId=99a30439-a3d5-4edd-82c8-944c8d940de2

(1) State of ICT Equipment Introduction

Since 6–7 years ago, Copenhagen has distributed iPads to all of its teachers, and made it mandatory to participate in ICT training and courses, with many being implemented.

Currently only voluntary ICT training is conducted.

For Grades 0 through 3 (6–10-year-olds), 5 iPads are provided per class (about 25 children), and these are mainly used for group learning. From Grades 4 through 5 (10–12-year-olds), each person uses their own laptop computer. In Grades 4 through 5, there are some BYOD children, while others have laptops borrowed from the school (the school lends laptops to children whose families cannot provide one). The school has about 15 laptops available for lending per class. If borrowed laptop computers break down, repair costs are generally borne by the parents. From Grade 6, everyone is basically BYOD.

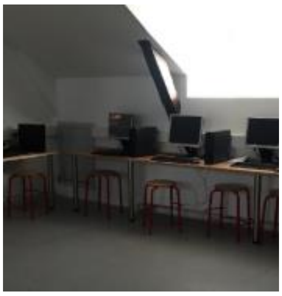
Student store their laptops in lockers in the corridors where they can also recharge them.

Electronic blackboards are installed in all classrooms. There are also ordinary blackboards, but few teachers use them, and they are often used as posting space.

There is also a computer room with 28 desktop computers. These are sometimes used for joint classes with lower and upper grades. Upper grade children sometimes teach the lower grade children how to use the computers.


Laptop computers storage lockers


Blackboard used to post things


Computer room

(2) Network Environment

Wireless LAN routers are installed in the ceilings of each classroom. The internet can also be used outside of classrooms, in corridors, the library, the home economics room, etc.

(3) Examples of ICT use in Learning

① Mathematics Class (Grade 1 (7–8-Year-Olds))

Primary school classes in Denmark have 2 teachers, but in this class, there were 3 teachers teaching 22 children. One of these was a so-called Math Counselor, a teacher providing support to children who need it in mathematics, and one Math Counselor was assigned to each of the lower and upper grades. In this class, the Math Counselor led the lesson and the homeroom teacher went around to assist. The other teacher offered special support to children as needed.


Teacher explaining the rules of the treasure hungt and how to use the iPad

This class was called "Treasure Hunt" and taught the children how to use an iPad while learning mathematics. Uni-Login digital teaching materials were used as the lesson materials. The children were divided into 5 groups, with each group given a single iPad. They worked together as a group to solve simple addition and subtraction problems, and if they were correct the screen switched to a QR reading screen. The teacher had hidden illustrations of dolls with QR codes around the classroom beforehand, and the children looked for them and read the QR codes on their iPads. This displayed a puzzle on the iPad. This activity was repeated 5 or 6 times and once all of the QR codes had been read and the puzzles completed a single picture could be seen. The children were able to learn how to use their iPads and learn math while having fun playing a game. The homeroom teacher also said that using ICT it was possible to include various activities for friends to cooperate together through the lesson, developing communication skills.

Wireless LAN router

Children solving math problems

② Danish Class (Grade 8 (14–15-Year-Olds))

PowerPoint for presentation

PowerPoint materials were made by each student

Students were preparing presentations on topics they chose. They used PowerPoint on their laptops while adding illustrations and photos. It was particularly interesting that the electronic blackboard at the front of the classroom was being used to show a live video of the student's favorite artists played from YouTube as background music. The students really concentrated and worked hard in this relaxed, free atmosphere. Danish school lessons incorporate a great deal of exploratory styles of learning. This seems to penetrate into the students to help them understand that learning isn't something that is done to you but something that you have to think deeply about yourself.

Children reading QR codes

Illustration with a QR code

Read all the QR codes to complete the puzzle

③ Everyday Challenge Project (Grades 6–7 (12–14-year-olds))

We visited a class that was preparing to participate in the local Everyday Challenge Project competition. This class had developed the idea of powering the town’s traffic lights with hydropower and was preparing to present this project at the competition. The class was divided into teams of 3 or 4 people that were responsible for different activities such as designing the generator motor, producing a model of the generator motor with a 3D printer, producing a mobile site for the project,designing and creating a logo for the generator, preparing a script for the presentation, creating business cards to be handed out at the competition venue, creating posters, etc. This school had 3 3D printers that had been purchased by the school.

Designing the motor

3D Printer

Creating a mobile site

Designing a logo for the project

Business Cards

Hand-drawn poster

④ Programming Materials

We were showed teaching materials for a lower grade programming lesson called Robot Bee. The cute bee-type robot (although it looked more like a ladybug) had buttons on the back, front, left, and right, and could be easily programmed with these buttons to make it move. For example, if you pressed the front arrow button twice, the right arrow button once, and then the start button, the Robot Bee would move accordingly. The children would program the Robot Bee to move across a sheet with A to Z written on it to spell out a word they thought of.

Robot Bee

Sheet showing A to Z

Sphero

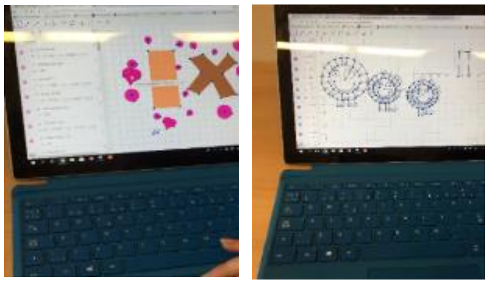
Sphero operation screen

This teaching resource was apparently used in lessons for Grades 0 through 1 (6–8-year-olds). Children naturally learn the basic principles of programming while having fun playing.

We were also shown Sphero, a programming resource for Grades 4 through 5 (10–12-year-olds). This was a plastic ball that could be programmed to move, change light colors, and flash lights, and the ball moved in the direction of the remote control when it is tilted.

⑤ Self-Study (Grade 1 (7–8-Year-Olds))

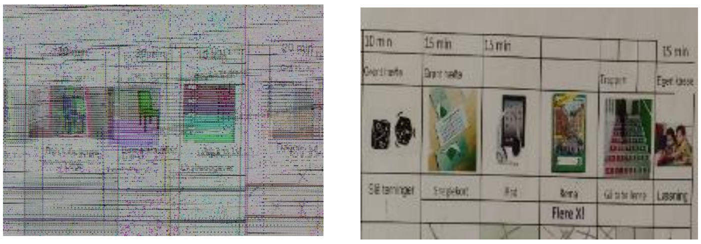
Whenever there was time left in lessons, it was devoted to self-study activities. During self-study time, children were allowed to use digital tools on their own. They could also draw pictures using the 2 laptop computers at the back of the classroom. The laptops contained the above-mentioned GeoGebra mathematical software, and could be used to draw shapes and color them in. This software was used from Grade 1 for drawing. etc.



Children’s drawings using GeoGebra

There were about 8 other self-study activities using iPads along with workbooks and LEGO. Children were free to choose the self-study activities that they wanted to do. The activities that are done are written on a self-study list at the back of the classroom and students check to make sure that the activities aren’t concentrated on certain types.

In any classes at all grade levels, the children think themselves about what they should learn and have many opportunities to choose for themselves. The diversity of learning activities was also impressive, with many group study and individual study opportunities, so that everyone in the class wasn’t always doing the same learning activities. When we asked a teacher about this, they responded that this style of learning was probably due to the underlying educational philosophy of Danish education to “strengthen what you are good at.”



List of self-study activities

Children study by choosing a workbook or iPad

(4) Digital Materials

Teachers at schools in Copenhagen use a lot of Uni-Login materials but other educational materials are regulated by the city and teachers have little freedom in selecting teaching materials. Smaller local governments tend to give more discretion in the choice of teaching materials to schools, making it easier to purchase digital teaching materials from textbook companies, etc.

(5) Other

The staff room was also moving toward being paperless. There were almost no printed materials, and the room was clean and had a kitchen area with tables and chairs. Teachers could sit wherever they liked and use their laptops or tablets that they carried around, or head to the computers to prepare for classes. There were hardly any paper materials such as printed matter. As with all of the classrooms, there was also an electronic blackboard in the front of the staff room.


Staff Room

Survey software was being used to ask the children about their school life. The children used their laptops to answer questions about friends and school life. Aggregating the surveys was easy for teachers to do on the computer. It was also possible to see in a graphical display which children in class tended to be isolated and who were good friends with each other.


Questionnaire results shown clearly in a diagram

2.3. Summary

One of the purposes of this study was to observe which subject Danish children used ICT equipment in, how often they used it, and how it was used. However, upon actually visiting the classroom, the use of ICT equipment was not limited to specific subjects but was used in almost all subjects and classes every day.

ICT equipment was introduced into classes by teachers not as “an effort” to include it in classes but because it was suitable to develop the abilities of the children, and this has had the effect of giving computer literacy to the children as well as implementing a wide range of instruction and learning measures.

Through these class visits and interviews with teachers, the following factors became apparent as being behind Danish teachers actively introducing ICT equipment into their lessons to such an extent.

✧ Development of High-Quality Digital Teaching Materials

In Denmark, there are a lot of digital teaching materials uploaded to Uni-Login and EMU operated by the national ICT promotion organization UNI-C, which teachers can use freely. These digital teaching materials include not only those developed by the state, but also those created by teachers and paid materials developed by companies.

Most of these digital materials can be used in classes as they are, some of which can be shown on electronic blackboards instead of writing on blackboard, while others are videos with explanatory audio that allow children to learn by themselves even without explanations from the teacher.

Also, national testing is carried out by computer-based testing (CBT), with test questions in a format similar to the PISA survey CBT with various questions shown on the computer screen to be read and answered. Danish children take these tests from the lower grades of primary school, so they are quite familiar with CBT-form tests, beginning with the PISA surveys themselves. With the high frequency of use of computers, not only in national testing but also everyday classes, children seem to be very familiar with reading sentences on computer screens. A collaborator of this survey, a teacher from Aarhus University who was involved in conducting the Danish PISA survey said that "for Danish students, CBT is easier than taking tests with pencil and paper."


National Test demonstration screen

We interviewed many teachers and children in this process, but no one mentioned any disadvantages of introducing ICT. It has only been about 10 years since the government launched the policy of ICT introduction, but both schools and children have accepted the ICT without obstacles.

✧ Teaching Styles and Education Concepts

Even in Japan, there is an increasing number of schools looking to emphasize individuality in classes by incorporating group learning and teaching materials that make children think independently, but the Danish schools that we visited had introduced individual learning in many classes and there was very little whole-class learning. Particularly at primary education level, many classes were divided into small groups for activities, with groups of 2–3 people seen taking their laptops to their favorite places around the classroom, or on the stairs and sofas outside the classroom, having discussions. The fact that ICT equipment is so suitable to such a free form of learning may be a factor in the swift introduction of ICT into education.


Children studying in groups into their favorite places, such as in corridors and edge of

A Grade 1 homeroom teacher at Øster Farimagsgades Skole said that "the most important thing in Danish education is the '4C (Critical Thinking, Creativity, Communication, Collaboration).'" Because of the emphasis on thinking for yourself, developing creative ideas and expressing yourself rather than memorizing large amounts of information, there were a lot of classes that took the form of each person thinking and choosing for themselves, working on learning tasks, and deepening their thinking through discussion, rather than whole-class lessons. The basic principle is that each child has different values and ideas, and the role of teachers is limited to supporting this. Innovation and entrepreneurship are also included in the national curriculum. The emphasis on gathering information, thinking, and developing ideas for yourself may make ICT use suitable to individual and group activities.

In this way, not only the spread of ICT, but ideas of education themselves differ between Japan and Denmark.

What we noticed during this visit was that while Japanese education places an emphasis on “how to teach children about ICT,” in Denmark it is about “the use of ICT as the best tools to provide a better education for children.” That is, while in Japan there is a sense of separating ICT as a “subject” different from other subjects, like a kind of technology class, in Denmark, ICT is used as a “tool” in all subjects to enhance the learning impact. This difference certainly seems to show itself in the differences in ICT utilization between the two countries.

Therefore, it would likely not be a good idea to incorporate the use of ICT in Danish education as it is in Japan. But these result also do suggest that there are a number of things that can be learned in a broad sense from the high frequency of ICT use in Denmark when considering the future of ICT utilization in Japanese education.

Chapter 3　2018 Field Study Results

In the previous Chapter, we saw examples of ICT utilization in Danish education from a fiscal 2017 field study, and in this Chapter, we will look at examples of ICT utilization in Estonian and Norwegian education from the results of a fiscal 2018 field study.

3.1. Examples of ICT Use in Estonian Education

In this Section, we will summarize the overview and the results of a study conducted in Estonia as part of the collection of reference information for the promotion of ICT use in schools in Japan.

3.1.1. Study Overview

3.1.1-1 Targets

In the fiscal 2018 study, we visited 2 schools in Estonia to look at the state of ICT utilization in primary and secondary education: one basic school (integrated primary and lower secondary school) and one Gümnaasium in the city of Tallinn. In addition to the school visits, we also conducted interviews with policy makers at the Estonian Ministry of Education and Research and HITSA.

Fig. 3.1 Study Targets

Date of Visit	School Visited	School Type
Monday, November 12, 2018	◆Estonian Ministry of Education and Research interview ◆Tallinna Südalinna Kool Visit	 Basic school (Integrated primary and lower secondary school) (Grades 1–9)
Tuesday, November 13, 2018	◆HITSA interview ◆Gustav Adolfi Gümnaasium Visit	 Gümnaasium (Primary and lower secondary school: Grades 1–9; Upper secondary school: Grades 10–12)

3.1.1-2 Study Items

Fig. 3.2 below shows a summary of the focuses for the school visits and the interviews.

Fig. 3.2 Study Focuses

School Visit	Interviews
1. State of ICT equipment introduction	1. Purpose of ICT use in school education
2. Network environments	2. Improvements in learning results from ICT use
3. Examples of ICT use in learning	3. Measurement of ICT skills
4. Digital teaching materials	4. Teacher training
	5. PISA reading comprehension and ICT

The main focuses for the school visits were the 4 areas of the state of ICT equipment introduction, network environments, examples of ICT use in learning, and digital teaching materials. Also, the main focuses during interviews survey with each organization were the 5 areas of the purpose of ICT use in school education, improvements in learning outcomes from ICT use, the measurement of ICT skills, teacher training, and the relationship between PISA reading comprehension and ICT.

3.1.2. School Visit Study Results

3.1.2-1 Tallinna Südalinna Kool (Basic School)

School building facing the main street

Tallinna Südalinna Kool is a public basic school (Basic School: 7–15-years-olds) opened in central Tallinn in 1996, having had its current name since 2013. There is a total of 440 students (2017) and 30 teachers. Classes are conducted in Estonian.

Our visit of Tallinna Südalinna Kool was guided by the school’s Educational

Technologist[24] Kerttu Molder. An interview was also conducted with Principal Veiko Rohunurm about ICT use in the school.

Tallinna Südalinna Kool website (Estonian[25]): https://www.tallinn.ee/est/sydalinna/

(1) State of ICT Equipment Introduction

In Estonia, the maintenance of IT infrastructure is generally the responsibility of the school owner (European Schoolnet, 2015), and at this school, ICT equipment was basically introduced on a BYOD system in line with government policy (Siiman et al., 2016). In addition, new classrooms (called Future Classrooms) were established in 2015, featuring the introduction of 3D printers, iPads, smart boards, VR, etc. (Tallinn, 2019). VR was introduced in 2017 and is used in subjects such as the natural sciences.

Top: ICT equipment available in Future Classrooms
Bottom: VR headset

(2) Network Environment

The spread of Wi-Fi has progressed since it was established in Estonia in 2001, and this school has a Wi-Fi infrastructure (Freedom House, 2014).

(3) Examples of ICT Use in Learning

At this school, ICT is simply considered to be a tool, and this tool is considered important in raising the effectiveness of learning, with various practical measures being made utilizing ICT. The most successful case study is Digital Learning Day (hereinafter “Digital Day”). Digital Day is a day on which all students can study at home and has been held twice a year for 3 years. Instructions from teachers to students are carried out by distance learning using the internet, such as by email or skype, with parents choosing whether their children will study at home or at school, and on the last Digital Day, almost all children chose to study at home. Teacher Molder said that the implementation of Digital Days has “led to students developing the spontaneous ability to learn.”

In normal classes, teachers give students various learning tasks, and internet searches are frequently used to solve these tasks. In addition, ICT use is incorporated from lower grades in math and science classes from Grade 1 with robotics and programming learning. Regarding the achievement targets of ICT use in each grade, they are basically in line with the Digital Competence Framework established by the Estonian government (See Fig. 3.5).

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[24] Educational Technologists are not IT engineers, but rather are teachers who play the role of promoting and supporting learning with the use of ICT, and improving educational practices (European Schoolnet, 2015).

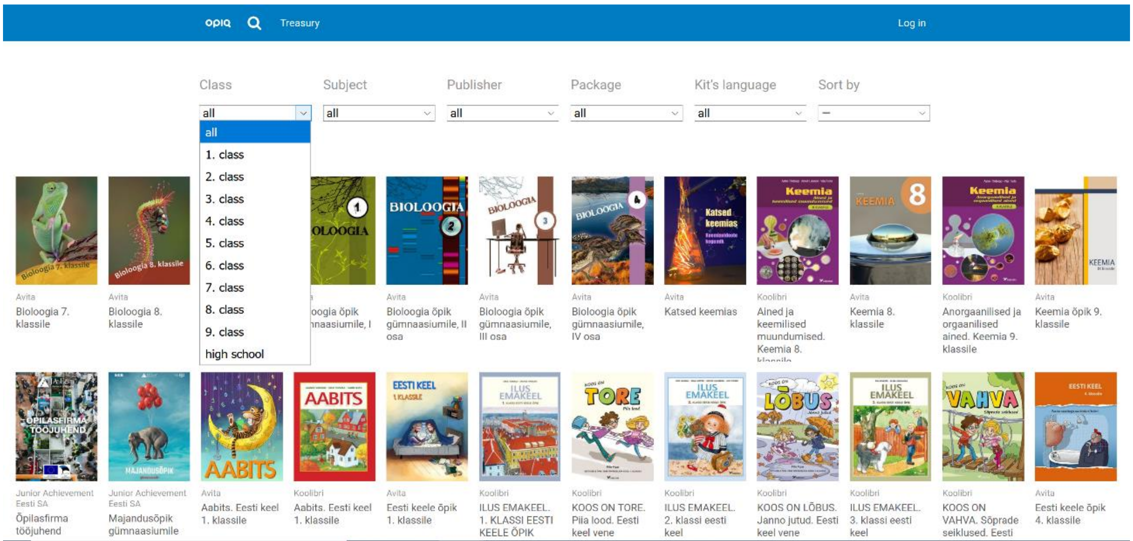
[25] Some listed in English.

(4) Digital Teaching Materials

In Estonia, each school basically follows the objectives of the government (Fig. 3.5, etc.) in determining which online resources to use, but online resources are used differently depending on the personalities of students. The Estonian government also has the aim of digitizing all teaching materials throughout the country by 2020 and making them available online on e-Koolikott (e-Schoolbag)[26] (e-estonia (Date of publication unknown)).

This school used Opiq[27] as a digital teaching material. Opiq digital materials are developed to make learning easier to understand, more effective, and more interesting (e-estonia (Date of Publication unknown)), and textbooks published by Avita[28] and Koolibri[29] can be selected. Opiq can not only be used for selecting teaching materials, but also provide tests and feedback to students.

Fig. 3.3 Opiq Textbook Search Screen



Source: Opiq (Date of publication unknown) https://www.opiq.ee/Search/Kits

(5) Teacher Training

Training on the use of ICT is provided by IT specialists at schools,[30] universities, and public institutions (HITSA, etc.), and many teachers participate in the training. While there are opinions that this has contributed to improving learning at school, the fact is that there is still little training on using ICT to improve learning. The training is paid for by

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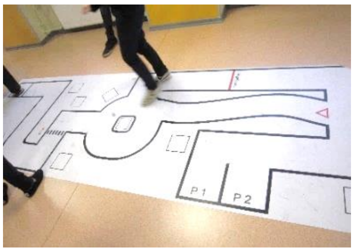
26 https://e-koolikott.ee/
27 https://www.opiq.ee/Catalog
28 https://www.avita.ee/
29 https://www.koolibri.ee/
30 In Estonian schools, IT Specialists supervise the coordination and development of learning using ICT and play a role in advising other teachers on how to utilize ICT in learning (European Schoolnet, 2015).

the government, with EU grants, or by the school, with teachers not required to pay for it themselves.

(6) Other

In about 85% of schools in Estonia, the learning information management system eKool (e-school),[31] introduced by the government in 2005, is used for the learning status and background information of students (e-estonia (Date of publication unknown)). eKool is used mainly for communication, assessment and measurement, feedback, teaching materials, and homework to manage the progress and submission of learning tasks for students. Some homework is given in paper form, but all homework is managed on eKool. Children, students, their families, school staff, including teachers, members of organizations that supervise schools, such as School Boards, etc. are able to access eKool.



Programming circuit drawn on the floor in a hallway

eKool is a private provider that regularly listens to the needs of schools, etc., and is regularly updated based on requests that arise, and while there are many advantages in daily use, conversely, the many functions that come from updates may feel inconvenient according to some.

The cost of introducing ICT equipment is covered by public funds as well as by each school by renting out school facilities (gymnasiums, etc.).

3.1.2-2 Gustav Adolfi Gümnaasium (Gümnaasium)

Gustav Adolfi Gümnaasium is the oldest Gümnaasium[32] in Estonia, founded in 1631 by the King of Sweden, Gustav II Adolf. The upper secondary school building is located in the old town of Tallinn, and the primary and lower secondary school building is located about 5–10 minutes away on foot from there.

When we visited, we were guided around the primary and lower secondary school by Educational Technologist Ingrid Maadvere, and the upper secondary school by Kersti Kukk, who is in charge of the upper secondary school.

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[31] https://ekool.eu/index_en.html

[32] In Estonia, both integrated primary and lower secondary schools and upper secondary schools are called Gümnaasium. Integrated primary and lower secondary schools are historically more common, and there are fewer upper secondary schools (Republic of Estonia Ministry of Education and Research, 2015). Gustav Adolfi Gümnaasium is an integrated primary and lower secondary school.

Gustav Adolfi Gümnaasium website (Estonian): http://gag.ee/en

Primary/Lower Secondary School located 5-10 minutes on foot from the Upper Secondary School

Upper Secondary School building located in the old city

(1) State of ICT Equipment Introduction

This school is also based on the BYOD system (Gustav Adolfi Gümnaasium, 2015), which was implemented as a solution to expand the use of technology into classes amid problems of insufficient funds and maintenance issues.[33]

Also, except for special classrooms, most classrooms have smart boards in addition to traditional blackboards. Computer classrooms at this school are divided into 3 sections. The first is a computer room, the second is a creative room where creative activities take place using digital tools such as 3D printers, etc., and the third is a VR classroom where students can relax on bean bags while learning.

VR Classroom

(2) Network Environment

At this school, wireless LAN is installed throughout the buildings on site, and there is separate Wi-Fi available for students and for teachers. Internet cables are also installed.

(3) Examples of ICT Use in Learning

At this school, teachers are constantly exploring ways to use ICT in classes and to develop more and more teaching methods that utilize ICT, not only to achieve nationally designated objectives, but also out of a recognition that this can improve the concentration of students and that it is an effective and practical means for acquiring knowledge useful to the students out in society.

Primary/Lower Secondary School Education

We visited primary and lower secondary school classes to see how ICT was used in

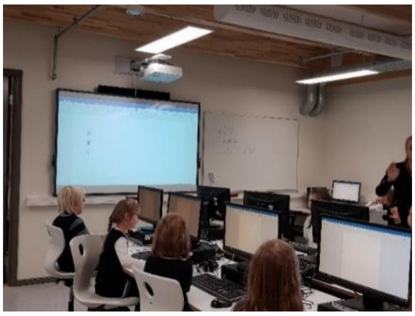
[33] http://fcl.eun.org/documents/10180/624810/BYOD+report_Oct2015_final.pdf

English classes.

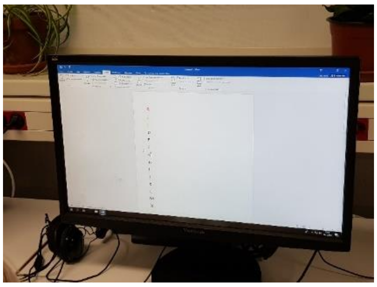
① English Class (Grade 1 (6–7-Year-Olds))

In a Grade 1 English class, rather than learning the alphabet in the traditional manner with a pen and paper, children were learning the alphabet at the same time as they were learning how to use a keyboard, how to operate Word, and how to edit text characters. The teacher in charge noted that this was based on research that “using computers makes it easier for the children to learn the alphabet.”

First, the children were handed a piece of paper with the letters A to Z written on it in advance, and they then typed the alphabet into Word while looking at the paper, after which they changed the color and wrote some words to complete their tasks for the day. All of the children in the class completed the tasks at their own pace, rather than at the direction of the teacher. While some of the children progressed quickly, children that were not familiar with how to use a computer received assistance from the teacher, including how to log on to the computer. The teacher also suspended work in the class at one point and had everyone practice pronouncing the letters.


Children doing assignments at their own pace


Paper with alphabet written on it (some students painted colors)


Word screen with multicolored letters


Child editing font color

Upper Secondary School Education

We visited English and Art classes in the upper secondary school to see how ICT is used there.

① English Class (Grade 12 (17–18-Year-Olds))

In the Grade 12 English class, ICT equipment is used on a daily basis, and on this particular day, a presentation was given in English using PowerPoint, on the topic of “Things you are passionate about (things you like, etc.).” The students did not read from documents or scripts but had basically memorized the presentations, with the text on the slides only summarizing the main points and used mainly as visual aid. After presenting, the students in the class naturally had questions, and a question and answer session ensued. The teacher in charge of the class mainly served as a facilitator, and the class was led by the students

Presentation using PowrPoint

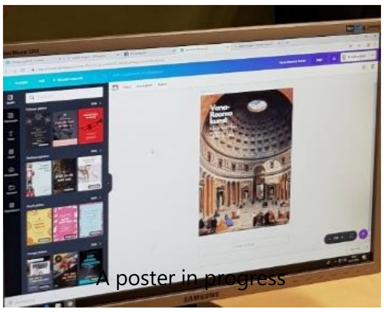
② Art Class (Grade 10 (15–16-Year-Olds))

The Art class that we visited was investigating buildings from Ancient Rome on computers and was working on a project to create posters. The assignment was primarily carried out in groups of 3 people, using various applications and software such as Lucidpress,[34] Word, Google Document, and Photoshop,[35] and the students were allowed to decide how to proceed on their own initiative. One group divided the work by having one student collect information and create the text, another searching the internet to decide which photos or materials to use on the poster, and the other combining this information into the actual poster. Other groups worked on the assignment using different ICT tools depending on their roles. Some groups had all 3 working together on the same tasks.

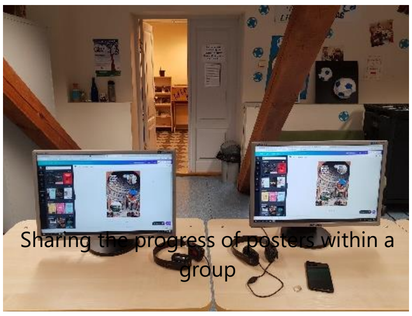
Holding a class

The collection of information and creation of posters was done in English, as English made it easier to collect appropriate information as opposed to doing searches in Estonian.

Students doing group work



A poster in progress



Sharing the progress of posters within a group

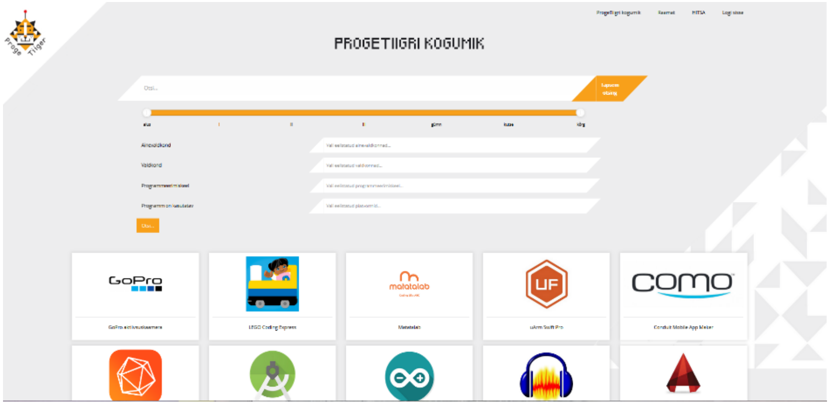
[34] https://www.lucidpress.com/

[35] https://www.adobe.com/jp/products/photoshop.html

(4) Digital Teaching Materials

In this school, teachers could decide what materials to use in learning, choosing from the various available teaching materials based on authenticity and reliability. Depending on the contents of the class, there were also cases where the students chose the teaching materials (See above-mentioned "(2) Art Class").

The digital teaching materials for this school were provided through online platforms such as ProgeTiger (For more details, see 3.1.3-2 HITSA (1) 1-1). ProgeTiger provides teaching materials suitable for the grade and age of students, as well as materials suited for students requiring special support.[36]



Progertiger textbook search screen[37]

(5) Teacher Training

At this school, in-school training on ICT is conducted about twice a year, with the theme of the training planned according to teacher requests. Recently, in-school training was held on how to use smart boards and Chromebook. Most teachers participate in such trainings as participation by teachers in school training is recommended by the school. One of the teachers, Kukk, said that "When ICT was first introduced, it initially took a lot of effort for teachers to learn how to use it, but now they want to use ICT to improve the effectiveness of learning." In addition to in-school training, teachers are also able to participate in training provided by universities and HITSA, with the cost borne by the school.

(6) Other

As with Tallinna Südalinna Kool above, eKool is also used at this school to manage the attendance of students, progress on learning assignments, the presentation and management of homework, grade management, etc. The management of eKool is carried out by an IT specialist.[38] Each teacher determines whether to give homework to

[36] https://media.voog.com/0000/0034/3577/files/Programm%20ProgeTiiger%202015_2017eng.pdf

[37] http://progetiiger.ee/?q=

[38] IT specialists are responsible for organizing school information, planning exchange programs and teacher trainings, creating proposals for teacher meetings. etc.

students using ICT.

An issue shared by the 2 schools is that teachers feel that while eKool is fundamentally useful, it has become more complicated with additional features, etc., and is not easy to use. 3 IT specialists have been appointed at the school in an effort to address these issues.

Also, students known as IT Students who are familiar with the use of ICT equipment play a role in supporting teachers and children who have trouble using ICT. IT Students are recruited from candidates in each class at the beginning of each academic year, and those chosen as IT Students are presented with a certificate. There are no particular limits on number per class, etc., with some classes having 6 IT Students in them, while others have just 2.

In addition to this, the school has its own student ICT skill assessments, developed and implemented by the Educational Technologist Maadvere.

3.1.3. Results of Interview Study

3.1.3-1 Republic of Estonia Ministry of Education and Research

This section summarizes an interview conducted with Kistel Rillo, Deputy Head of the E-service Department at the Republic of Estonia Ministry of Education and Research.

(1) Estonia Education Policy

Under the Estonian educational policy, the highest priority is “The Estonian Lifelong Learning Strategy 2020” (European Schoolnet, 2015), and the objective of this strategy is to provide lifelong learning opportunities to everyone in Estonia, based on their needs and abilities, and to allow them to pursue an independent life in their private life, workplace, and society overall (ibid.). The following 5 strategic goals have been put in place to achieve these objectives, and ICT is considered to be indispensable to the achievement of these goals (ibid.).

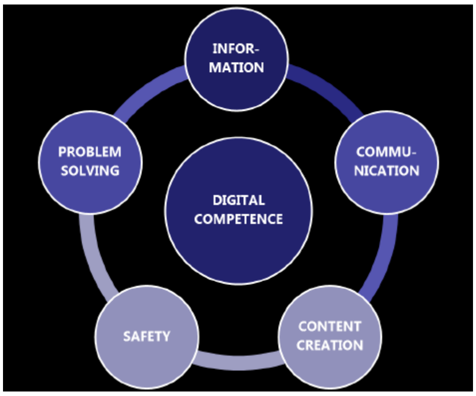
1. Changing the approach to learning
2. Talented and motivated teachers and school leadership
3. Align opportunities for lifelong learning with labor market demand
4. Focus on digital skills for lifelong learning
5. Equal opportunities and increased participation in lifelong learning

Also, various educational policies have been formulated to promote this strategy, with an emphasis on equality and fairness (Republic of Estonia Ministry of Education and Research, 2018b). Examples of educational policies that emphasize equality and fairness include the provision of free lunch and teaching materials, the provision of free extracurricular activities at schools (some schools have fee paying activities), and the provision of free learning support (ibid.).

(2)　ICT Skills

The framework for ICT skills in Estonia is based on the European Commission's Digital Competence Framework for Citizens (DigComp),[39] and consists of the 5 areas of information, communication, content creation, safety, and problem-solving (ibid.) (see Fig. 3.4). A digital competence assessment model has been established in Estonia based on this Digital Competence Framework, according to the age and learning progress of students, and detailed goals have been established for each stage of education (Republic of Estonia Ministry of Education and Research, 2016) (see Fig. 3.5).

Fig. 3.4 Digital Competence



Source: Republic of Estonia Ministry of Education and Research (2018b)

(3)　Measurement and Assessment Measures

Progress is being made in the use of ICT in learning assessment and ICT skill measurement for students in Estonia. We presented "ICT learning assessments" in Chapter 1.2.3 Computer-based Testing, and in terms of the "measurement of ICT skills," various tests have been developed and are being implemented in Estonia in consideration of the importance of the development and improvement of digital skills and digital competencies, as well as their promotion, measurement, and assessment.

One of these has involved a pilot national test, implemented from the spring of 2018 by the Estonian Ministry of Education and Research with the cooperation of the European Commission, to measure the ICT skills of Grade 9 and 12 students and vocational education and training (VET) school students in the extraction survey (European Commission, 2018a and interview content).

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[39] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-20-digital-competence-framework-citizens-update-phase-1-conceptual-reference-model

Fig. 3.5 Framework for the Assessment of Student Digital Competence in Estonia

The model describes the components of digital competency at the end of basic school stages, upper secondary school and vocational school.

Component skill	**Level 1 - stage 1 of basic school**	**Level 2 - stage 2 of basic school**	**Level 3 - stage 3 of basic school**	**Level 4 - upper secondary school and vocational school**
1. Management of information				
1.1. Searching for and browsing of information - based on the goal, the students determine their need for information and choose appropriate methods for searching and browsing digital information				
	Students find the necessary sources of information by using a search engine and keywords, browse them and select (filter out) appropriate digital materials with the help of a tutor.	Students find the necessary information from different sources of information by applying various search methods: keyword search, ranking, filtering, tag cloud.	Students vary the search methods according to the objective, use alternative search methods where necessary, and justify the superiority of the chosen search method.	Students: 1) determine their information needs and find appropriate information for purposes related to personal development, learning, handling social and problem situations, research, etc.; 2) test, compare and design effective search methods which cover different publications and information systems.
1.2. Assessment of information - students collect and process digital information, identify important information and analyse and assess i				
	Students structure the collected information by forming ranked lists and grouping information on the basis of predefined criteria with the help of a tutor.	Students: 1) find on the Internet digital material in various formats and, where necessary, copy it to a text file or presentation and process it according to the prescribed requirements; 2) explain the need to assess the discovered information in a critical manner, assess the objectivity of sources of information, and where necessary, find sources which provide an alternative viewpoint on the same topic, 3) distinguish facts from opinions.	Students: 1) use social bookmarks, categories and tags for marking and structuring sources of information they have created or found on the Internet; 2) critically assess the relevance, reliability and integrity of the information they found; 3) compare predefined sources of information on the web in terms of appropriateness, objectivity/bias and relevance.	Students: a) critically analyse different information, compare and use contextually appropriate discursive practices (e.g. social media, judicial practice, entertainment, communication between friends), respecting the applicable practices of communication; 2) explain the general mechanisms of functioning of the media industry, incl. the role of media on the labour market.
1.3. Saving and reproduction of information - students save digital information in the light of their goals, and structure and process the collected information with a view to its reproduction.				
	Students save and reproduce discovered information according to the requirements set by the tutor.	Students: 1) correctly refer to and reuse digital material retrieved from the Internet and other sources of information, refraining from plagiarism; 2) save the completed work in a predefined format and location (incl. web environment), find and reopen the saved file, save it using a different file name, copy files from one location to another, and compare file sizes with the available space on the data medium; 3) proficiently use the graphic user interface of the operation system (adjust window size, work in multiple windows, change views, sort files, search for whatever necessary).	Based on the objective, students structure and process digital materials created by them or others respecting the good practices of intellectual property protection and the licensing conditions set by the author.	Students: 1) save and manage digital materials in different web environments (incl. cloud environments) and physical devices by employing various classification systems to this end; 2) intentionally select the appropriate environment and solution (e.g. synchronising, backup copies, etc.) to store digital materials.

2. Communicating in digital environments				
2.1. Communication using digital devices				
	Students communicate with parents, fellow students and teachers using digital devices and applications according to their age and the agreed rules.	Students: 1) explain the advantages and setbacks of digital communication devices in a specific context and choose the most appropriate one; 2) add comments to a web site, participate in a discussion held by means of a web forum and mailing list respecting the generally accepted communication practices and the requirements set by the specific environment.	Students: 1) join the predefined digital communication environment, fill in the user profile and participate actively in a discussion; 2) choose the appropriate form, means and method of communication depending on the purpose and environment; 3) manage, delete, copy and file away different types of messages and discussions depending on the purpose.	Students describe the information environment, analyse it in a critical manner and function therein according to their goals and socially accepted communication ethics.
2.2. Sharing of information and content - students share with others the location and content of discovered information and respect the good practices of intellectual property protection.				
	Students share with others, according to prescribed requirements, the digital materials using the help of a tutor.	Students share information in web environments using various digital devices and respecting the requirements of the specific environment.	Students: 1) use the prescribed or self-selected web environment purposefully and safely (e.g. select a secure password, create a user profile, add materials); 2) participate in virtual networks and use the web environment for publishing digital materials in accordance with the good practices of intellectual property protection.	Students: 1) compare the advantages and setbacks of sharing digital materials (both from their own point of view and that of others); 2) analyse the value of shared information and its suitability for the target group.
2.3. Civil initiative on the web - students are involved and they involve others in community activities using ICT equipment and facilities.				
		Students purposefully use the school's educational information system and/or the e-learning environment.	Students purposefully use the information systems and e-services provided by local and central government bodies (e.g. citizens' portal, Estonian Education Information System (EHIS), document management system, ID card or mobile ID).	Students describe and purposefully use the opportunities provided by digital devices for participating in the civil society whilst respecting the socially accepted practices related to communication ethics.
2.4. Cooperation using digital technology - students use digital devices for teamwork and cooperative development of resources, digital materials and knowledge.				
	Students work with others in a predefined environment (e.g. digital communication or working offline with digital devices).	Students work with others in the form of teleworking and use, across certain projects, the digital devices and web environments designed for teamwork.	Students: 1) find and join on the Internet the required communities in the light of the learning objective; 2) where necessary, set up a new virtual community and create a web-based teamwork environment for that end; 3) create, in cooperation with other students, interactive digital materials (e.g. commenting of documents or resources, tags, supplementation of Wiki, tracing, etc.).	Students: 1) employ digital devices to apply their creativity, teamwork skills and initiative in various (innovative) projects; 2) use, based on the objective, new/different web-based teamwork services and their various functions.

2.5. Net etiquette - students apply behavioural standards and good practices in digital communication, and consider cultural characteristics and diversity while communicating.				
	Students apply the agreed behavioural standards in both private and public environments (e.g. digital communication on the web).	Students: 1) recognise the ethical principles of using and publishing information, appropriate behaviour, context and target group when engaging in digital communication; 2) explain the potential consequences of unethical behaviour in digital communication.	Students: 1) respect the legal provisions on using and publishing information in the course of digital communication; 2) explain the importance of recognising and respecting cultural diversity in digital communication (e.g. different ethnic nationalities, generations, views, choices, origin, etc.).	Students: 1) accept and value diversity and apply suitable strategies for detecting inappropriate behaviour; 2) formulate reasoned (well-argued/justified) views on ethical issues related to technological development and the use of technology.
2.6. Management of digital identity - students develop and manage their digital identity and monitor their digital footprint.				
	Students describe the opportunities and threats related to digital identity.	Students: 1) develop, manage and protect (recognise the consequences) their digital identity and digital footprint; 2) do not use the identity of other persons.	Students use their digital identity safely and ethically, and exercise caution when communicating digitally with strangers (fake identity).	Depending on the context and objective, students make use of different possibilities to manifest their identity and personal characteristics using digital devices.
3. Creation of content				
3.1. Creation of digital content - students create digital content in various formats, and modify and develop content created by others.				
	Students create and format digital materials (e.g. creative works) with the help of a tutor.	Students: 1) create, format, save and, where necessary, print digital materials in predefined formats (incl. synopsis, poster, announcement, presentation) respecting the applicable criteria; 2) copy photos, videos and audio recordings on a data medium (both physical and virtual); 3) reflect on their learning experience in an appropriate digital environment.	Students: 1) are able to handle creative work (incl. data collection, processing and analysis, and presentation of results) using a computer; 2) choose the appropriate software for collecting and processing data and presenting their research results; 3) create digital portfolios to present their learning outcomes.	Students create various types of new digital content, according to the objective, using different platforms and environments (e.g. short film, web page presenting a profession and/or hobby, etc.).
3.2. Creation of new knowledge - students modify and integrate the available digital materials to create new knowledge.				
	Where necessary, students modify digital materials (e.g. text document) created by them or others.	Students: 1) use the available open digital study materials to create new knowledge; 2) take into account the digital amendment proposals made by others (e.g. comments, tracking changes, etc.).	Students reuse and integrate available digital materials when presenting new knowledge.	Students: 1) justify the selection of appropriate methods and tools for modifying digital materials; 2) use a domain-specific software application for learning.
3.3. Copyright and licences - students respect the principles related to intellectual property when creating digital content and using conte				
	Students: 1) recognise that some digital material available on the Internet may be protected by copyright; 2) where possible, ask the author's permission to make changes, using the help of a tutor.	When creating new content, students respect the goof practices of copyright and intellectual property protection, and any licence conditions.	Students: 1) duly format the creative work and correctly refer to sources within the text; 2) where possible, ask the author's permission to make changes, using the help of a tutor.	Students: 1) recognise in their learning process and daily routines the various kinds of licence conditions applicable to programs and applications; 2) where possible, ask the author's permission to make changes, using the help of a tutor.

3.4. Programming - students use programming language to develop simple programs.				
	Students use a visual programming language to develop simple programs which contain variables, cycles, conditional sentences and procedures.	Students use a visual programming language to develop robot control software, an interactive game operated in a browser, or a mobile device application.	Students contribute to the software development project implemented under the cross-cutting topic "Technology and innovation" in the capacity of team members (programmer, designer, tester, analyst or team leader).	Students develop computer programs using a modern programming language and development environment.
4. Safety				
4.1. Protection of devices - students take safety and security measures to avoid physical and virtual risks.				
	Students: 1) use digital devices prudently at home and at school; 2) list the risks related to using digital devices; 3) ask the tutor for help where necessary.	Students: 1) protect their digital devices by implementing security measures (e.g. anti-virus and anti-malware programs, tracking applications, etc.) 2) connect and integrate various external equipment with digital devices (e.g. memory stick, mouse, printer, external hard drive); 3) follow the rules for disconnecting digital devices.	Students: 1) use digital technology purposefully and with due respect to the risks; 2) take safety measures, if the device is at risk (e.g. infected with a virus, immersed in water).	Students analyse the general rules for implementing security measures in public space and describe the required action to be taken in the case that the said rules are violated.
4.2. Protection of personal data - students recognise the privacy of other individuals and common terms of use in exercising their digital activities, and protect their personal data and themselves from Internet fraud, threats and cyberbullying.				
	Students explain in their own words why delicate information should not be disclosed (about themselves or others) in a public environment.	Students: 1) create and use strong passwords to protect their digital identity from misuse in private and public environments; 2) do not disclose delicate information about themselves or others in a public environment.	Students distinguish between the security levels of digital environments (e.g. http vs. https, security certificates) and consider them whilst using various web environments.	Students analyse and formulate reasoned positions on the impact of technological innovations on our working environment in the past, present and future.
4.3. Health protection - students avoid health risks arising from the use of digital technology and digital information.				
	Students use digital technology in a healthy manner (choose the correct sitting position, observe the duration and place of using the device, adjust the device according to light conditions to protect their eyesight).	Students explain the potential health risks of misusing digital device (addiction, joint and posture problems, deterioration of eyesight) and avoid risks related to digital technology in their daily routines - practising physical exercises (for eyes, wrists, etc.).	Students analyse the impact of technology on daily life and the environment, and strike a balance between the use of digital and physical environments.	Students: 1) assess health risks related to using digital devices (from ergonomic aspects to technology addiction); 2) draw conclusions as to how the digital environment could make life better or worse based on how it is used and which rules are followed.
4.4. Environmental protection - students acknowledge the environmental impact of digital technology.				
	Students give examples and associate technology use with environmental protection.	Students: 1) list the positive and negative environmental effects of using digital technology; 2) use digital technology in an energy- and resource-efficient manner.	Students: 1) analyse the positive and negative environmental effects of the development of digital technology (e.g. on the natural, economic, cultural environment, etc.); 2) make reasoned decisions when choosing digital technologies (e.g. when creating and consuming information, buying or repairing equipment).	Students formulate their position in a reasoned manner and provide an opinion on environmental issues related to the use of digital technology (e.g. opportunities, problems).

5. Solving of problems				
5.1. Solving of technical problems - students use troubleshooting techniques to identify technical problems and find possible solutions (from simple troubleshooting to more complex problems).				
	If a digital device or application fails to operate, students seek assistance and describe the encountered problem.	Students independently (if necessary, according to instructions) identify and solve simpler problems which occur when digital device, programs or applications fail to operate.	Students: 1) find information and assistance for solving technical problems and for troubleshooting, using predefined sources; 2) find alternative solutions in the course of problem solving.	Students: 1) independently find information and assistance for solving technical problems and for troubleshooting, using various sources; 2) guide others in clearing simpler technical problems and finding solutions.
5.2. Identifying needs and finding the corresponding technological solutions - students select and critically assess the appropriate technological possibilities and digital solutions according to their needs.				
	Students select the appropriate digital solution for solving the provided tasks with the help of a tutor.	Students: 1) assess the suitability of the selected digital device or application in view of its functionality; 2) recommend digital devices to the group in the course of teamwork exercises and work with the device chosen by the group.	Students: 1) use purposefully and creatively the possibilities offered by digital technology to solve real-life problems and making their learning process more effective; 2) describe the functioning and development trends of technology in various areas of life.	Students analyse, based on the needs, the effectiveness and impact of using various digital technologies, and make decisions and recommendations based on such analysis.
5.3. Innovation and creative use of technology - students creatively use technology for expressing themselves and finding innovative solutions to problems.				
	Students use digital technologies for creative purposes subject to teacher's guidance.	Students use digital devices purposefully to present or solve a task which interests them or others.	Students: 1) use digital devices for solving problems and initiate teamwork for developing creative and innovative solutions; 2) use digital devices to solve issues arising in various fields of daily life which require mathematical and logical thinking; 3) use the possibilities of digital technology for expressing themselves and creating knowledge.	Students: 1) participate in an innovative development project in cooperation with fellow students and/or a technology company; 2) explain the reciprocal effects and interconnections of technological, economic, social and cultural innovation.
5.4. Identifying the gaps in digital competence - students are up to speed with the latest developments in digital technology, consistently identify the gaps in their digital competence, develop themselves and support others in building digital competence.				
	Students describe in their own words the level of their digital competence and development possibilities using the help of a tutor.	Students: 1) control their learning process in the field of digital technology with the help of a tutor; 2) are up to speed with the latest developments in digital technology in line with their needs.	Students: 1) analyse the digital competencies necessary for attaining their goals; 2) identify the gaps in their digital competence and envisage the required action to eliminate such gaps.	Students: 1) assess and reflect on their digital competence and experience in using digital technology, and knowingly plan digital competence building; 2) advise and support others in digital competence building.

Source: Republic of Estonia Ministry of Education and Research (2016)

3.1.3-2 HITSA

This section will summarize the results of interviews with Heli Aru-chabilan, Chairman of the Management Board, and Elo Allemann, Head of Innovation Center of HITSA (Information Technology Foundation for Education).

As already mentioned in the Estonia section in Chapter 1, HITSA is a non-profit organization that was established in 2013 with the merger of the Tiger Leap Foundation, EEnet (The Estonian Education and Research Network), and the Estonian Information Technology Foundation to promote the use of information and communications technology in education and to support the training of talented IT specialists (HITSA, 2018). Thus, HITSA is engaged in a variety of efforts to improve the digital skills of all people in Estonia, starting with students and teachers. Of these, here we will introduce the 3 initiatives of education support programs, teacher training, and self-assessment frameworks.

(1) Education Support Program

This program aims to promote and strengthen cooperation between the ICT industry, universities, other educational institutions, and the state. There are two educational support programs, the ProgeTiiger program and the Study IT in Estonia program, handled by HITSA.

① ProgeTiger Program

In 2012, programming and robotics (robotics engineering) were introduced into school education in Estonia, and the ProgeTiiger program also commenced with the financial support of the Ministry of Education and Research in the same year (HITSA (Date of publication unknown) a). The ProgeTiiger program is operated by HITSA with the purpose of encouraging the use of technology (including programming and robotics) by teachers, from the perspective of expanding children’s future prospects (ibid.). Through this program, various opportunities are provided to integrate technology into training courses for in-service teachers, subject-based mock lessons, learning materials, curricula, etc. Financial assistance is also provided for equipment to be introduced into schools (ibid.).

② Study IT in Estonia Program

Study IT in Estonia (StudyITin.ee) is a program operated in cooperation between the state, universities, and the IT industry with the purpose of training skilled ICT specialists within higher education institutions. This program is operated by HITSA, with financial support from the Ministry of Education and Research and Skype[40] (ibid.).

(2) Teacher Training Program

In Estonia, it is not compulsory to attend in-service teacher training, and schools and individual teachers can decide whether they will participate in training. A basic ICT-related teacher training program has been implemented since 1997 by the TigerLeap Foundation as part of its TigerLeap Program (HITSA, (Date of publication unknown) b). In 2017, about 4,000 teachers (about 30% of the teacher population) participated in training provided by HITSA throughout the year (HITSA, 2018).

In the training, teachers learn about new teaching methods, new approaches to learning, methods for supporting learning with the use of ICT tools, etc. (European Schoolnet, 2015). Participants can select the courses that match their needs from among more than 50 courses in the training program (ibid.). The training program is also divided into categories in the following 6 areas (ibid.).

- Creating teaching materials using digital resources
- Learning processes in the digital age
- Digital learning environment and resources
- Teacher professional development
- Technology education
- Management of educational institutions in the digital age

All courses can be taken free of charge with funding from the Ministry of Education and Research, and 70% of the courses are conducted at the school.

(3) Self-Assessment Framework

Digital Mirror,[41] which is under development by HITSA, is an online tool for assessing to what extent digital tools including ICT are used in teaching and learning. Thietool consists of 3 pillars (objectives) and 5 assessment criteria. The tool is still being developed, but once completed, schools will be able to conduct self-assessments of their use of digital tools and will also be able to assess each other, using this as an effective tool for clearly understanding what issues there are and where they need to make improvements.

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[40] https://www.hitsa.ee/it-education/grants/skype-and-study-it-in-estonia-master-s-scholarship/statute
[41] https://digipeegel.ee/

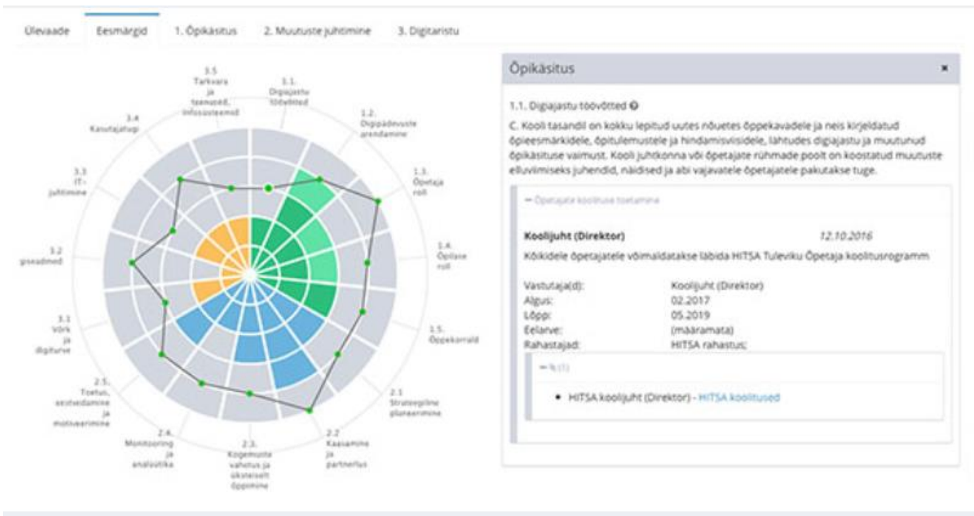
The 3 Pillars of Digital Mirror

1. Preparation for digitization (promotion of BYOD, spread of Wi-Fi, provision of technical support, etc.)
2. Improved teaching (enrichment of learning environment, resources, etc.)
3. Operational reforms (improved school objectives/policies, learning systems)

5 Assessment Criteria

1. Alternatives: Are digital tools being used in conventional teaching methods?
2. Reinforcement: Have new teaching methods been tried using digital tools? Is information exchanged between teachers?
3. Improvement: Have school learning systems been transformed into a framework based on scientific evidence? Have students been involved in this reform?
4. Integration: Is technology being widley used in school activities and learning? In that process, are students giving their own opinions and acting on their own learning environment?
5. Application: Are all learning activities, not only those at school, carried out digitally? Have efficient learning methods been developed, and are children taking responsibility for their own study plans and are they able to teach each other?

Fig. 3.6 Example of school conducting self-assessment with Digital Mirror



3.2. Examples of ICT use in Norwegian Education

This section will summarize and organize the results of our study in Norway conducted as part of the collection of reference information to promote ICT utilization in Japanese schools.

3.2.1. Study Overview

3.2.1-1 Targets

For the 2018 study, we visited 2 schools in Oslo city (1 primary school and 1 lower secondary school) to see how ICT is used in primary and secondary schools in Norway. In addition to the visits to the schools, we also conducted interviews with policy makers at the City of Oslo Education Agency, Norwegian Directorate for Education and Training, and Oslo University.

Fig. 3.5 School Study Visits

Date of Visit	School Visited	School Type
Thursday, November 15, 2018	◆Smestad skole visit ◆City of Oslo Education Agency interview ◆Haugerud Ungdomsskole visit	Primary School (Grades 1–7) Lower Secondary School (Grades 8–10)
Friday, November 16, 2018	◆Norwegian Directorate for Education and Training interview ◆Oslo University interview	

3.2.1-2 Study Items

The focuses of the school visits and interviews in Norway were the same as those for the Estonia study (see Fig. 3.2, p. 41). The main areas of focus during the school visits were the 4 areas of the state of ICT equipment introduction, network environments, examples of ICT use in learning, and digital teaching materials. In addition, the main focuses of the interviews at the various institutions were the 5 points of the objectives of ICT use in school education, improvements in learning effectiveness due to ICT use, the measurement of ICT skills, teacher training, and the relationship between ICT and PISA reading comprehension.

3.2.2. Results of School Study Visits

3.2.2-1 Smestad skole (Primary School)

Smestad skole is a primary school located in the Ullern district, about 5 km northwest from central Oslo. Near the school is the Vigeland Park, which is a well-known tourist destination for its line of statues representing “Aspects of Life.”

The school has about 700 students and about 40 teachers. Each grade is organized into 4 classes, with each class containing about 25 children. At Smestad skole we were guided on our visit by Lene Rønning-Arnesen, Principal of the school (second from the right in the photo), and Katrine Kristiansen, Inspector of the school (far right in the photo). In addition to them, we also had a group interview with 6 teachers at the school and 2 Grade 5 children.

Smestad skole website (Norwegian): https://smestad.osloskolen.no/

School building located in a quiet residential area in the suburbs of Oslo

(1) State of ICT Equipment Introduction

At this school, each student has been lent an iPad from the school for free for 3 years, as part of a new initiative to introduce ICT equipment. Children in Grades 1 through 5 use iPads, but children in Grades 6 and 7 find it difficult to use iPads without Microsoft Word, Excel, etc., in their learning activities, so they use PCs.

Generally, children bring their own headsets, but the school does have some headsets that can be borrowed. Teachers are lent headsets from the school, and other needed equipment is basically provided by the school.

Teachers also prepare assignments where iPads are not needed because some children may forget to bring their iPads to school.

(2) Network Environment

In Norway, primary schools and lower secondary schools are owned by the local governments, and each local government is responsible for providing the schools with ICT infrastructure and access to digital learning resources (European Schoolnet, 2018).

The City of Oslo was responsible for the introduction of ICT equipment at this school (ibid.), and there is a full network environment consisting of Wi-Fi installed in each classroom.

(3) Examples of ICT Use in Learning

Smestad skole uses applications and software based on the contents of each class. A teacher at the school said that “the advantage of ICT is that it makes it possible to provide guidance to each student based on their different proficiency levels, and to give the appropriate volume of tasks to children at the appropriate time.”

The objectives to be achieved in each grade using ICT are defined by the Norwegian government in its Digital Skills Framework (see Fig. 3.6).

① Mathematics Class (Grade 1 (5–6-Year-Olds))

Children were thinking about combinations of 2 numbers that add up to 10 and were doing a task to find them. When children found a combination that added up to 10, they drew the numbers on the iPad screen. For example, as shown in the photo on the right, they would draw “7+3” or “9+1” on the iPad screen. It was not so that the classroom teacher wrote the answers on the blackboard and had the children write them down, but the students themselves were thinking about the arithmetic process and recording it, clearly showing that ICT was being utilized well in this class.

Learning with an iPad

② English Class (Grade 2 (6–7-Year-Olds))

In the English class of Grade 2, the children greeted us with “Ohayo Gozaimasu” (Good morning in Japanese), and were working on creating an English book using an application selected from the online teaching material collection Epic![42] Epic! can be used for free at school, but costs money to use at home. Each child created an original book by using the application to edit text, insert images, and insert voice and sound effects.

Work posted on the classroom wall

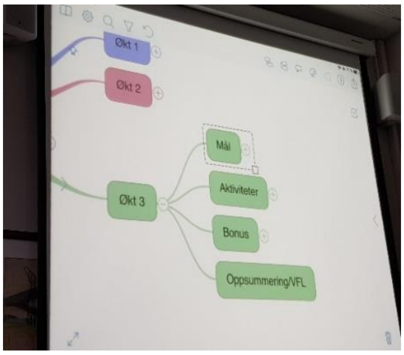
The handwritten compositions of the children were displayed on the walls of the classroom. This was the result of a process of the children writing their sentences on an iPad, having the teacher correct them 2–4 times on a tablet, and then the children writing

[42] https://www.getepic.com/

the final deliverable onto paper by hand.

③　Norwegian Class (Grade 3 (7–8-Year-Olds))

The Grade 3 Norwegian class took the approach of projecting for the children a schematic of the lesson plan with a so-called “Mind Map” at the beginning of the class. By providing not just verbal but also diagrammatic instructions, children better understood the concrete flow of the class, which likely promotes effective learning. The teacher said that they believed that these Mind Maps were mainly effective for lower-grade children.

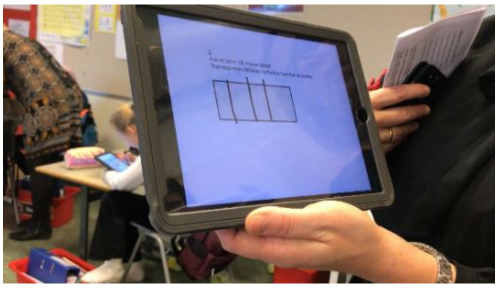


Mind Map (class plan)

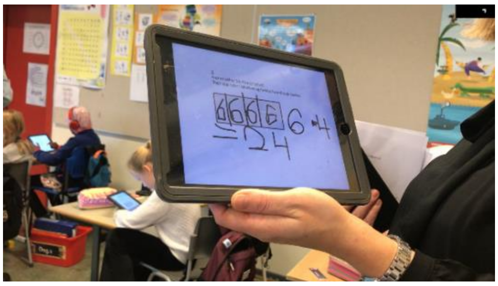
④　Mathematics Class (Grade 4 (8–9-Year-Olds))

In the Grade 4 math class, as with the Grade 2 class, the children were asked to explain how they solved problems and learned how to think through the process of deriving their solutions. In this class, they were using an application called Explain Everything[43] that had been introduced just a few weeks earlier. This is an application that allows teacher and student to create videos of the learning process (problem solving process) for the benefit of math learning. The children created a single video of the process leading to the solution, adding their voice, formulas, and auxiliary lines to the diagram, as well as various memo information. As soon as children finished their assignment, the completed video was converted into a PDF file format and submitted to the teacher.


During the lesson



43 https://explaineverything.com/



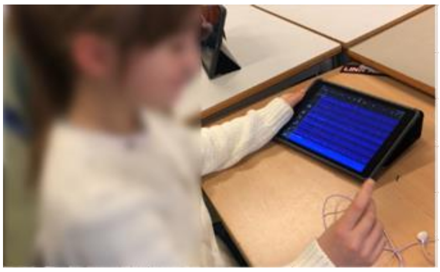
Upper/Lower Left: Children making videos

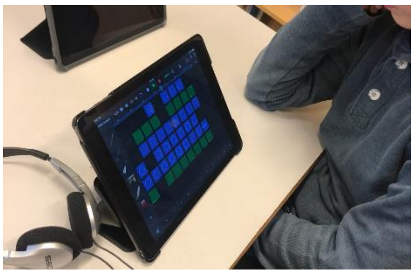
Upper/Lower Right: Screen of videos received by the teacher from the children

In classes taught by this teacher, they were always using some kind of application, with about 5–8 applications used depending on the type of assignment. Microphones were also installed at each child's seat for children with hearing impairments, and the teacher also wore a headset so that the children's voice could be heard well.

⑤ Music Class (Grade 5 (9–10-Year-Olds))

The main learning contents of this class was making music and arranging it (mixing) on the iPad using an application called GarageBand.[44] The children thought about the instruments and rhythms that they wanted to use, selected them in the application, and made a short piece of music about 1 minute long. They also mixed together some of the songs that they had already created to create new songs. Each child was focused on their task using headphones or earphones, so in spite of it being a music class, the classroom was very quiet. The teacher said that the children were having a lot of fun with this assignment, and the children were all concentrating on their compositions without chatting. The children were also really pleased with the songs that they had created and arranged, with some children showing off their music.





Left: Classroom during lesson

Center/Right: Children playing music

(4) Digital Teaching Materials

As mentioned above, this school uses various applications, such as the following, as

[44] https://itunes.apple.com/jp/app/garageband/id408709785?mt=8

teaching materials in learning activities.

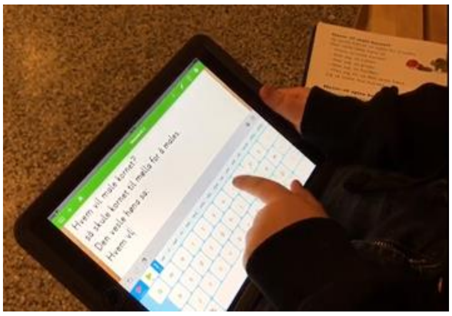
- Book Creator[45]: Children create their own books incorporating text, photos, pictures, sound, video, etc.
- Epic![46]: Create English books with attached sound files.
- Mentimeter[47]: Create fun and attractive presentations incorporating questions, voting, quizzes, slides, images, GIFs, etc.
- Explain Everything: Create explanatory videos.

When asked about the strengths and weaknesses of using digital teaching materials, a teacher noted the strength of “access to a lot of teaching materials with ICT” and the weakness of “children always wanting to use YouTube or social media.” Applications have been developed to deal with such problems, and Google Classroom,[48] for example, can monitor the use of inappropriate applications by children.

The budget for the introduction of digital equipment and teaching materials depends on local government funding, but the distribution is determined by the school leader.

(5) Teacher Training

The City of Oslo provides optional training for teachers on how to use iPads and applications. Some schools organize training by asking private companies to come to their schools for training, while some visit another school to conduct joint training. Teachers that participate in training share what they learned with other teachers at their school.



Child using an iPad

When teachers were asked what kind of training they thought was necessary for the use of ICT in classes, their responses were training to support the children’s learning, methods for providing feedback useful to learning, how to use applications and iPads most effectively, etc.

(6) Other

This school uses showbie[49] to monitor child progress in learning tasks, homework assignments, etc., and for daily communication between students and teachers. Showbie is an application developed by a Canadian company and is a very popular in Canada and Norway. Each teacher is responsible for the management of showbie. Parents can access showbie through their children’s account.

Homework is usually given using ICT, but paper homework may be given at the discretion of the teacher.

45 https://bookcreator.com/
46 https://www.getepic.com/
47 https://www.mentimeter.com/
48 https://edu.google.com/intl/ja/products/classroom/?modal_active=none
49 https://www.showbie.com/

3.2.2-2 Haugerud Ungdomsskole (Lower Secondary School)

Haugerud Ungdomsskole is a lower secondary school located in the Alna district about 10 km northeast of the central Oslo. At our visit to Haugerud Ungdomsskole, we were guided by Kiell Antvort, ICT Leader[50] of the school.

Haugerud Ungdomsskole Website (Norwegian): https://haugerud.osloskole

Trosterud school (Primary School) is next to the school ground

(1) State of ICT Equipment Introduction

Like Smestad School above, this school has also purchased iPads and lend one to each student free of charge. PCs are also lent out to students as necessary for programming classes, etc. If a student damages the iPad, the school will lend a new one free of charge up to 2 or 3 times. The management of ICT equipment and applications at this school is handled by the ICT Leader.[51]

This school also has other equipment such as a machine that manufactures cups, etc. from plastic, a machine that prints on fabric, 3D printers, etc.

(2) Network Environment

Wi-Fi is installed in the ceilings of each classroom. The Wi-Fi connective environment is good, and unless there is a problem throughout the City of Oslo, there should no problems with the school Wi-Fi, and there have not been so far.

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50 Manages ICT equipment and provides advice to other teachers on how to use ICT in learning.

(3)　Examples of ICT Use in Learning

This school uses ICT in learning to increase both student motivation and learning opportunities. We visited a Grade 10 programming class for a specific example of this use.

3D printers

①　Programming Class (Grade 10 (14–15-Year-Olds))

The programming class is normally a 1.5-hour class of 16 students, but on the day of our visit, there was a special class of 7 students. The programming task for this day's class was to program a small flashing traffic light on the computer.

In this class, the teacher first explained the blinking mechanism of traffic lights with a projector onto the whiteboard at the front of the class, and showed the students the assignment and tasks for the class. The students consulted with each other and proceeded by themselves to do the programming through trial and error.

Programming class

After this, OneNote[51] was shown on the screen to show the students the correct way of doing the programming. Students uploaded their progress to OneNote, took a screenshot of the programming code, and sent it to the teacher. In this way, the teacher grasped the progress of the students, and could provide extra assignments to students that finished the task early. More details will be described later in Chapter 4 (see 4.1.2). At this school, other subjects than programming also progress in a similar manner using ICT such as OneNote, etc.

(4)　Digital Teaching Materials

The main effective digital teaching materials used at this school were the 3 applications Kahoot![52] Mentimeter, and Quizlet.[53] Kahoot! and Quizlet are mainly used in social science subjects, while Mentimeter is used in mathematics. Of these, a teacher we interviewed said that using Kahoot! had increased the interaction between teachers and students, leading to improved learning.

Guidelines are provided by the Oslo City Council on the selection of software for use

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51 https://products.office.com/ja-jp/onenote/digital-note-taking-app
52 https://kahoot.com/
53 https://quizlet.com/ja

in school education, but their use in each subject is decided by each school and teacher. The software is provided by the city free of charge.

(5) Teacher Training

Training on the use of ICT is also carried out in the school, but it is necessary to participate in training outside of the school to learn more advanced ICT utilization methods (such as programming, entrepreneurial skills, etc.). However, many of the teachers are so busy that they are not currently able to participate in such training. Based on requests from teachers, the school provides financial assistance for participation in outside training.

(6) Other

The learning information management system used in this school is called itslearning,[54] which manages learning assessments all together. In addition to itslearning, teachers in each class also use the above-mentioned OneNote at their own discretion. Itslearning has more features than OneNote and is capable of managing all kinds of information such as student profiles, grades in each subject, lesson plans, necessary teaching materials, homework submission status, future events, letters from the school, etc., and because of its communicative functions, it is also often used as a communication tool between the school and parents. However, the school recommends the use of text messages (SMS) when reporting to parents, as some parents are not familiar with the use of ICT.

3.2.3. Interview Study results

3.2.3-1 Norwegian Directorate for Education and Training

The Norwegian Directorate for Education and Training is an administrative agency of the Norwegian Ministry of Education and Research, responsible for the development of pre-school, primary, and secondary education. Its purpose is to guarantee that all Norwegian children receive quality education.

This section will summarize the results of an interview with Senior Advisor Morten Søby of the Norwegian Directorate for Education and Training.

(1) ICT Education Policy

After the 1980s and 1990s when IT use at all school levels in Norway took effect, descriptions of digital technologies have been included in the educational policy. The "Action Plan for ICT in Norwegian Education – Plan for 2000 to 2003" (MERCA, 1999) was enacted in 2000, which further strengthened the use of ICT in school education. In 2003, the Programme for Digital Competence was adopted, and it was enacted the

[54] https://itslearning.com/global/

following year. Under this policy, 1 of the 5 basic skills to be learned by students, namely "the ability to use digital tools," defined digital competence through the use of ICT. Following this, along with The Knowledge Promotion[55] in 2006, the new national curriculum required all schools to utilize ICT in all subjects (Krumsvik, 2011). Then, with the revision of the national curriculum in 2012, digital skills were defined as 1 of the 5 basic skills (Norwegian Directorate for Education and Training, 2012), and the direction of ICT policy was clarified with the 2016 white paper "Digital Agenda" (Norwegian Ministry of Local Government and Modernisation, 2016). Under this Digital Agenda, the following 5 priorities are set.

1. ICT that puts the user first
2. ICT that improves innovation and productivity
3. Strengthened digital competence and inclusion
4. Efficient digitization of public institutions
5. Appropriate data protection and information management

The Norwegian Ministry of Education and Research has also implemented a digital strategy for primary/secondary education and vocational education in the period 2017–2021. This strategy involves the following 2 major objectives (European Schoolnet, 2018).

- Students develop necessary digital skills to participate in society and to succeed in private life, education, and work.
- Schools effectively use digital technologies and digital resources to improve learning outcomes of students.

This digitization strategy is not only aimed at learning how to use digital tools but also emphasizes the need for digital competence to include elements such as critical thinking, technical understanding, basic skills, and social skills etc. (ibid.).

Various ICT-related policies are currently being promoted under these educational policy reforms for primary and secondary education in Norway.

Also, a new national curriculum that will come into effect from 2020 will have the purpose of furthering the 2006 knowledge promotion reforms, with the goal of strengthening the integration between digital technologies and each subject. One example of this is the

[55] https://www.regjeringen.no/globalassets/upload/kilde/kd/bro/2006/0002/ddd/pdfv/292311-kunnskapsloftet2006_engelsk_ii.pdf

strengthening of programming (Norwegian Directorate for Education and Training, 2018a).

- Increased coding and programming in multiple subjects
- Provide programming as an elective subject at all schools

Since fiscal 2016, the Norwegian government has experimentally introduced programming as an elective subject in lower secondary schools (European Schoolnet, 2018). This effort is a 3-year pilot and will be evaluated in 2019 (ibid.). The main aim of this introduction is to contribute to an improvement in programming skills and to provide deep learning opportunities for interested students. It has been decided that programming will be introduced as an official elective by fiscal 2019 (ibid.). Also, by 2020, programming will be integrated into other classes such as mathematics and music (Norwegian Directorate for Education and Training, 2018a).

(2) ICT Skills

① Student ICT Skills

The framework for students' digital skills is classified into the 4 subcategories of exploration and processing, creation, communication, and digital judgement (Norwegian Directorate for Education and Training, 2012: 12).

Based on this digital skills framework, the Ministry of Education and Research has determined that these are indispensable in learning activities, and that ICT should be part of the learning activities for all students at all levels of primary and secondary school (European Schoolnet, 2018).

② Teacher ICT Skills

Regarding the development of teacher ICT skills, the Norwegian government announced the "Teacher Education 2025 – National Strategy for Quality and Cooperation in Teacher Education" in 2017. This strategy emphasizes the need for teachers' professional digital competence so that they are able to evaluate new teaching and learning methods using digital technologies (European Schoolnet, 2018).

The teacher ICT skills framework "Professional Digital Competence Framework for Teachers" (SENTER FOR IKT I UTDANNINGEN, 2017) was issued as a National Guideline in 2017. This framework consists of the following 7 competence areas (fields), including descriptions of the knowledge, skills, and competencies required (ibid.).

- Subjects and basic skills
- Schools in society
- Ethics
- Pedagogy and subject didactics
- Leadership of learning processes
- Interaction and communication
- Change and development

This framework is used by teacher educators and policy makers for the development of national and regional frameworks for teacher training, the planning and implementation of teacher training and in-service training, and the evaluation and follow-up of teacher professional digital competence. This framework itself was also created based on white papers, the basic skills framework, the national curriculum, the national qualification framework, and teacher guidelines framework (ibid.).

(3) Measurement and Assessment Measures

Like Estonia, Norway is currently in the process of developing and improving methods measure the ICT skills of students, and to evaluate learning using ICT. Below we will look separately at ICT skills measurement and the evaluation of learning using ICT.

① ICT Skill Measurement

National Test (Digital Skills)

The measurement of digital skills began with the start of large-scale testing on the local government level in 2007. After this, a national level measurement test was launched in 2013, targeting Grade 4 and measuring digital judgement (see Fig. 3.5 “Digital judgement”), digital production (see Fig. 3.5 “Produce”), digital communication, and general software usage skills among students. National level tests have been also introduced for Grade 8 since 2015 (Norwegian Directorate for Education and Training, 2018b). The main purpose of this national test is to identify low-performing students and to measure learning results. Participation is voluntary (ibid.).

In addition to the national test, the City of Oslo also conducts testing of students in Grades 6, 7, and 10 (ibid.).

Monitor Surveys

Optional questionnaire surveys called monitor surveys have been conducted measure overall progress in ICT use in Norwegian schools. These surveys have so far been held 7 times, in 2003, 2005, 2007, 2009, 2011, 2013, and 2016 (held every two years from 2003 to 2013), and were conducted at a total of 650 schools (Norwegian Directorate for Education and Training, 2018b). Until the 2013 survey, subjects of the survey were Grades 7, 9, and 12 children/students, teachers, and school leaders, but the 2016 survey targeted Grade 7 children/students, teachers, and school leaders. These monitor surveys are currently conducted by the ICT Center of the Norwegian Ministry of Education and Research (ibid.).

In addition to the monitor surveys at schools, tMonitor Family surveys were also conducted in the past. Questionnaire surveys were carried out in 2013 and 2015, targeting parents (families) of preschool children. Qualitative surveys were also conducted in 2010 and 2012 (ibid.).

The monitor surveys measured the 4 areas of ICT usage, digital maturity, digital competence, and ICT use in mathematics. 3 areas of improvement were identified as future challenges from the results of the 2016 survey. The first is the development of the concept of “digital maturity.” The second is supplementing the monitor surveys with relevant data (e.g., Feide (single sign on platform), survey candidate logs, and other surveys). The third is improved measurement and understanding of digital competence (ibid.).

② Assessments based on ICT

National Test (National Unified Test)

A National Quality Assessment System was established in 2004, prior to the revision of the curriculum in 2006 (OECD, 2011). As part of this, as a first measure, the National Test was introduced in that same year (ibid.). The National Test is held every fall for students in Grades 5, 8, and 9, and testing is mandatory for all students. In Grades 5 and 8, 3 subjects are tested in Norwegian, English, and Mathematics, and in Grade 9, Norwegian and Mathematics are required. This National Test has been carried out on computers since its inception. The development and implementation of such online type tests is consigned to Inspera (Inspera, 2019).

Fig. 3.6 Framework for Digital Skills of Students in Norway

Digital skills as basic skills

Field of skills	Level1	Level2	Level3	Level4	Level5
Search and process	Can read hypertexts and simple interactive information. Can use picture- and iconbased navigation.	Can make simple digital searches, and read and interpret information from digital sources. Can use simple digital resources and tools for information processing and learning.	Can choose and use search strategies and assess information from digital sources. Can use different digital tools and resources for information processing and learning.	Can filter, transform and collate information from digital sources. Can use relevant search tools and master search strategies in subject-related tasks.	Can find, organize and update digital information. Can use advanced search strategies and sources in subject-related work.
Produce	Can write simple texts on keyboard and produce simple composite stexts. Knows simple digital use of sources and copyright rules.	Can produce digital composite texts following simple formal requirements. Can make use simple use of digital sources observing copyright rules, also in re-use, and further development.	Can make digital composite texts with linked content. Can understand and use digital formal requirements in one's own texts. Can refer to digital sources and apply copyright rules.	Can produce and edit complex digital texts. Can refer to and assess digital sources in relevant subject-related situations.	Can choose and use target group relevant digital tools and digital formal requirements. Can administer copyright rules to one's own digital products and master digital source referencing.
Communicate	Can use simple digital tools and media for presentation and communication.	Can use a selection of digital tools and media for presentation and communication.	Can make varied use of different digital tools and media to convey a message both in one-to-one and group communication.	Can use digital media and tools to convey a clear and detailed message for communication and documentation.	Can choose, assess and apply digital communication tools according to different subjectrelated needs.
Digitaljudgement	Can follow basic rules for digital interaction. Knows basic rules for protection of personal privacy on the Internet.	Can apply basic netiquette and knows about rules for protection of personal integrity on the Internet.	Can apply netiquette and follow rules for protection of personal integrity on the Internet and in social media.	Can use the Internet and social media efficiently and appropriately.	Can reflect ethically on and assess the Internet and social media as a communications and information channel.

Source: Norwegian Directorate for Education and Training (2012)

3.2.3-2 City of Oslo Education Agency

This section will summarize the results of an interview with Bjarte Rørmark, Assistant Head of the Department of Department of Educational Quality and Development at the City of Oslo Education Agency.

(1) School Education and ICT Policies in Oslo City

There are 170 schools in Oslo City: 78 primary schools, 28 integrated primary and lower secondary schools, 26 lower secondary schools, 1 secondary school, 22 upper secondary schools and 15 special support schools. There is a total of 87,000 people in primary education, secondary education, and adult education, 3,400 vocational trainees, and 22,000 children in childcare. There is a total of 15,240 educators, of which 12,244 are full time. There are 8,571 teachers, of which 7,647 are full-time teachers.

Oslo City is culturally diverse with a large number of immigrants, and 40% of students in Oslo speak a language other than Norwegian as their native language. Thus, language is a future challnege in the field of education, but as Assistant Rørmark notes, this may be resolvable with ICT.

The ICT Section of Oslo City is roughly divided into two sections, with the City Council/City Government/Department of Education mainly in charge of hardware and infrastructure, etc., while the Education Agency/Director/Assistant Director make policy decisions on how students actually use them. As can be seen from the results of the school visit in 3.2.2, ICT is used at schools in Oslo for school management and for the management of student learning, and the city actively recommends the incorporation into learing of applications developed around the world.

3.3. Summary

In the 2018 field study, in addition to our school visits in Estonia and Norway, interviews were also carried out with policy making agencies in both countries, and it was possible to learn about actual trends in the use of ICT in educational settings in each country. The following is a summary of information that may be useful with reference to the introduction of ICT in Japan. First, as a major premise, even in Scandinavia with its advanced digitization, the effective use of ICT in schools is still in development, and given this, we think it is important not to look to “learn from Scandinavia” but rather to “learn with Scandinavia,” not to imitate them but rather to examine their strengths and weaknesses in view of the educational objectives of Japan in the introduction of ICT.

3.3.1. ICT Development

Strengths

In both Estonia and Norway, all students receive ICT devices (iPads and computers), and Wi-Fi is installed throughout schools. This makes it possible for students to smoothly use ICT in learning. Teachers are also able to access a variety of digital teaching materials free of charge, making it possible to develop a variety of classes.

Estonia is also working to allow upper secondary education to be completed remotely using ICT.[56] This is expected to reduce truancy while also decreasing the burdens of students who need special support.

Weaknesses

ICT equipment is expensive, and it also costs money to update the contents of digital teaching materials (applications, etc.). Since there are constantly new digital teaching materials becoming available, teachers need to always be learning how to use them but given that they are already busy with their normal work, they don’t have time to participate in training to learn how to use them. It is also necessary to take care of safety and information management (outflow of personal information) via public Wi-Fi.

Regarding distance learning, while this can solve the problem of truancy, a major issue remains with the burden on teachers having to prepare and evaluate tasks rather than engaging in the teaching itself.

Proposed Improvements

For ICT equipment that require expensive and frequent updates, measures such as equipment rental can be taken. This will be implemented in Oslo. The regular inspection and updating of ICT equipment being used will lead to improved information management and security, and switching from computers to tablets allows more flexibility in equipment selection based on the class.

With regard to digital teaching materials, a process with the city or local government selecting teaching materials for easy in-class use in advance, making a list of them, and allowing teachers to select which ones to use can facilitate trainings without the need to confuse organizers and removes the need for teachers to attend an unspecified number of training courses. The City of Oslo makes a list of applications that can be used as teaching materials, and there is a measure to allow the use of applications not included on the list through negotiations with the city.

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[56] https://www.hm.ee/sites/default/files/summary.pdf

Also, for distance learning, in addition to examining the causes of the burden experienced by teachers, improvements can be made by securing human resources and reviewing working hours to make up for the lack of time and manpower that we already know exists.

3.3.2. Clarification of Objectives

Strengths

Both Estonia and Norway have clearly defined objectives for the use of ICT in their own education white papers, etc., and each has clearly defined objectives for the improvement of learning skills (improving the ability to think independently) when using ICT equipment, and for the improvement of digital skills.

Regarding the improvement of digital skills, there are indicators for each school level (Grade), and specific objectives are shared between schools and teachers. Tests have also been developed to measure these digital skills.

Weaknesses

Both Estonia and Norway are in the early stages of studies on the effectiveness of ICT equipment and whether learning with computers and tablets exceeds learning with paper and pencil in terms of effectiveness and results, so there is still little scientific evidence that learning with ICT is more beneficial than conventional methods. The definition of digital skills is also still under development (for example, Digital Maturity) as these need to be established.

Proposed Improvements

It is necessary to verify the effects of learning with ICT and increase the number of quality studies. In Japan, we need to collect prior studies from Europe and the United States, and analyze them in consideration of Japanese circumstances and need to conduct research that matches our own current circumstances. In doing so, there is a need to confirm the definitions of “digital skill indicators” and “learning effects in ICT” in line with the educational objectives of Japan, and to develop tests based on this to measure digital skills and each subject.

3.3.3. Diversity of Use

Strengths

In both Estonia and Norway, ICT is used not only for learning but also for the management of student learning information. These learning information management systems are used for the submission of learning tasks, the management of learning progress, feedback, assessment and measurement, and daily communication, and they are a sites for interaction among teachers, students, and parents. Teachers in both countries also felt that using such learning information management systems made it possible to provide more detailed approaches and support for each individual student.

Weaknesses

The use of a single management system to gather all information like in Norway and Estonia has the risk of all personal information leaking at once in the event of an information leak. Also, given that learning management systems are constantly being updated, while the addition of new functions is convenient, it can also make them difficult to use.

Proposed Improvements

Also in Japan, it has been noted that "the development of new methods is desired for the qualities and abilities that need to be nurtured in new courses of study, in learning activities related to self-assessment that utilize formative evaluation, performance evaluations, portfolios, etc. By using ICT for this, it is expected that it will be possible to grasp information about learning outcomes that previously could not be grasped, and to realize a method more accurate than conventional assessment methods" (Ministry of Education, Culture, Sports, Science and technology, 2017: 24). The learning information systems used in Estonia and Norway may be effective to this end. However, this would require the establishment of safe learning information management systems and enhancement of training for teachers (including reduced working hours and financial assistance). It is also expected that it would be necessary to deploy ICT specialists, such as IT specialists and IT leaders, in each school for teachers that have difficulty using the system. As such, it would be helpful to understand what kinds of specialties experts in other countries have, and what their working conditions and environments are.

References

・City of Oslo Education Agency (2018) Visit from Japan – PISA <https:// cgi-bin/cbgrn/grn.cgi/mail/file_download/-/Microsoft+PowerPoint+-+Japan%2C+november+2018.pptx.pdf?mid=1639118&fid=0&pids=&hash=e88d1d8e866467c3c482055aacd44ba7cc1e2f44&.pdf> Last access June 24, 2019

・Dai Nippon Printing Co., Ltd. (2015) Study of Programming Education in Other Countries: MEXT 2014 Information Education Leadership Improvement Support Project – Report, Dai Nippon Printing (in Japanese)

・e-estonia (Date of publication unknown) other-school solutions <https://e-estonia.com/solutions/education/foxcademy/> Last access June 21, 2019

・European Commission (2019) Eurydice: Norway National Reforms in School Education <https://eacea.ec.europa.eu/national-policies/eurydice/content/national-reforms-school-education-48_en > Last access June 21, 2019

・European Schoolnet (2015) Country Report on ICT in Education: Estonia

・European Schoolnet (2018) Country Report on ICT in Education: Norway

・Freedom House (2014) Estonia <https://freedomhouse.org/report/freedom-net/2014/estonia> Last access June 21, 2019

・Gustav Adolfi Gumnaasium (2015) *Gustav Adolf Grammar School – Tallinn ・Estonia (Leaflet)*.

・HITSA (Date of publication unknown a) IT EDUCATION: Educational programmes <https://www.hitsa.ee/it-education/educational-programmes> Last access June 21, 2019

・HITSA (Date of publication unknown b) Historical overview: 1997-2000 <https://www.hitsa.ee/about-us/historical-overview/1997-2000> Last access June 21, 2019

・Innove (Date of publication unknown) Examinations and Tests <https://www.innove.ee/en/examinations-and-tests/standard-determining-tests/> Last access June 21, 2019

・Inspera (2019) Digitise the Norwegian National Tests at Scale <http://www.inspera.com/blog/digitise-the-norwegian-national-tests-at-scale> Last access June 21, 2019

・International Test Commission (2005). International Guidelines on Computer-Based and Internet Delivered Testing. <www.intestcom.org> Last access June 26, 2019

・Krumsvik, J, Rune (2011) Digital competence in Norwegian teacher education and schools, Högre utbildning, Vol. 1, Nr.39-51

・MEXT (2017) Study on Understanding and Assessment Support for Learning

Effectiveness from the use of ICT – Report p.24. (in Japanese)

- Norwegian Directorate for Education and Training (2012) *Framework for Basic Skills*.
- Norwegian Directorate for Education and Training (2018a) Introduction to the Norwegian educational system and Directorate's role < https://is.gd/JMetyM> Last access June 24, 2019
- Norwegian Directorate for Education and Training (2018b) Monitoring and assessing digital skills for schools < https://is.gd/pQOOZq> Last access June 24, 2019
- Norwegian Ministry of Local Government and Modernisation (2016) *Digital agenda for Norway in brief - Meld. St. 27 (2015–2016) Report to the Storting (white paper)* <https://www.regjeringen.no/en/dokumenter/digital-agenda-for-norway-in-brief/id2499897/sec2> Last access June 24, 2019
- OECD (2011) *OECD Reviews of Evaluation and Assessment in Education - Norway – MAIN CONCLUSIONS*.
- Republic of Estonia Ministry of Education and Research (2015) Secondary Education <https://www.hm.ee/en/activities/pre-school-basic-and-secondary-education/secondary-education> Last access June 21, 2019
- Republic of Estonia Ministry of Education and Research (2018a) Mailis Reps: focus on pre-primary education, digital school books and appreciation of teacher's profession < https://www.hm.ee/en/news/mailis-reps-focus-pre-primary-education-digital-schoolbooks-and-appreciation-teachers> Last access June 21, 2019
- Republic of Estonia Ministry of Education and Research (2018b) DIGITAL FOCUS <https://is.gd/L26Tj9> Last access June 24, 2019
- Republic of Estonia Ministry of Education and Research (2016) MODEL FOR ASSESSING THE DIGITAL COMPETENCE OF STUDENTS <https:// cgi-bin/cbgrn/grn.cgi/mail/file_download/-/Digipadevuse+hindamismudel_apr2016--EN-T.doc?mid=1640590&fid=0&pids=&hash=2d027c5011cfc35d8dd7966bd6222c161c042a4b&.doc> Last access June 24, 2019
- Hitoshi Sato (2015) A Comparative Study of PISA Penetration into Education Policy– Focusing on National Curriculum in Japan and Norway, Fukuoka University review of literature & humanities, 47 (3), pp.731-756. (in Japanese)
- SENTER FOR IKT I UTDANNINGEN (2017) *Professional Digital Competence Framework for Teachers*.
- Siiman L.A. et al. (2016) An Instrument for Measuring Students' Perceived Digital Competence According to the DIGCOMP Framework. In: Zaphiris P., Ioannou A. (eds) Learning and Collaboration Technologies. LCT 2016. Lecture Notes in Computer Science, vol 9753. Springer, Cham

・Tallinn (2019) Tallinn.ee: Tallinna Südalinna Kool <
https://www.tallinn.ee/est/sydalinna/In-English> Last access June 21, 2019
・University of Tartu (Date of publication unknown) Admissions: Educational Technology (MA) <https://www.ht.ut.ee/en/admissions/educational-technology-ma> Last access June 21, 2019

Chapter 4　Prior Studies in Other Countries on the Effect of ICT Use

In the chapters 2 and 3, we saw various examples of how ICT education has penetrated into the school through ICT study casebooks of other countries since 2017. The question that arises here is whether this has a positive effect on teaching and learning. To answer this question, our study not only collected cases, but also made an analysis how to make effective use of ICT, relying on local interviews in Estonia and Norway. We also performed a literature review regarding whether there are differences in reading comprehension between PBT and CBT, which was the starting point of this study.

What is important in determining whether ICT has had a "positive effect" in such a study, is the issue of definition. There are various definitions, but when we looked at Estonia and Norway, in both cases the emphasis at the level of compulsory education was formative assessment, and thus, management was basically not done by grades, but with student progress recorded instead of test formats to allow learning at individual pace (Tveit, 2014; Republic of Estonia Ministry of Education and Research, 2017). For this reason, "positive effect" is not just a matter of whether test scores have increased, but how much the student has learned or how much their skills have improved (of course, this is suggested by increased test scores, but this is not the main goal). Therefore, "positive effect" in this report is defined as "whether children/student learning skills have increased".

The use of ICT in education began particularly with the spread of computers in the 1980s, followed by the start of this study. Looking at the study results from various countries so far, rather than just blindly introducing ICT it has been advocated that it is possible to effectively use ICT when it is introduced with a comprehensive perspective of circumstances, objectives and resources (Schacter, 1999 p.10; Johnstone and Baker, 2002 pp.140-141; Cox, Abbott et al., 2004 p.12; Higgings, 2003 p.17; Livingstone, 2012). ICT is a tool for improving the quality of teaching and learning, but if the introduction of ICT itself is the objective it has no meaning. That is, the use of ICT and learning effect on students are deeply related to how the ICT is used, and as such it can be said that teaching methods and systems of the school and teacher are the main decisive factors of whether ICT use is effective.

If the teacher or the whole school have clear objectives, with appropriate ICT tools they can improve the learning skills of students. In this way, it is difficult at this point to develop a universal framework for ICT and its effectiveness to be applied to any school in any country at any time, and it is necessary to look on a case by case basis. Therefore, in this Chapter, based on the literature, we will look at (1) for what purpose, (2) what ICT tools (or learning method) were used and how this was (3) connected to improved learning skills in Estonia and Norway.

4.1. Effective Use of ICT

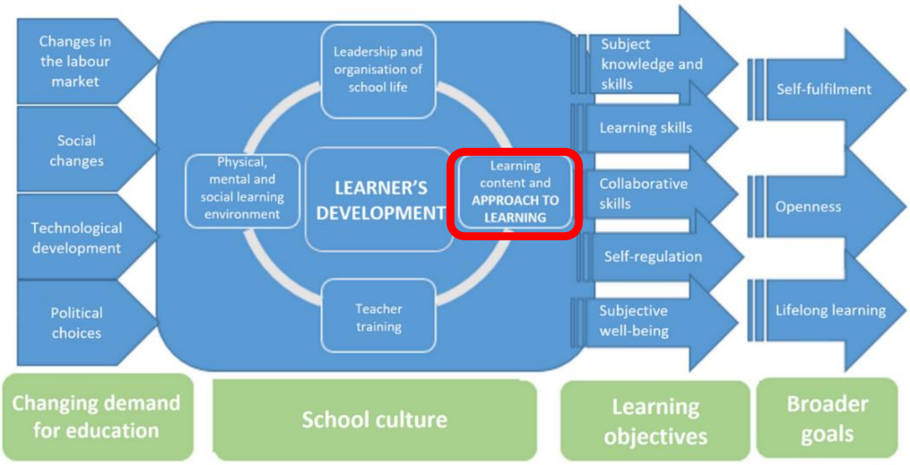
4.1.1. Estonia

(1) Objectives

When considering ICT use and its effectiveness in learning, one possible objective that can be considered is whether the tools and usage methods have been introduced in a way that the educational objectives set by the government are accomplised.

According to a report issued by the Estonian Ministry of Education and Research in 2017, educational reforms have been conducted in Estonia together with universities and

Fig. 4.1 Approach to Learning



research institutes with the objective of “The Estonia Lifelong Learning Strategy 2020.”[57] The purpose of these reforms was given as “Practicing a learning approach that encouages each learner’s individual and social development, the acquisition of learning skills, and the enhancement of creativity and entrepreneurship at all levels and in all types of education,” and this was implemented along with the new concept of “Approach to Learning” in Fig. 4.1 (red frame) for school learning. As can be seen in Fig. 5.1, this framework arose out of the “need for educational reforms in line with the times,” and this became a framework for the achievement of the 4 targets of child and student development in “school culture,” the 5 “learning objectives,” and the 3 “comprehensive goals.” Within “Learning Skills,” as one of these 5 goals, it is important that studentsstudents gain new knowledge both inside and outside of school, learn meta-knowledge (that is, understand their own knowledge and skills), recognize internal

[57] https://www.hm.ee/sites/default/files/estonian_lifelong_strategy.pdf

processes of utilizing what they have memorized, recalled, and learned, as well as knowing the nature of their motivation. When considering this, one of the important skills for this is “inquiry”. This recognition that the skill of inquiry is important was noted in Estonia’s 2011 national curriculum and based on this, the skill of “inquiry” was measured particularly for Grades 4 and 7 in national science exams. Here, “inquiry” means that whetherstudents think about questions and definitions themselves, analyze phenomena and objects that occur in nature, think about the cause, and draw conclusions (Siiman, L., Pedaste, M., et al. 2017). Several studies have revealed that this skill of “inquiry” can be improved utilizing computer simulation software (de Jong, 2006; Zacharia, de Jong, 2014), and in Estonia, universities and research institutions have collaborated to create various online applications and sites. Here, we will introduce one example of this.

(2) ICT Tool: Go-Lab（Global Online Science Labs for Inquiry Learning at School）

Go-Lab[58] is an online science teaching material developed in collaboration with the EU. It is a learning materials platform which can be used freely by science teachers around the world, which has been created by various public institutions (research institutions and universities) around the worldby reviewing and adopting online teaching materials. Go-Lab can be used for the purpose of assisting classes just like conventional electronic plackbards or projectors but one of its features is that it makes it possible to do experiments online that would normally require dedicated equipment in a science room. This is referred to as the Virtual lab (Fig. 4.2) and it is now possible to do science experiments with only computers or tablets.

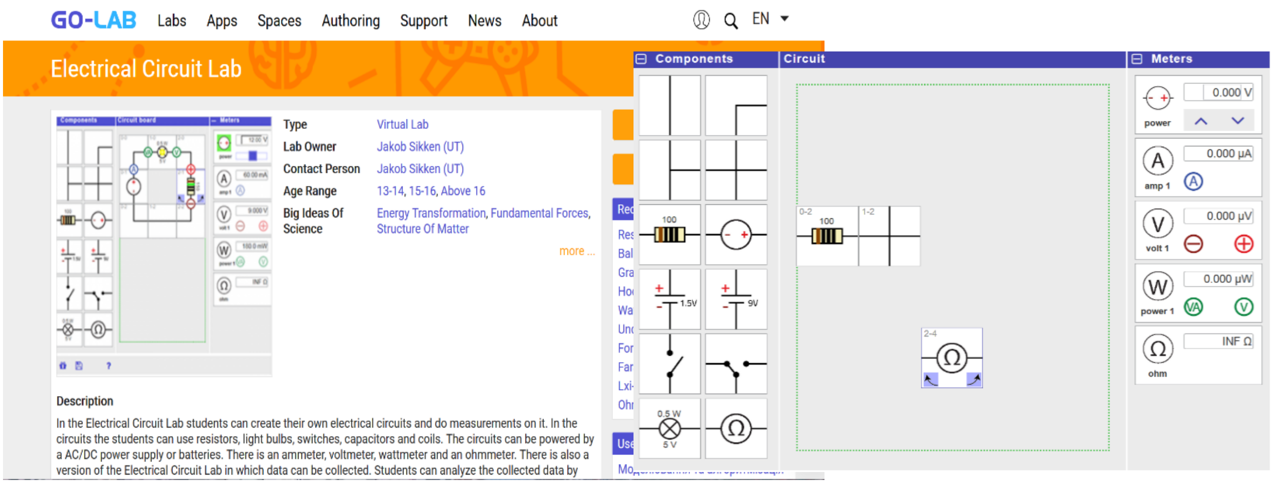


Fig. 4.2 Example of Go-Lab Virtual Lab*

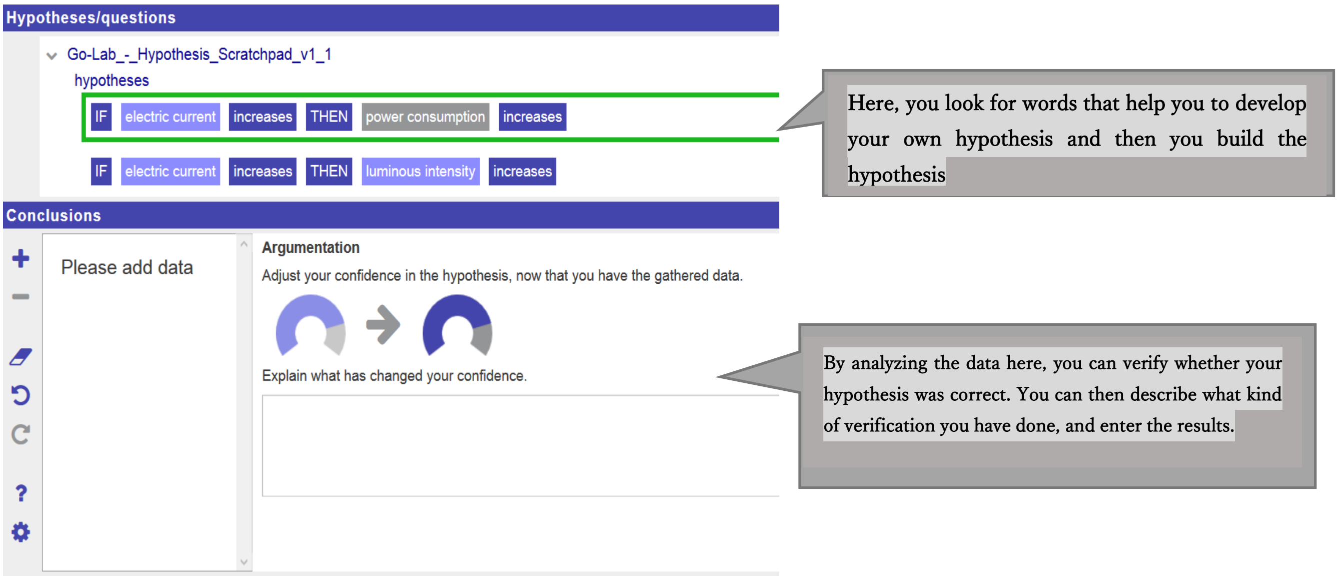
*A Lab used to learn about electronic circuits. Students can experiment with how much current flows with what kinds of electronic circuit connections.

[58] https://wwwGo-Labz.eu/

Go-Lab includes “Online Labs,” “Inquiry Learning Apps,” “Inquiry Learning Spaces,” and “Authorizing” functions, and it has two main roles. The first is that students can use it as a virtual or normal textbook-like materials, and the second is that it can be used by teachers as an online “record book” of the learning progress of students. The point of consistency of these two functions is that when students use it as a material and teachers use it as a record, they are both based on Inquiry Based Learning (IBL). The 4 functions above (Labs, Apps, Spaces, and Authorizing) are created to allow this.

“Labs” refers to online learning materials that students use for learning, and “Apps” are not the materials themselves but the applications that help learning process of students (Fig. 4.3) (For example, when thinking about solving a problem, it provides a worksheet or framework to help).

Fig. 4.3 Example of Apps



“Spaces” is mainly for teachers to summarize a series of IBL learning methods to be shared with other teachers or students, and the difference from “Labs” is that the learning objectives and method are specified. In addition to functions like those in “Spaces,” “Authorizing” allows for student’s learning results to be recorded and for support to be provided according to their progress, and along with the full use of the other functions this becomes a complete and tailored teaching portal for teachers.

(3) Connection to Learning Skill Improvement

In this way, Go-Lab utilizes various functions, playing a role in promoting IBL, but does it really lead to the development of the inquiry skills of students?

Tartu University in Estonia conducted several studies with other universities on the IBL effect of Go-Lab, proving that Go-Lab dramatically improved inquiry skills.

Normally, when building an IBL class with Go-Lab, the framework includes going through the 5 exploratory stages of orientation, conceptualization, investigation, conclusion, and discussion (Pedaste et al., 2015). Teachers are then able to use Go-Lab to provide support at each stage as students feel difficulty. Of these, conceptualization is considered particularly difficult, with the need to create theoretical questions and hypothesis on your own but Go-Lab has shown results in dramatically improving conceptualization as part of the skill of inquiry (Siiman et al., 2017). A possible reason for this is that by going through the 5 stages,

Students are able to work constructively, ask key questions, and pose key hypothesis to find necessary values without deviating from the inquiry activities (ibid.).

A study by Hovardas et al. (2018) also verified that effective “model-based inquiries” were made using Go-Lab. Model-based inquiry involves setting certain learning content and purposes as a “model”, having students proactively explore it, and comparing what they do to the original model to see the learning status and progress of the student. (For example, creating a model of how a weather system moves and asking students to create a simulation without giving them detailed instructions). In this regard, while not the case with all of Go-Lab, in the example above such as the “Electronic Circuit Lab,” students select circuits and voltages on their own, in other words, in the Lab where they can select and explore values (coils, wiring, voltage, etc.) on their own, the result is that the exploration skills of the model are fully used. Even for Labs that are not set up like the Electronic Circuit Lab, the same results can be produced by using additional software to allow students to choose values on their own (Hovardas et al., 2018).

In a study conducted in 2016, Go-Lab was also found to produce effective “reflection” required for exploring. This reflection is based on the idea that student learning becomes more effective when they understand what they have learned and learn through experience, so that the higher the quality of the reflection, the more their experiences from class will stick, thus improving the effectiveness of learning (Leijen, A. et al., 2012). As a result of the study of public schools in Estonia conducted by Tartu University with other universities, the contents and depth of student reflections were shown to have good results when the “reflection tool” attached to the Go-Lab Inquiry Learning Spaces was used (Mäeots, et al., 2016).

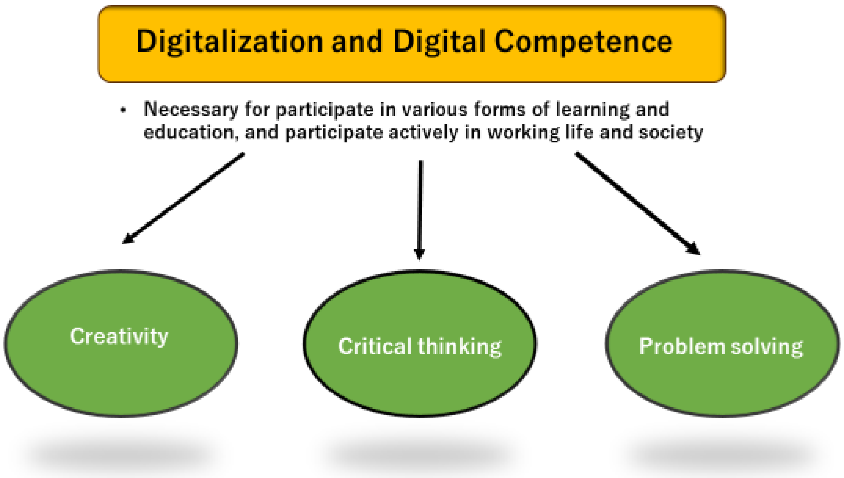
Based on the results of these studies, the use of Go-Lab can be said to promote inquiry learning. However, to really use it effectively it is necessary for teachers to think about what tools are be used for what purpose, and what results are expected. In addition to Go-Lab, web-based online materials such as Young scientist and Young Researcher have also been shown to improve inquiry skills (Mäeots et al, 2009; Mäeots, et al. 2008; Pata, et al., 2007). According to a study by Zacharia et al. (2015), to conduct smooth inquiry learning it is important to establish a support system according to the learning progress and background of each student, and to create an environment in which students can manage their learning and study independently. This makes it easier for them to carry out the difficult tasks of looking back at their own learning and contemplating it. This may also be helpful to remember.

4.1.2. Norway

(1) Objectives

As mentioned in Chapter 3, Norway is currently reforming its education toward digitization, and the basis for this can be understood by reading Norway's education white paper (The School of the Future Renewal of subjects and competences, 2015[59]). In Norway, digitization and digital competence are regarded as "Necessary for participate in various forms of learning and education, and participate actively in working life and society," and the skills required for this digitization include creativity, critical thinking, problem-solving abilities, etc. In a fluid society, the ability to utilize creativity based on scientific evidence, and to actively accept and createnew things are necessary, and these skills are considered important for students to overcome the difficulties that they will face in life.

Fig. 4.4 Digitalization and Digital Competence



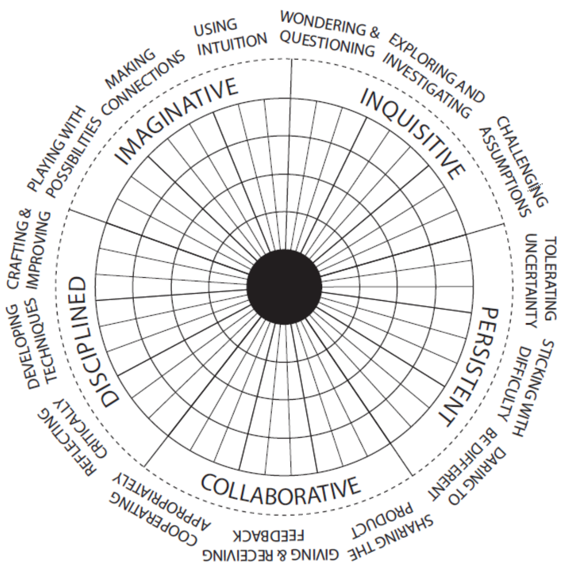
[59] https://www.regjeringen.no/contentassets/da148fec8c4a4ab88daa8b677a700292/en-gb/pdfs/nou201520150008000engpdfs.pdf

Creativity and Innovation

Creativity and innovation are inquisitive and are skills for taking initiative with completely new ideas and making things happen, and these are important skills for entrepreneurship, risk assessment, etc. when working in a competitive society. These are discussed in more detail below and are shown in Fig. 4.5.

1. Inquisitive: Ability to look at the "wonders" in the world, have questions, explore them, investigate them, and overturn fixed concepts
2. Persistent: Ability to not give up when difficulties arise, not to be afraid to be different from other people, and to be tolerant of unknown things
3. Imaginative: Ability to create creative solutions and opportunities, take advantage of various opportunities, and connect things intuitively
4. Collaborative: Ability to share results with others, give feedback to each other, and cooperate effectively
5. Disciplined: Ability to acquire skills, look back critically, find elements to improve, and connect to the next task

Fig. 4.5 Creativity and Innovation



Source: Spencer et al 2012

Critical Thinking and Problem-Solving Skills

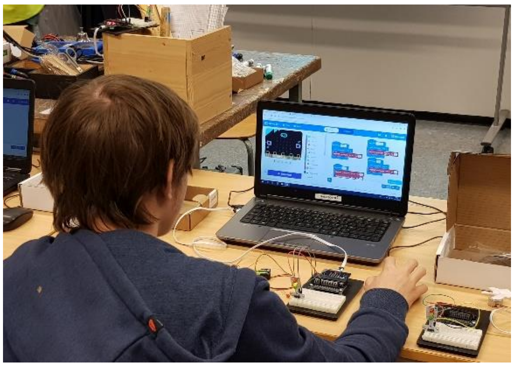
Critical thinking and problem solving are considered equivalent skills, and it is said that it is only by thinking critically that problems can be solved. To critically view something, one first needs to analyze it and be guided to the solution in an appropriate way, and this is considered an important skill for young people to survive in the information society of today. This will be described in more detail below.

1. Reason:	Ability to reshape acquired information and accepted explanations into opinions of your own, based on scientific evidence in a way that makes sense from the perspective of a third party.
2. Analyze:	Ability to evaluate what is causing a problem or making it worse, taking evidence from that claim or various sources, to find clues to solve a problem in the most suitable way.
3. Make decisions:	Ability to put rational decisions into practice based on theory and analysis.

Creativity/innovation and critical thinking/problem-solving skills are indispensable skills in an era when a lot of information overflows and technology handles human work instead, so in order to make this work, the use of ICT is also essential. There are various ways to develop these skills, and here we will examine how the programming classes which have been newly introduced in Norway are considered particularly effective.

(2) ICT Tools: Programming

In Norway, programming was an elective subject in lower secondary schools from 2016 to 2017, and in 2019, it was also offered as an elective course in upper secondary schools (Søby, 2018). During our visit to Norway, we observed an actual programming



class at the Haugerud secondary school. In this class, the teacher presented students with wires with a miniature bulb attached to one end, asked what kind of programming would light up the bulb, and made the students think, without detailed explanation. The students then began coding on their computers and learned how to make the miniature bulb blink like a traffic light through trial and error programming, with only basic instructions from the teacher. At this school they used a microcomputer (ultra-compact computer; Fig. 4.6) called micro:bit, developed in the UK, which could be connected to a desktop or other device for online coding. This micro:bit has functions such as temperature, speed and light measuring sensors, radio and compass etc., and using these functions properly, it is possible to provide guidance in other subjects in addition to simple coding. For example, when conducting environmental education in science class, this micro:bit can be used to measure water transparency in the process of examining how dirty the local pond is. This is possible by coding the light sensor in micro:bit to measure how much light is passing through the water (the more the water is contaminated, the lower the light transmission). In fact, as shown in Fig. 4.8, coding is done on the computer and synchronized with the equipment shown in Fig. 4.7. Aside from this, it is also possible to measure the moisture conditions, the speed of sound and radio waves, distances, etc.

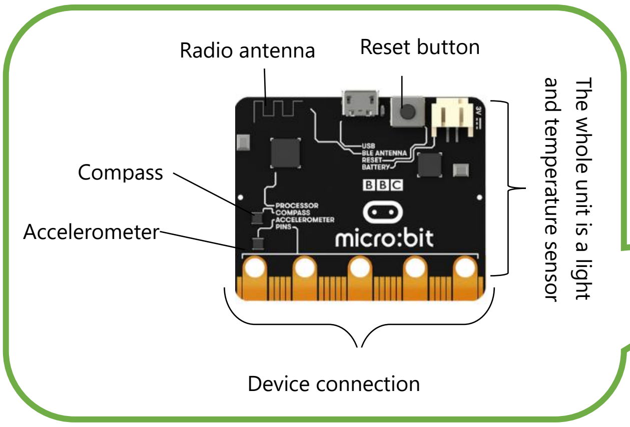
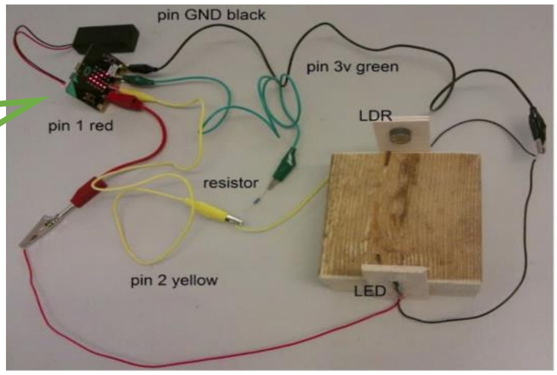


Fig. 4.6 Microcomputer enlarged view

Fig. 4.7 Microcomputer and Equipment



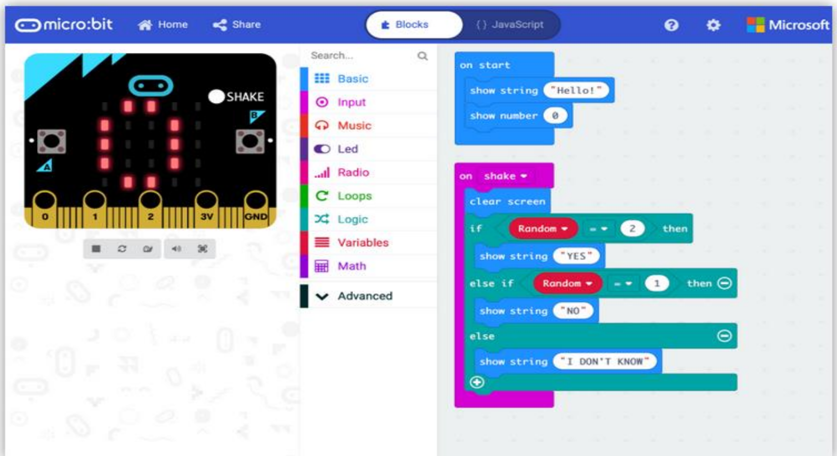


Fig. 4.8 Coding Screen on the Computer

Aside from science, micro:bit can also be used in a variety of other ways, such as creating music and art works. In addition to micro:bit, Haugerud secondary school supports learning with the abovementioned the Microsoft OneNote online platform to check the progress of student learning and to give tasks to individual students based on their learning progress as well as provide feedback. Apps are also used in each subject in addition to programming. Efforts have been made to make learning fun and effective with the use of software such as Mentimenter in mathematics classes and V-ahoot in social studies etc.

(3) Connection to Improvements in Learning Skills

So, is programming with micro:bit, and programming in general proving useful in improving the learning skills proposed by Norway's education policy?

The following became clear from a qualitative study led by King's College London,

- 90% of students said that programming with micro:bit was something that anyone could do.
- 86% of students said that micro:bit made computer science more interesting.
- 70% of girls said that they wanted to choose technology after using micro:bit at school.
- 85% of teachers said that after using micro:bit they wanted to make ICT and computer science more fun.
- Even teachers that said that they are not very confident in computer education said that they confidence increased using micro:bit.

University of London in the UK,[60] where about 1 million micro:bit were distributed to lower secondary school students in the UK.

The following results were also obtained from a survey by the British Council together with the micro:bit Education Foundation.

- 100% of teachers said that micro:bit was a useful teaching material.
- 86% of teachers said that micro:bit was an effective part of the educational curriculum.
- 93% of teachers said that micro:bit would be inspiring for students in the classroom.
- 90% of teachers said that micro:bit inspired students to use computers and programming even outside of the classroom.

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[60] https://microbit.org/ja/research/

According to this, the qualitative research suggests that in addition to micro:bit use raising awareness and confidence in programming, it seems to have been effective in inspiring and boosting creativity.

These results are consistent with research into programming that has continued since the 1990s. For example, in a study conducted by Clements (1991), programming was found to produce significantly higher creativity, not only spatially but also verbally (for example giving verbally creative answers) than in groups that had done no programming. In addition, a quantitative study by Liao and Bright (1991) found that the ability to assemble theories and solve problems was raised through programming, and Barr and Stephenson (2011) showed in a study that programming fosters problem-solving abilities that were applicable to all subjects. In a meta-analysis conducted by the University of Oslo in Norway and other educational research institutions (Scherer et al., 2018), it was investigated as to whether increased programming skills was connected with the raising of other skills (creativity and critical thinking skills), and the results showed that while there was a difference in degree depending on which skills were focused on, it was considered effective overall. This is thought to be because the skills required for the coding process itself (for example thinking about what programming parts will make things happen the way you imagine it) is similar to problem-solving skills and is thought to be caused by skills investigated being similar (creativity and critical thinking). Among these, at the University of Oslo, study improvements in creativity and mathematical ability showed better results than other skills.

Thus, programming can be expected to improve creativity/innovation and critical thinking/problem solving skills, and with the introduction of programming as a subject in recent years, these skill improvements can be expected in Norway.

4.1.3. Conclusions

The skills and ICT tools discussed here are just examples, and each of the countries has broad and comprehensive education policies and use various tools (not only ICT) to achieve their objectives.

Of these, this Chapter has focused on inquiry skills (Estonia) and creativity/ innovation and critical thinking/problem-solving (Norway) to see what kinds of ICT tools had what kinds of effects on improving individual skills.

The digitization of education not only makes it possible to improve skills that are difficult to measure in tests, but also has the potential to simplify administrative work by making it paperless. However, there are still many uncertainties regarding the effects and benefits of digitization in education, and it is possible that conventional paper may be considered more efficient, even if in terms of cost. Therefore, it seems to make sense that the study of digitization in education be examined not only in terms of improvements in cognitive and non-cognitive skills, but also on the larger scale of economic impacts in each country as a result of its introduction. One possible way of doing this may be to improve both the amount (perform studies on many more apps) and quality (critically review studies and conduct deeper follow-up studies) of studies into the effectiveness of existing apps and software, such as those performed by Go-lab at Tartu University in Estonia and micro: bit at the University of London, and then to collect the data to compare it with the education policies and objectives of each country.

4.2. Differences in Study Forms, and Literature Review and Discussion on the Impact on Reading Comprehension

The OECD's Programme for International Student Assessment (PISA) is a particularly high-profile international comparative survey that has been examined in many ways in many countries. PISA changed its format, shifting to a computer-based survey from the 2015 survey after previously being a written survey solving problems in a paper test. There were many voices that questioned the comparison of results from the 2015 survey (which was computer-based) with those of previous surveys (written) prior to the change of format. This Section will review the literature from the perspective of whether the differences in format of this survey have had an impact on the reading comprehension of students.

4.2.1. Difference between Reading on Screen and on Paper, and Literature Review of the Impact on Reading Comprehension

It has been concluded that differences in implementation method (mode) of various tests will lead to differences in the results of the test itself (Chan and Unsworth 2011; Coiroa and Dobler 2007; Leu et al 2007), and there may be several reasons for this. One is that in addition to the skill of reading comprehension, reading from a computer screen requires other skills than those required to read from paper.

According to Rasmusson and Eklund (2012), the following 5 abilities are required to read from a screen.

1. Traditional literacy:	Ability to understand essential spelling and vocabulary even when reading on paper.
2. Multimodal literacy:	Ability to understand virtual charts and signs viewed only on computer when mixed with traditional text-only text
3. Path finding:	Ability to clarify the purpose, know what you are accessing to achieve it, and to explore without giving up until you achieve the purpose
4. IT ability:	Ability to identify how best to operate devices, including basic computer operations
5. Information ability:	Ability to recognize what information you are accessing and to judge the "design" of the page that you are viewing

As far as looking at these five abilities, while traditional skills are of course important it can also be said that additional skills are required because it is on a screen. For example, if students lack 4. IT ability and 5. Information ability when operating CBT screens, they may be confused upon seeing them for the first time and make mistakes such as pushing the wrong buttons.

From the above, it can be understood that there are difficulties in reading simply because it is on a computer, and this has been regarded as a problem since the 1980s, which can be broadly classified into the following 2 types.

The first is the possibility of physical barriers which make it more difficult to read text on devices such as computers.

For example, Garland and Noyes (2004) conducted a study of LCD screens and learning, which found that features of LCD screens, such as screen update frequency, color contrast, light fluctuations, etc., had the effect of hindering the cognitive processes of subjects, blocking the long-term memory required to make reading easier. There have also been claims that differences in reading comprehension may be affected by the number of pixels on the screen, affecting the visibility of characters when reading characters on a computer (Dillion&Emurian 1995; Lee, Ko, Shen et al., 2010). Further, in a study by Piolat et al., (1997), it was argued that the scrolling behavior of using a mouse to read sentences in surveys on computers hinders the flow of text recognition, making it more difficult to read. It has also been suggested that the readability of text depends greatly on the size of screens (Eklundh,1992, p.76). In other words, because of the many functions on computers, in addition to simply reading characters, these functions can inhibit awareness, making it more difficult to perform reading tasks.

The second is related to the first, in that the visual and spatial differences between computer screens and paper make a difference in reading comprehension.

For example, a study by Haas and Hayes (1986) found that because of spatial and visual factors, recalling letters, drawing information, and the proper rearrangement of characters on computer screens did not go as well as when reading on paper. This study conducted three experiments, the one of which was to divide the subjects into paper media and electronic media groups to measure spatial recognition, with each medium being given 9 pages of articles to read, before being asked write down where specific information was on which page as far as they could remember. The result was the group that read the articles on paper and that wrote down information asked with a paper and pen were better able to remember where the information was written. In a different experiment, a paper group and computer group were asked to read the same text and were then asked questions about the content of the text, with the subjects encouraged to answer questions with quotes from the original text. In this experiment, the paper group responded to questions more quickly. Based on these studies, Eklundh (1992) has claimed that from a global perspective, reading text on a computer screen is more difficult.

The global perspective when reading a sentence refers to the mental expression of characters. When we write, we review what we are writing and construct a "cognitive map" which forms a kind of guideline for our writing, suggesting what text will come next.

For example, a sentence with a line break implies a different nature from the previous sentence and the first words of a paragraph show the "theme" of the general contents of the rest of the paragraph. Readers use such hints in the text to understand and find consistency in the whole sentence so that they can understand the contents. Also, as mentioned above, readers use spatial cognition (for example, remembering the relevant parts of the previous sentence to what you are reading) to connect sentences, replaying memories and repeating while reading. Eklundh claims that this is more difficult to do on a computer, and that paper is more efficient. Similarly, a study by Giulia and Oakhill (2000) said that the ability to mentally build the composition of a sentence is related to reading comprehension. When reading text on paper, the character position is fixed, and this is thought to help the reading to be smoother and for sentences to be easier memorized and remembered, but on a computer in many cases the character positions will vary, making mental cognition (construction) more difficult, and this is claimed that it makes the reading process of recognizing sentence information as a whole and positioning more difficult.

Also, in a study in 2012, Ackerman and Goldsmith concluded that given that reading comprehension is related to the meta-cognition of students, there will be differences between taking a test on a computer and on paper. In this study, subjects were divided into two groups, On-Screen-Learning (OSL) and On-Paper-Learning (OPL), and differences between the groups were investigated when they were given tests with finely set time limits and those without. As a result, in the test with normal time setting there was no significant difference between the two groups, but in the groups that needed to allocation their own response times in the test, the results for OSL students were worse than those for OPL students. In other words, in different test conditions, specifically, when the students' meta-cognition was demanded, OSL may be disadvantageous, proving that in certain conditions different modes can lead to differences in reading comprehension.

Piolat (1997) also claimed that given that visual and tactile sensations are used in reading text on paper, with reading that captures the entire length and flow of the text, while the viewing range of the text on a computer is limited (only one page at a time etc.), this makes reading comprehension more difficult as it is difficult to understand the composition of the entire text. Similarly, in a study by Vispoel (1992), it was noted that tests on computers do not allow students to freely return to the previous page like with paper, and will not allow them to look ahead, which affects the answering methods on the test. This was also proven by Eklundh (1990), in a study which gave subjects computers to write academic papers on, measuring how much the pages were navigated and how much review was done in completion, and it was found that in 45 minutes they scrolled on average 13.5 times to review. In other words, when taking a test or studying on a computer, you can freely go back and forth between pages, which is an important task for understanding the contents of the test and of the overall text. In this way, it can be seen through various studies that there is a difference even if reading the same sentences or characters, depending on whether they are read on a screen or on paper.

4.2.2. Literature review of the impact on reading comprehension and the migration from PBT to CBT in PISA

Considering the above, it is understandable why there are researchers who cast doubt on the claim by the OECD (2016) that comparison of past PBT with PISA 2015 CBT is possible. As can be seen in 4.2.1, reading comprehension on computers requires different abilities to those conventionally required for reading (on paper), and here, assuming that students who are used to using computers are better at at least 2. Multimodal literacy and 4. IT ability when compared to students not used to computers, we may hypothesize that "<u>students more familiar with computers could achieve better results in CBT reading comprehension.</u>"

Several research institutions are studying this question. One of these is a 2018 study by Mid Sweden University in Sweden and Stockholm University under the hypothesis that "Students with longer computer usage time had better results in CBT reading comprehension tests," studying the effect of the change of PISA mode. This study was conducted in 5five Scandinavian countries for the results of PISA 2012 and 2015, and summarized the changes based on factors such as the time per day that students spend on the internet, as well as gender, etc. The study concluded that, in Sweden, especially for boys, more computer use resulted in better results in the PISA 2015 reading comprehension test (Rasmusson, et al., 2018).

Of the countries participating in this study, Swedish students used computers for the most hours per week outside of school, with almost half saying that they spent 4 hours or more. In other countries, for example in Finland, 29% of boys and 27% of girls responded the same way (ibid. p.135). According to the study, Swedish students that spend 6 hours or more per day using a computer raised their average reading comprehension scores from PISA 2012 to PISA 2015 from 455 points to 484 points, which was the highest in any studied country. Students in Sweden using computers 4–6 hours per day were the next best, improving from 485 points to 512 points, the second highest growth rate. However, looking at the trend in other countries, using computers for a long time did not give the same results as those in Sweden. For example, Finnish students who spend 6 hours or more on the computer did not exhibit higher reading comprehension. But we need to consider this based on an understanding of when the students became used to using the computer for such long hours. We may know that the Swedish and Finnish students who answered the PISA 2015 spent the same 6 hours outside of school per week using computers, but we don't know how long they have been doing so. For example, in Sweden this may be a trend that has been around for decades, while it may be a recent trend in Finland. One possible reason for this is that computer access in Sweden is at the top in Europe, with top internet access, meaning that students are in an environment in which computer use is more familiar than in other countries (European Schoolnet, 2012). This is evidence of the high consciousness of making the internet a part of life in Sweden, with its long history of ICT education at schools.

In fact, Sweden already had a subject called "informatics" in the 1960s that included simple coding (Polandsson, et al., 2014). In the 1970s, in some upper secondary schools, there were lively discussions and experiments on how to integrate programming in subject teaching (mainly mathematics and science). Then, since the 1980s, the need has been widely known, and a large supplementary budget was passed in Parliament in 1985 that made it possible for computers to be distributed to all schools and all students (ibid.).

Given this, it can be seen that Sweden was faster than other countries at discussing and implementing the introduction of computers to schools, and that statistics, programming, etc. were actively incorporated. For example, in neighboring Finland, the first computers for education introduced into schools in the late 1970s came from Sweden (Koivisto, 2014). Given this long history, and the factors surrounding the improvement in reading comprehension scores by Swedish students in PISA2015, it is possible that this was due to comfort with the operation of computers. At the same time, it is also possible to hypothesize that the existence of programming from as early as the 1960s also made the difference.

Various studies (Adams, 1990; Blachman, Ball et al., 1994, 2004) recognize the importance of the encoding of sentences and words in reading comprehension, that is, the process of representing and recognizing a character/word from hearing a sound or seeing it, and conversely decoding, which is the process of reading written characters and knowing how to pronounce them and recognize the pattern correctly. Then these processes finally need to result in an understanding of the sequence of characters, or in other words give them context so that they can be recognized and "read as text" (Mäeots 2005). Regarding this continuity of characters, Tufs University studies by Kazakoff (2012, 2014) have learned that programming improves this skill, which suggests that programming can lead to improvements in reading comprehension. This is said to be important, and the task of connecting character patterns is particularly difficult when reading on a computer (Carter, 2014). This is similar to the claim of Giulia and Oakhill (2000), who thought this was because it differed from reading on paper where the eye reads in a regular manner from the start to the end of the paragraph, since computers have hyperlinks, buttons, and other irregular items in the text that often have to be read along with the text.

While the reading comprehension score of Sweden in 2012 was 36th out of the 65 participating countries and regions of the PISA, this improved to 17th despite the increase in the number of participating countries to 72 countries and regions in 2015. The improved results by Swedish students in the CBT reading comprehension test over the previous year is considered to be due in part to the long history of ICT education, even in comparison with other European countries, and the fact that Swedish students overall are used to computer use and are equipped with the ability to read sentences on the computer, as was demonstrated in the CBT.

At the same time, programming has been implemented in Sweden longer than in many other countries, and you could hypothesize that this is related to gradually rising reading comprehension ability, particularly on computers. Further verification is required to prove this, but these conclusions are consistent with other findings. For example, we have the results from the Computer Based Assessment of Science (CBAS) that boys who are familiar with computers get better test scores on computers than girls (Martin, cited in Rasmusson 2018). Also, the gender difference in the Electronic Reading Assessment (ERA) with hypertext and navigation tools in PISA2009 was smaller than that in normal PISA reading comprehension tests (OECD2010). Girls' scores tend to exceed those of boys in the PISA reading comprehension test, but in the ERA this difference was smaller, or in other words, boys who tend to spend more time on computer had better results on the computer test than in the normal PISA reading comprehension test. In another OECD report (2015), encouraging students to read a moderate amount on computers was said to be effective for generally improving reading comprehension, and, for example, in 16 countries with valid data the results showed that students who view the internet at school 1–2 times a month had higher digital reading comprehension in the PISA survey than those who never viewed it (pp. 175–176). In addition, Jerrim (2016), in a study comparing the PBT and CBT of PISA, noted that significant differences in tests using computers depend on socio-economic and other backgrounds (family, etc.) (p. 22), or in other words, groups with socio-economical attributes that afford them opportunities to use computers and the internet had better CBT results, so given the similarity, this hypothesis is not entirely misplaced.

4.2.3. Discussion

Based on what has been described so far, it is not possible to state that it is unrealistic that "students that had good results in CBT reading comprehension were used to reading and operating computers, and so their scores were good." To investigate this further, it seems necessary to clarify in detail how reading comprehension on a computer differs from reading comprehension on paper. In particular, given that some scholars have argued that there are no significant differences between the skills required to read on computers and on paper (Baker, 2010; Kim & Huynh, 2010), it will be necessary to verify why these conclusions are different and where the differences lie from the studies introduced in this literature review. Also, the OECD (2016) report on the 2015 CBT transition concludes that there were no significant differences in comparison with previous tests, claiming that there was no difference in the nature of the answers in any of the PISA tests, whether on computer or previously on paper, while studies such as Jerrim, Micklewright, et al. (2018) claim that it is difficult to say that there was little effect on CBT, given that the average scores for CBT are generally lower than PBT (pp. 481–482), particularly per item. It certainly seems worth investigating this difference.

The research so far has mostly been carried out in Europe and North America, but given that there may be differences in the contents of the research based on differences in national culture, language, etc. (for example, differences between the Latin alphabet and *kanji* characters), further research on the skills required for computer reading comprehension should be conducted in Japan. Given that various tests and not only PISA are likely to be implemented on computers in the future, such surveys are meaningful.

References

・Ackerman, R., & Goldsmith, M. (2011). Metacognitive Regulation of Text Learning: On Screen Versus on Paper. *Journal of Experimental Psychology: Applied, 17*(1), pp. 18–32.

・Adams, M. J. (1990). *Beginning to Read: Thinking and Learning about Print*. Cambridge, MA: MIT Press.

・Baker, R. D. (2010). *Comparing the Readability of Text Displays on Paper, E-book Readers, and Small Screen Devices*. Ann Arbor, MI: ProQuest.

・Barr, V., & Stephenson, C. (2011). Bringing Computational Thinking to K-12: What Is Involved and What Is the Role of the Computer Science Education Community? *ACM Inroads*, *2*(1), pp. 111–122.

・Blachman, B. A., Ball, E. W., Black, R. S., & Tangel, D. M. (1994). Kindergarten Teachers Develop Phoneme Awareness in Low-Income, Inner-City Classrooms. *Reading and Writing*, *6*(1), pp. 1–18.

・Blachman, B. A., Schatschneider, C., Fletcher, J. M., Francis, D. J., Clonan, S. M., Shaywitz, B. A., & Shaywitz, S. E. (2004). Effects of Intensive Reading Remediation for Second and Third Graders and a 1-Year Follow-Up. *Journal of Educational Psychology, 96*(3), pp. 444–461.

・Carter, C. E. (2014). *Mindscapes: Critical Reading Skills and Strategies*. Boston, MA: Wadsworth.

・Chan, E., & Unsworth, L. (2011). Image-Language Interaction in Online Reading Environments: Challenges for Students' Reading Comprehension. *Australian Educational Researcher*, *38*(2), pp. 181–202.

・Clements, D. H. (1991). Enhancement of Creativity in Computer Environments. *American Educational Research Journal*, *28*(1), pp. 173–187.

・Coiro, J., & Dobler, E. (2007). Exploring the Online Comprehension Strategies Used by Sixth-Grade Skilled Readers to Search for and Locate Information on the Internet. *Reading Research Quarterly*, *42*, 214–257.

・Cox, M. J., Abbott, C, & Webb, M. (2004). *ICT and Attainment: A Review of the Research Literature*. Coventry/London, UK: Becta/DfES.

・de Jong, T. (2006). Computer Simulations: Technological Advances in Inquiry Learning. *Science*, *312*(5773), pp. 532–533.

・Dillon, T. W., & Emurian, H. H. (1995). Reports of Visual Fatigue Resulting from Use of a Video Display Unit. *Computers in Human Behavior, 11*(1), pp. 77–84.

・European Schoolnet & University of Liège (2012). Survey of Schools: ICT in Education, Country Profile: Sweden. Accessible at:

http://ec.europa.eu/information_society/newsroom/image/document/2018-3/sweden_country_profile_30141CE0-E643-5AC4-511FC13CBA34A32C_49456.pdf

・Søby, M. (2018) European Schoolnet, NorwayCountry Report on ICT in Education

・ Garland, K. J., & Noyes, J. M. (2007) CRT Monitors: Do They Interfere with Learning? *Behaviour & Information Technology*, *23*(1), pp. 43–52.

・Giulia Cataldo, M., & Oakhill, J. (2000). Why Are Poor Comprehenders Inefficient Searchers? An Investigation into the Effects of Text Representation and Spatial Memory on the Ability to Locate Information in Text. *Journal of Educational Psychology, 92*(4), pp. 791–799.

・Haas, C., & Hayes, J. R. (1986). What Did I Just Say? Reading Problems in Writing with the Machine. *Research in the Teaching of English*, *20*(1), pp. 22–35.

・Higgins, S. H. (2003). *Does ICT Improve Learning and Teaching in Schools?* Southwell, UK: British Educational Research Association.

・Hovardas, T., Pedaste, M., Zacharia, Z., & de Jong, T. (2018). Model-Based Inquiry in Computer-Supported Learning Environments: The Case of Go-Lab. In M. Auer, A. Azad, A. Edwards, & T. de Jong (Eds.), *Cyber-Physical Laboratories in Engineering and Science Education*, Cham, Switzerland: Springer, Cham, pp. 241–268.

・Jerrim, J. (2016). PISA 2012: How Do Results for the Paper and Computer Tests Compare? *Assessment in Education: Principles, Policy & Practice*, *23*(4), pp. 495–518.

・Jerrim, J., Micklewright, J., Heine, JH., Salzer, C., & McKeown, C. (2018). PISA 2015: How Big Is the ‘Mode Effect’ and What Has Been Done about It? *Oxford Review of Education*, *44*(4), pp. 476–493.

・Johnstone, J., & Baker, L. T. (2002). *Assessing the Impact of Technology in Teaching and Learning: A Sourcebook for Evaluators*. Ann Arbor, MI: University of Michigan.

・Kazakoff, E. R., Bers, M. U. (2014). Put Your Robot in, Put Your Robot out: Sequencing through Programming Robots in Early Childhood. *Journal of Educational Computing Research*, *50*(4), pp. 553–573.

・Kazakoff, E., Bers, M. (2012). Programming in a Robotics Context in the Kindergarten Classroom: The Impact on Sequencing Skills. *Journal of Educational Multimedia and Hypermedia*, *21*(4), pp. 371–391.

・Kim, D. & Huynh, H. (2010). Equivalence of Paper and Pencil and Online Administration Modes of the Statewide English Test for Students with and without Disabilities. *Educational Assessment*, *15*, pp. 107–121.

・Koivisto J. (2014). Computers in Education in Finland. In A. Tatnall & B. Davey (Eds.), *Reflections on the History of Computers in Education*. Berling: Springer, pp. 239–245.

・Lee, DS., Ko, YH., Shen, IH., & Chao, CY. (2011). Effect of Light Source, Ambient Illumination, Character Size and Interline Spacing on Visual Performance and Visual Fatigue with Electronic Paper Displays, *Displays*, *32*(1), 1–7.
・Leijen, Ä., Pedaste, M., Mäeots, M., & Sarapuu, T. (2012). Improving Students' Inquiry Skills through Reflection and Self-Regulation Scaffolds. *Technology, Instruction, Cognition and Learning*, *9*, pp. 81–95.
・Leu, D. J., Zawilinski, L., Castek, J., Banerjee, M., Housand, B. C., Liu, YJ., & O'Neil, M. (2007). What Is New About The New Literacies of Online Reading Comprehension? In L. S. Rush, A. E. Eakle, & A. Berge (Eds.), *Secondary School Literacy: What Research Reveals for Classroom Practice*, Urbana, IL: National Council of Teachers of English, pp. 37–68.
・Liao, YK. C., & Bright, G. W. (1991). Effects of Computer Programming on Cognitive Outcomes: A Meta-Analysis. *Journal of Educational Computing Research*, *7*(3), pp. 251–268.
・Livingstone, S. (2012). Critical reflections on the Benefits of ICT in Education. *Oxford Review of Education*, *38*(1), pp. 9–24.
・Mäeots, M., Pedaste, M., & Sarapuu, T. (2008). Transforming Students' Inquiry Skills with Computer-Based Simulations. Paper presented at the 8th IEEE International Conference on Advanced Learning Technologies, Santander, Cantabria, Spain.
・Mäeots, M., Pedaste, M., & Sarapuu, T. (2009). Developing Students' Transformative and Regulative Inquiry Skills in a Computer-Based Simulation. *Proceedings of the 8th IASTED International Conference on Web-based Education*.
・Mäeots, M., Siiman, L., Kori, K., Eelmets, M., Pedaste, M., & Anjewierden, A. (2016). The Role of a Reflection Tool in Enhancing Students Reflection. *Proceedings of INTED 2016 Conference*.
・Martin, R. (2008). *Utilising the Potential of Computer Delivered Surveys in Assessing Scientific Literacy*. Sydney: Australian Council for Educational Research.
・Moats, L. C. (2005). How Spelling Supports Reading: And Why It Is More Regular and Predictable Than You May Think. *American Educator*, *Winter 2005/06*, pp. 12–22, 42–43.
・OECD (2011). *PISA 2009 Results: Students on Line: Digital Technologies and Performance (Volume VI).* Paris: OECD.
・OECD (2016). *PISA 2015 Technical Report*. Paris: OECD.
・Pata, K., Pedaste, M., & Sarapuu, T. (2007). The Formation of Learners' Semiosphere by Authentic Inquiry with an Integrated Learning Object Young Scientist. *Computers & Education*, *49*(4), pp. 1357–1377.

・Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riese, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of Inquiry-Based Learning: Definitions and the Inquiry Cycle. *Educational Research Review*, *14*, pp. 47–61.
・Piolat, A., Roussey, JY., & Thunin, O. (1997). Effects of Screen Presentation on Text Reading and Revising. *International Journal of Human-Computer Studies, 47*(4), pp. 565–589.
・Rasmusson, M., & Eklund, M. (2013). "It's Easier to Read on the Internet—You Just Click on What You Want to Read…" Abilities and skills needed for reading on the Internet, *Education and Information Technologies*, *18*(3), pp. 401–419.
・Rasmusson, M., & Fredriksson, U. (2018). PISA, Reading Literacy, and Computer-Based Assessment. In *Northern Lights on TIMSS and PISA 2018*, Copenhagen: Rosendahls, pp. 123–160.
・Republic of Estonia Ministry of Education and Research (2017) Pre-school, basic and secondary education. Accessible at< https://www.hm.ee/en/activities/pre-school-basic-and-secondary-education>
・Rolandsson, L., & Skogh, IB. (2014). Programming in School: Look Back to Move Forward. *ACM Transactions on Computing Education (TOCE)*, *14*(2), Article 12.
・Scherer, R., Siddiq, F., & Sánchez Viveros, B. (2018). Learning to Code: Does it Help Students to Improve Their Thinking Skills? Paper presented at the conference Computational Thinking Education, Hong Kong.
・Schacter, J. (1999) The Impact of Education Technology on Student Achievement What the Most Current Research Has to Say, Milken Exchange on Education Technology, Milken Family Foundation
・Severinson Eklundh, K. (1990). Global Strategies in Computer-based Writing: The Use of Logging Data. In Ö. Dahl & K. Fraurud (Eds.), *Papers from the Second Nordic Conference on Text Comprehension in Man and Machine*, Stockholm: Stockholm University, pp. 15–29.
・Severinson Eklundh, K. (1992). Problems in Achieving a Global Perspective of the Text in Computer-based Writing. *Instructional Science*, *21*(1), pp. 73–84.
・Siiman, L. A., Pedaste, M., Mäeots, M., Leijen, Ä., Rannikmäe, M., Zacharia, Z. C., & de Jong, T. (2017). Design and Evaluation of a Smart Device Science Lesson to Improve Students' Inquiry Skills. In H. Xie, E. Popescu, G. Hancke, & B. Fernández Manjón (Eds.), *Advances in Web-Based Learning – ICWL 2017: 16th International Conference, Cape Town, South Africa, September 20-22, 2017, Proceedings*, New York, NY: Springer International Publishing, pp. 23–32.
・Sverre Tveit (2014) Educational assessment in Norway, Assessment in

Education: Principles, Policy & Practice, 21:2, 221-237, DOI: 10.1080/0969594X.2013.830079

・Vispoel, W. (1992). How Review Options and Administration Modes Influence Scores on Computerized Vocabulary Tests. N/A. Accessible at: <https://www.researchgate.net/publication/234634051_How_Review_Options_and_Administration_Modes_Influence_Scores_on_Computerized_Vocabulary_Tests>

・Zacharia, Z. C., & de Jong, T. (2014). The Effects on Students' Conceptual Understanding of Electric Circuits of Introducing Virtual Manipulatives within a Physical Manipulatives-Oriented Curriculum. *Cognition and Instruction*, *32*, pp. 101–158.

・Zacharia, Z. C., Manoli, C., Xenofontos, N., de Jong, T., Pedaste, M., van Riesen, S. A. N., Kamp, E. T., Mäeots, M., Siiman, L., & Tsourlidaki, E. (2015). Identifying Potential Types of Guidance for Supporting Student Inquiry When Using Virtual and Remote Labs in Science: A Literature Review, *Educational Technology Research and Development*, *63*(2), pp. 257–302.