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Challenges of implementation of digital literacy through science and maths subjects in the context of new curriculum in Latvia.

MA thesis

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Abstract

Challenges of implementation of digital literacy through science and maths subjects in the context of new curriculum in Latvia.

The aim of the thesis is to identify the challenges posed by teachers in implementing the new learning content, improving the digital literacy of pupils in science and mathematics in classes 1 - 12.

An analysis of the sources of theoretical literature about the 21st century skills and digital literacy, science and mathematics programmes analysis was carried out. The author developed a survey for science and mathematics teachers.

Summarising all the findings of the study, the author concludes that there are four main problems in order to implement digital literacy in science and mathematics programmes in Latvia.

Keywords: 21st century skills, Skola2030, digital literacy, digital competence.

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Introduction

Each democratic country's aim is to make its society successful. Society consists of individuals and each successful individual brings together a more successful society. It follows that the goal of each country would be to build its own population into industrious individuals. One of the keys to creating a successful personality is qualitative education.

The rapid development of technology and innovation changes our lives more than ever. It changes our daily lives, our understanding of what is important and materially, to teach and learn in nowadays schools. It is common knowledge that children that are starting to learn at school will work in professions that don't exist yet. It means that learning content and approach to learning has to change, to be able to provide students with those kinds of skills, so that they are capable of adapting to future challenges. Countries that are working towards making their students adaptive to the future, can say that they are working towards the goal of making a successful society.

Quality education is one of the key elements for successful development of the country. In the end of the 20th century the world was introduced with four basic elements of education for the 21st century. They were: 1) learning to know, 2) learning to do, 3) learning to be, 4) learning to live together (Delors et al., 1996). Around that moment there was a paradigm shift in education. There became more and more researches about skills that are necessary for every person living in the 21st century. They are now known as 21st century skills or sometimes called - competencies. Nowadays education is not only about knowledge but also about skills that go throughout every aspect of a person's life.

Latvian society and education policy makers also came to the conclusion that we have to improve our education. The Ministry of Education started a huge project in 2016 for changes in our curriculum and approach to learning from preschool till high school focusing on knowledge, skills and attitudes of the future generation (“Par projektu”, n.d.). This project is the biggest educational project in Latvia since regaining independence in 1991. It is called “School 2030” as referring to a student that will end school with a changed approach in 2030.

Project has got three main phases: development of learning content, approbation and implementation. Since September of 2020 the implementation phase has started. Teachers from kindergarten till high school are introducing students with a competence approach in learning content.

In spite of the fact that teachers have to teach different learning content and skills related to subjects in the new approach, teachers must also teach transversal skills. In Latvia,

six cross-curriculum skills have been identified and outlined with concrete results to be achieved at the end of different learning phases (Noteikumi par valsts pamatizglītības standartu un pamatizglītības programmu paraugiem, 2018; Noteikumi par valsts vispārējās vidējās izglītības standartu un vispārējās vidējās izglītības programmu paraugiem, 2019). These skills are 1) critical thinking and problem solving, 2) innovation and entrepreneurship, 3) self-regulated learning, 4) collaboration, 5) civil participation and 6) digital literacy. All competencies, including digital literacy, are already embedded in standard and programs by new content developers. The programme of each subject may see the grounds for developing each competence. Transversal skill is a skill that runs through all subjects, so it cannot be developed in just one subject.

We can not deny that technologies nowadays are a big part of our lives. World's economies are driven by development of technologies and every citizen of the world in order to be successful, has to learn about technology, learn to use technology, learn to live in technological century and to live with technologies. In other words people have to be competent in digital literacy. There are a lot of unknown technologies in the future, so educational policies have to prepare their citizens to be as capable as possible to deal with unknown knowledge and skills in the future.

This master's work will look at how the new learning content involves achieving digital literacy in science (nature sciences, biology, physics, chemistry, geography) and maths at grades 1 - 12, and how teachers actually manage to teach this skill to pupils.

The aim of this work is to identify the challenges posed by teachers in implementing the new learning content, improving the digital literacy of pupils in science and mathematics in classes 1 - 12.

Research question is: “What difficulties are encountered by teachers to improve pupils' digital literacy in science and mathematics in classes 1 - 12?”

The author advances a hypothesis that the difficulties to improve pupils' digital competence in science and mathematics are linked to the lack of technologies in schools and teaching aids.

Using content analysis and survey methods, the researcher collected data and information from teachers in Valka Janis Cimze gymnasium and analysed Science and Mathematics programmes.

This thesis consists of 6 chapters. Chapter 1 is the theory review about 21st century skills. In chapter 2 the author establishes cross-cutting competencies in Latvia's new curriculum, while chapter 3 is underpinning the theoretical framework of digital literacy.

Chapter 4 focuses on the methods used in the thesis work. In chapter 5 are described results from content analysis and survey. Chapter 6 is a discussion where results and theory is linked together and conclusions about research questions were made.

1. 21st century skills

1.1. What are 21st century skills?

In this chapter the author describes different frameworks that refer to 21st century skills.

Since the 1970s there has been a new term invented - information society. It means that information is the defining feature of society. Before the information society there was an industrial society whose distinguishing elements were steam power and fossil fuels. (Oxford reference, n.d.)

Information society can be characterised by three main points:

a) Information is used as an economic resource;
b) There is a greater use of information among the general public;
c) Information sector is developing within the economy. (Moore, 1997)

Despite the time of the invention of the term, when we are talking about the information society, we are talking about developed countries in the late 20s and 21st century. In some literature information society is meant as synonymous to knowledge society, but UNESCO (2005) describes differences between information and knowledge societies. “Knowledge societies are about capabilities to identify, produce, process, transform, disseminate and use information to build and apply knowledge for human development. They require an empowering social vision that encompasses plurality, inclusion, solidarity and participation.” Information society we can only see in the countries where informational technologies are available. Castelfranchi (2007) describes the information society as the society that creates and disseminates data while knowledge society transforms information into resources. Transformed information can be used for society to take effective decisions and actions.

Although there are differences in terminology about technology/digital and knowledge society, we can establish that nowadays society has changed from industrial to the one where technologies and knowledge are the bases of development. With the changes of the society individuals also have to change.

Amount of data and technology expansion of our life changes our society from memory-based to knowledge-based societies. Our learning behaviour changes. Now we use the expression “learning how to learn” Peter Drucker (1969) described in the context of knowledge society.

In the UNESCO glossary of Curriculum Terminology (2013) we can read that “the changes in economy and the labour market caused by globalisation and internationalisation

are an important driving force for the need of 21st century skills". This concept of 21st century skills combines the knowledge, skills and attitudes individuals need in knowledge society to be able to fully participate and contribute in it.

International Commision on Education for the Twenty-first Century (Delors et al., 1996) introduced one of the first frameworks of the skills necessary for the person in the 21st century. In the Delors Report were formulated four pillars or the foundations of education: 1) Learning to know; 2) Learning to do; 3) Learning to be; 4) Learning to live together.

There are various frameworks describing and comparing competencies for this century, for example, Four educational pillars (Delors et al., 1996), Partnership for 21st century skills (Partnership for 21st Century Skills, 2009), Other 3Rs (Sternberg and Subotnik, 2006), Four-dimensional education (Fadel et al., 2015).

Cynthia Luna Scott (2015) has summarised different frameworks and outlined common competencies for citizens of the knowledge society. Some of these competencies are critical thinking, problem-solving, communication and collaboration, creativity and innovation, information, communication and technology literacy (ICT), social and cross-cultural skills, metacognitive skills etc.

The European Union has defined its own eight key competences. This sum of the skills are: 1) communication in the mother tongue and 2) in foreign languages; 3) competences in mathematics, science and technology; 4) digital competence; 5) learning to learn; 6) interpersonal, intercultural and social competences, and civic competence; 7) entrepreneurship; 8) cultural expression (EU, 2006). All these competencies are developed throughout an individual's life, through learning, formal, non-formal and informal, in different environments, for example, family, education facility, workplace, local communities etc. (European Commision, 2019).

In this thesis' work author is going to base the theory about competencies in the European Parliament and the Council set framework about 21st century skills (EU, 2006). All of these previously described competencies are equally important and they are eloping in different situations.

There are a lot of conceptions about these 21st century skills that are used as synonyms, for example, key competencies or skills, core competencies or skills, general competencies, cross-curricular competencies, cross-cutting competencies; transversal competencies etc.

In the next subdivision the author is going to distinguish some of these terms.

1.2. Terminology of the 21st century skills

Competence is a combination of knowledge, skills and attitudes appropriate to the context (CEDEFOP, 2011). In the same glossary word “skills” are defined as the ability to perform tasks and solve problems. Sometimes the term “skills” is used in a broader meaning as equivalent to “competencies” (UNESCO, n.d.). In the context of participants of knowledge society core skills or core competencies are with the same meaning. Nevertheless, competence is a more comprehensive word than skills.

UNESCO glossary of curriculum terminology (2013) terms “21st century skills”, “Key competencies”, “Overarching competencies” and “General competencies” are described as synonyms. “The key competencies are a combination of knowledge, skills and attitudes,” is written by the European Commission (2019). These eight competencies are written above in the previous subdivision.

The British Council uses the term “Core competencies” when referring to 21st century skills (British Council, 2016).

In this chapter the author described different frameworks that are used in the context of 21st century skills and different terminology that are used in regards. In the next chapter the author describes the changes in the Latvian curriculum and cross-cutting competencies are implemented in Latvian curriculum.

2. Cross-cutting competencies in Latvia

In this chapter the author of the thesis outlines how the educational system in Latvia is built, describes how the new content of education has been carried out.

Education in Latvia is separated into 4 main blocks: 1) pre-school education (1,5-6 years old students); 2) elementary education (6-15 years old students); 3) secondary education (15-18 years old students); 4) higher education (18+ years old students).

In the autumn of 2016 in Latvia started a huge project in education called “Skola2030” or in english - School 2030. This project's aim is to develop, approbate and consecutively establish general education content and approach in Latvia from preschool till high school, as a result student's would get necessary knowledge, skills and attitudes towards nowadays needs. (“Par projektu”, 2022)

There was a huge oversight of the previous educational content. Firstly, the knowledge, skills and attitudes students should possess were looked at in the bigger picture - from 1,5 years old students till 18 year old ones. Pre-schools education content was divided into three periods. These periods are based on the age of the students. These periods are: 1) 1,5 - three year old students, 2) three till five years old students, 3) five till six years old students (Brice et al., 2018).

Elementary education in Latvia is 9 years long and it was also divided into three periods: 1) grade one to three, 2) grade four to six and 3) grade seven to nine.

Secondary education in Latvia was most reviewed and changed so that young people could start specialising in the high school years according to their own interests. Now every subject in high school is available in two levels - optimal and in-depth. Student's have to take an optimal level course and then he or she can choose to take this course also in-depth. Every high school can also make their own courses in addition to their specialisation programme. For example, in an author's school there are three main programmes students can choose from - 1) medicine and IT, 2) sports and communication and 3) entrepreneurship and logistics.

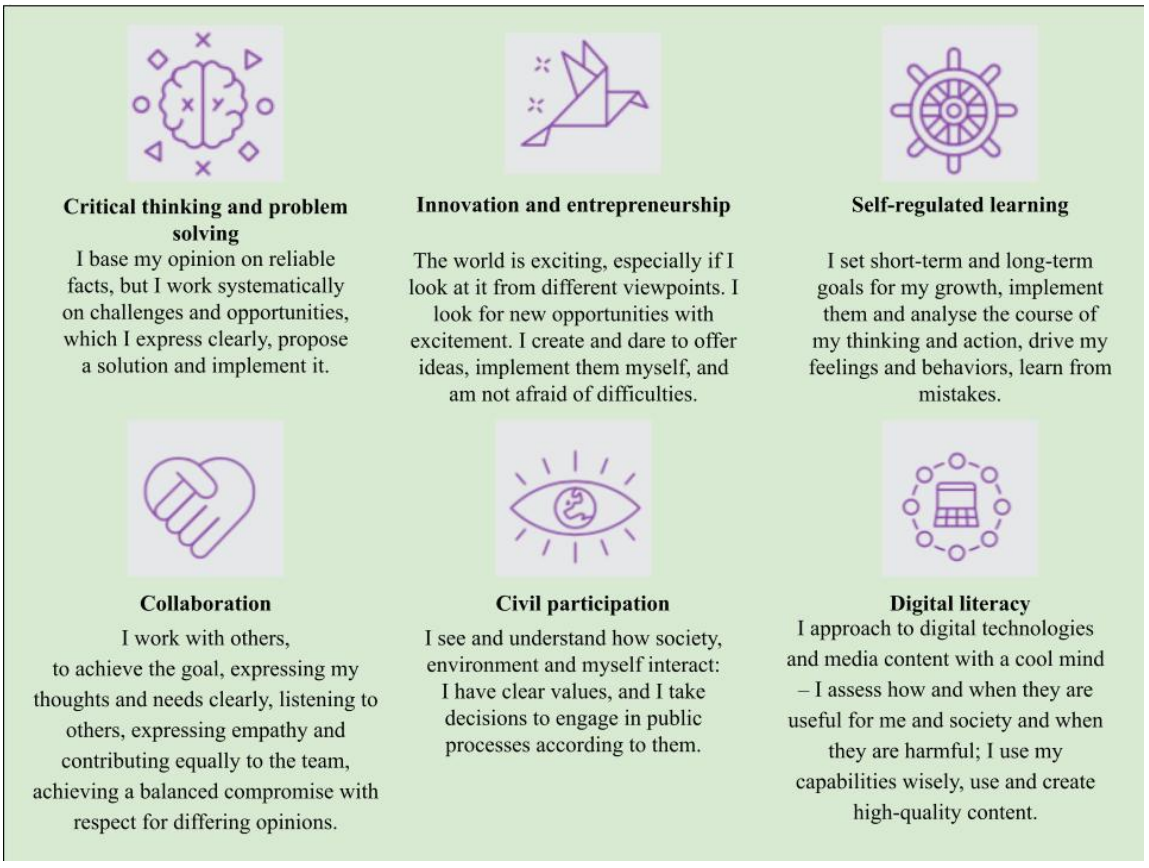
All of the subjects students should learn from preschool to high school are divided into seven fields based on their main goals and relationship with each other. They are: 1) science (natural sciences, biology, geography, chemistry, physics); 2) health and physical activity training (P.E. and health); 3) mathematics (maths); 4) technologies (design and technologies, computing, engineering); 5) languages (Latvian, minority languages, foreign languages); 6) social and civil learning (social sciences, history of Latvia, world's history); 7) cultural

awareness and self-expression arts training (visual art, music, literature, theatre art) (“Mācību jomas”, 2022).

Into each of the fields there are main ideas students should get while learning these subjects. There are standards that describe the outcome of the learning process in each of the fields at the end of each learning period. There are set achievable results at the end of the pre-school, at the end of the middle school and the end of the high school each student should reach. These achievable outcomes are not only about knowledge, they are also about students' skills and attitudes at the end of one learning process.

Despite the fact that each of the fields have their own main goals to achieve, there are also six cross-cutting competencies that are implemented in every field's programmes. These transversal skills are: 1) critical thinking and problem solving; 2) innovation and entrepreneurship; 3) self-regulated learning; 4) collaboration; 5) civil participation; 6) digital literacy. New content developers have described these cross-cutting skills from the view of the self-aware student (see Figure 2.1.).

Figure 2.1. Cross-cutting skills from the view of the self-aware student (Hačatrjana and Mazpane, 2020).



Purpose of implementation of the transversal skills in education is to develop every pupil into a responsible and active citizen in society, develop a personality with self-confidence that respects and cares for himself and others, in the growth of creative practitioners and connoisseurs for whom learning has became a gateway, develop a personality that is loyal to the country. (Hačatrjana and Mazpane, 2020)

In the cross-cutting manual (Hačatrjana and Mazpane, 2020) there is written that some of the learning fields can implement cross-cutting skills more than others. The table 2.1. shows in which learning fields the content makers consider that certain transversal skills are most meaningful to develop. Nevertheless, they also write that cross-cutting skills have to develop in each of the fields of learning. It is also stressed that transversal skills can be meaningfully carried out in the schools if there is going to be a collaboration between teachers in the same fields and also between different field's teachers.

Table 2.1. Expression of transversal skills in different learning fields (Hačatrjana and Mazpane, 2020).

	Languages	Maths	Science	Social and civil learning	Cultural awareness and self-expression arts training	Health and physical activity training	Technologies
Critical thinking and problem solving	x	x	x	x			x
Innovation and entrepreneurship					x		x
Self-regulated learning		x	x		x	x	
Collaboration	x			x	x	x	
Civil participation			x	x			
Digital literacy	x						x

Implementation stage of the new curriculum in pre-school started in September 2019, but in schools in September 2020. In table 2.2. is visible how the new improved content and approach is step-by-step implemented in the context of the school year. Students who started grade 1 in September 2020 in 2032 will finish the school and will be a “product” of this improved educational system. (“Ieviešanas grafiks”, 2022)

Table 2.2. Step-by-step implementation plan of an improved content and approach in Latvia ("Ieviešanas grafiks", 2022).

2019 / 2020	2020 / 2021	2021 / 2022	2022 / 2023
grade 12	grade 12	grade 12	grade 12
grade 11	grade 11	grade 11	grade 11
grade10	grade10	grade10	grade10
grade 9	grade 9	grade 9	grade 9
grade 8	grade 8	grade 8	grade 8
grade 7	grade 7	grade 7	grade 7
grade 6	grade 6	grade 6	grade 6
grade 5	grade 5	grade 5	grade 5
grade 4	grade 4	grade 4	grade 4
grade 3	grade 3	grade 3	grade 3
grade 2	grade 2	grade 2	grade 2
grade 1	grade 1	grade 1	grade 1
pre-school	pre-school	pre-school	pre-school

In this chapter the author outlined Latvia's educational system and cross-cutting skills that are implemented in the curriculum. In the next chapter the author describes what is digital literacy, its frameworks and digital literacy's role in education.

3. Digital literacy

3.1. What is digital literacy?

Digital literacy also known as digital competence is defined as a lifelong competence of the European Union since 2006, but redefined in 2018 by Council Recommendations. “Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking.” (European Commision, 2019). UESCO (2018) revealed their own interpretation “Digital literacy is the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technolo-gies for employment, decent jobs and entrepreneurship. It includes competences that are variously referred to as computer literacy, ICT literacy, information literacy and media literacy.

There are also shorter definitions, for example, Jisc (2014) writes that digital literacies are those capabilities which fit an individual for living, learning and working in a digital society.

The Digital Competence Framework for Citizens or also called as DigComp is an European Union created tool to: 1) improve EU citizens' digital competence; 2) help policy-makers in decision making about digital competences; 3) implement digital competence in education and training (European Commision, 2022).

DigComp 1.0 was published in 2013, but in 2016 came the improved version - DigComp 2.0. In 2017 the previous framework was updated and called DigComp 2.1. In 2022 there is the newest framework about citizens' digital competences - DigComp 2.2. This framework “describes which competencies are needed today to use digital technologies in a confident, critical, collaborative and creative way to achieve goals related to work, learning, leisure, inclusion and participation in our digital society” (Kluzer, Pujol Priego, 2018).

Digital competence framework for citizens describes five competence areas needed today to live in digital society. As visible in table 3.1. these five competence areas include 21 digital competence. In addition to five competence areas and described 21 digital competence, there are also outlined each competence in its eight proficient levels. Despite that there are eight proficient levels to each competence, they are also described from the

perspective of knowledge, skills and attitudes related to digital competence. (Kluzer, Pujol Priego, 2018)

Table 3.1. 21 digital competencies described in DigComp 2.2. for digitally competent citizens.

Information and data literacy	1.1. Browsing, searching and filtering data, information and digital content. 1.2. Evaluating data, information and digital content. 1.3. Managing data, information and digital content.
Communication and collaboration	2.1. Interacting through digital technologies. 2.2. Sharing information and content through digital technologies. 2.3. Engaging in citizenship through digital technologies. 2.4. Collaborating through digital technologies. 2.5. Netiquette. 2.6. Managing digital identity.
Digital content creation	3.1. Developing digital content. 3.2. Integrating and re-elaborating digital content. 3.3. Copyright and licences. 3.4. Programming.
Safety	4.1. Protective devices. 4.2. Protecting personal data and privacy. 4.3. Protecting health and well-being. 4.4. Protecting the environment.
Problem-solving	5.1. Solving technical problems. 5.2. Identifying needs and technological responses. 5.3. Creatively using digital technologies. 5.4. Identifying digital competence gaps.

Creators of DigComp state that this framework is an essential support and guidance of education to develop digital competence. The author in the next subsection describes digital literacy's role in education.

3.2. Digital literacy in education

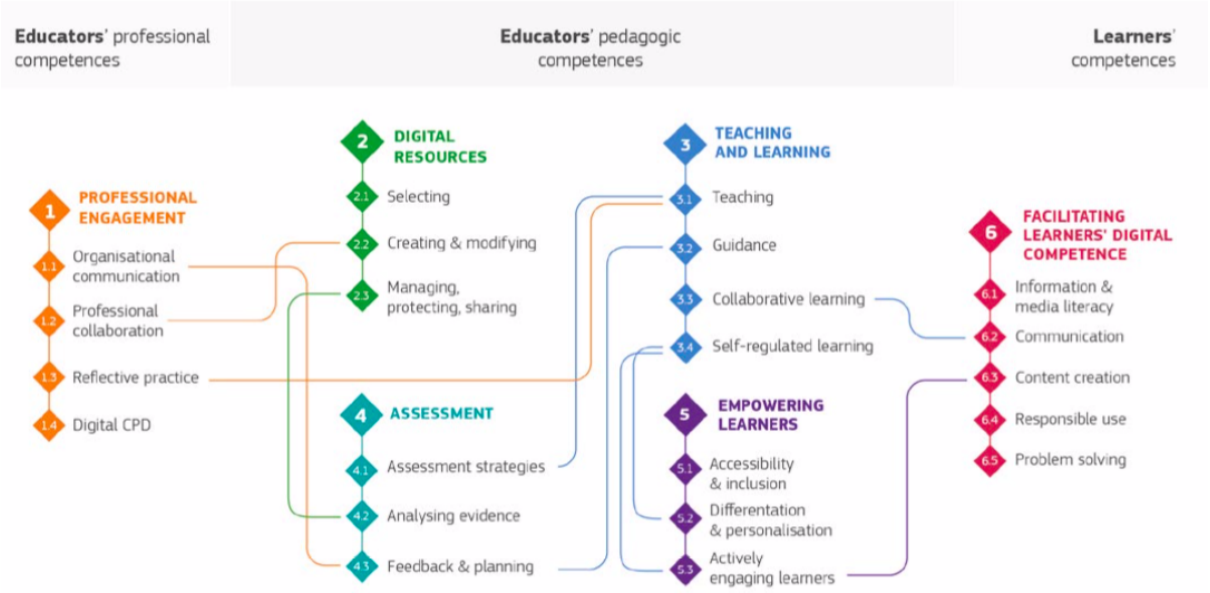
Digital literacy, also known as digital competence, is one of the 21st century skills that students should master. The best way to learn digital literacy is by competence oriented approaches (European Commission, 2019).

> *Competence oriented approaches should therefore be embedded in initial training of educational staff and their continuing professional development. Educational staff need to be supported in developing innovative competence-oriented approaches and*

encouraged to collaborate within and beyond their educational institutions. (European Commission, 2019)

Digital competence framework is created for every citizen. The European Commission's science and knowledge centre - Joint Research Centre (JRC) in 2017 published a digital competence framework for education "The European Framework for the Digital Competence of Educators (DigCompEdu)". In this framework are described competences that are necessary to develop for educators in order to enhance learners digital literacy. There are six areas in which educators' digital literacy is expressed through 22 competences, in Figure 3.1. is visible those areas and competences, how they are connected.

Figure 3.1. DigCompEdu framework's areas and competencies (Redecker, 2017)



Educationalists are professionals in the field of education, they are supposed to use technologies not only for educational purposes, but to enhance organisational communication (with learners, parents, third-parties), to collaborate with other colleagues through technologies, to reflect about pedagogical processes and to continue to develop digital skills.

Nowadays there are almost no teachers who would not use digital resources in their work. Pedagoges select specific digital resources for teaching and learning. They also modify existing digital resources or create their own with various digital tools, share their digital content with others, and are supposed to know digital content sharing right.

There are 45% of teachers who fully agree with the statement that "technologies improves their effectiveness in their work", 43% rather agree. (Lielvārds, 2022). DigCompEdu's 3rd area is about how teachers use digital tools to enhance learners in their

lessons. Digital tools can be used in order to amend learning through collaboration and also self-regulated learning processes.

Technologies in the educational process are used not only for the advanced learning process, but also for assessing students' results both formative and summative. Educational process results are necessary to analyse and to give feedback about them - technologies are a great support for educationalists in order to do so. Author observed that Covid-19 situation showed - smarter technology use helped to reduce workload during distance learning.

Nowadays education is about including everyone and giving accessibility to it. Technologies are one of the best ways to empower learners. Digital devices and content allows for teachers to differentiate and personalise the educational process in order to actively engage learners in the process of learning.

Educators are not only supposed to use technologies in their lessons in order to enhance the learning process, assess and evaluate students, give feedback, they also need to improve student's digital competence. In DigCompEdu there are distincted five competencies that are part of digital literacy. It is important for students to obtain information and media literacy, digital communication and collaboration, digital content creation, responsible use of technologies, and digital problem solving.

There are discussions about technology use in education and implementation in the lessons not only theoretically but also practically. For example, in 2019 European Commission organised an international conference with more than 230 participants on *Supporting Key Competence development: learning approaches and environments in school education*. In this conference, where participants were policy makers, practitioners, researchers, crystalised some important thoughts. They identified problems in regards of technologies: 1) Lack of time and space for teachers to experiment with new technologies; 2) Fear of new technologies is the first barrier for teachers; 3) Lack of clear purpose - there are good and bad reasons to include technology in the classroom; 4) Some school culture can make it difficult for teachers to engage with the technology. (European Commission, Directorate-General for Education, Youth, Sport and Culture, 2020)

One of the six transversal skills in Latvia - digital literacy, in its aims are based on DigComp (European Digital Competence Framework for Citizens). In Latvia teachers' goal in regards to digital literacy is to raise awareness about: 1) digital technologies; 2) digital tools; 3) the meaningful use of technologies; 4) digital identity; 5) the realities created by the media; 6) health impacts of digital devices; 7) environmental impact of digital devices (Kosolapova, 2020)

4. Methodology

In this chapter the author describes methodology used to gain results in order to answer the research question: “What difficulties are encountered by teachers to improve pupils' digital literacy in science and mathematics in classes 1 - 12?”

There were two methods used in this thesis work. Firstly, there was content analysis carried out about science and maths programmes. Secondly, there was a survey. In the 4.1. subsection author describes methodology of content analysis.

4.1. Science and maths programmes analysis

In Annex 1, the Latvian rules on samples of national basic education standards and basic education programmes, may read the defined results for all six cross-cutting skills to be achieved at the end of grade three, six and nine (Noteikumi par valsts pamatizglītības standartu un pamatizglītības programmu paraugiem, 2018) and in annex 1 in Latvian rules on samples of national general secondary education standard and general secondary educational programmes, may read the defined results for all six cross-cutting skills to be achieved at the end of the grade 12 (Noteikumi par valsts vispārējās vidējās izglītības standartu un vispārējās vidējās izglītības programmu paraugiem, 2019).

Students have to develop digital literacy in four main aspects, to be capable of: 1) using effectively digital tools to gain information; 2) using technologies to create content or new information; 3) using technologies more efficient communication and collaboration; 4) using technologies responsibly and conscientiously while making one's own digital identity (Hačatrjana and Mazpane, 2020).

In the Appendix 1 are visible outcomes of digital literacy at the end of each learning cycle in each of four digital literacies' aspects, that are defined in the standards of elementary education and general secondary education. These outcomes of betterment of digital literacy are built on a step-by-step method. Learning outcomes becoming more and more demanding towards the student makes it at each learning cycle better and better in digital literacy.

In Latvia science subjects are defined to be biology, chemistry, geography and physics. In the pre-school and in classes one to six students are learning these science subjects in a mixed subject called “natural sciences”. Students in seventh grade start to take science subjects separately. Biology and geography starts at grade seven, but chemistry and physics at eighth grade (see Figure 4.1.). After students finish basic school, they have to choose between basic secondary schools or professional schools. In basic secondary schools students learn

science subjects separately in optimal level or combined subjects - natural sciences (depends on the programme of the school). If a student has learnt biology, geography, physics and chemistry separately, he or she can choose to learn these subjects in-depth in the grade 12. Students are learning mathematics from grade one to grade 11, then students can also take enhanced mathematics.

Figure 4.1. Science subject time table in Latvia.

Grade 1 - 6	Grade 7	Grade 8 - 9	Grade 10 - 11	Grade 12
* Mathematics * Natural sciences	* Mathematics * Biology * Geography	* Mathematics * Biology * Geography * Physics * Chemistry	* Mathematics (O) * Biology (O) * Geography (O) * Physics (O) * Chemistry (O) OR * Natural sciences	* Mathematics (E) * Biology (E) * Geography (E) * Physics (E) * Chemistry (E)

The entire learning content for a specified period of time (two or three years) is divided into more detailed topics / units. Each topic is described separately in the programs, with the results to be achieved, and the actions to be performed under the unit.

The analysis of the grade one to twelve maths and science programmes (Ančupāns et.al., 2021; Avena et.al., 2020; Balanda et.al., 2021; Belogrudova et.al., 2021; Bērtule et al., 2020; Bērtule et.al., 2021a; Bērtule et.al., 2021b; Bērziņa et.al., 2020; Bērziņa et.al., 2021; Burgmanis et.al., 2021a; Burgmanis et.al, 2021b; Cīrule et.al., 2020; Greitāns et.al., 2021a; Greitāns et.al., 2021b; Koroševska et.al., 2020; Koroševska et.al., 2021) covered all units of science and mathematics subjects. As described in the second chapter, improved content creators were not putting emphasis on implementing digital literacy throughout science and maths' fields, nevertheless, the researcher looked for activities that would improve and strengthen the digital skills of students.

Each learning year in the programmes was looked into separately, also each unit was looked apart in the context of learning year. Students' learning skills were classified according to the four digital literacies' aspects whose goals are described at the end of each learning cycle. Following each specific digital skill action, the brackets contain letters indicating which of the subjects includes the development of that skill in the content - biology (B), chemistry (Ch), geography (G), mathematics (M), natural sciences (N), physics (Ph).

4.2. Teacher's survey

An online survey (made in Google Forms) was conducted in Valka Janis Cimze gymnasium for science and maths teachers in Latvian. From grade 1-12 there were 20 teachers who were asked to answer questions, 15 responded.

All questions were divided into two blocks: 1) questions about personal attitudes towards digital literacy and knowledge about digital literacy; 2) questions about digital literacy in their lessons.

There are six questions in the first block and seven in the second. Translated survey in English is visible in Appendix 2.

First and second questions are statistical questions about the grades teachers are working with and subjects they are teaching in Valka Janis Cimze gymnasium. The aim of the third question was to find out what teachers are understanding with the term “digital literacy”.

Part of digital literacy is educational technologies educators use in order to achieve specified goals and to develop digital skills. Aim of the fourth question was to understand what kind of technologies that are available in Valka Janis Cimze gymnasium, they consider as educational technologies to promote digital literacy.

Teachers evaluated their own digital literacy skills in the scale of one to four in the fifth question. The aim of this question was to understand how teachers are appraising their own digital literacy skills and to compare how much they are developing students' digital literacy skills. These results also were analysed in the context of their responses to question No.3 un No.4.

Sixth question was complex, because teachers evaluated seven different assertions on the scale of one (totally disagree) to four (fully agree). These statements help to distinguish some of the problems teachers face in order to implement digital literacy in the lessons.

Question eight, nine, ten and eleven are very much alike. Aim of these four questions were to understand how frequently teachers are implementing digital literacy development in their lessons.

Goal of the twelfth question is to understand what kind of actions that are mentioned in the maths and science programs teachers usually do in their lessons. At the end of the questionnaire there are two open questions. Aim of the thirteenth question is to understand if teachers think that it is important to develop digital literacy and to understand also why they think so. Fourteenth question is going to be a significant answer to explain teachers' answers to eighth to eleventh questions.

5. Results

5.1. Science and maths programmes analysis

In Appendix 3 are given data about how many units there are in each grade in each subject in order to understand further tables with results from content analyses.

As visible in table 5.1. in grade one students from four digital literacy goals have to develop through nature sciences and mathematics two - search for information and content and information creation. Students have to learn to use technologies to take photos, to draw or gain information. There are several topics, where programmes do not outline anything that is related to digital competence.

Table 5.1. Implemented digital literacy elements in grade one maths' and nature sciences' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1		* Use technologies to take photos. (N)		
No. 3		* Use technologies to take photos. (N) * Make drawings of shapes with digital tools. (M)		
No. 4		* Use technologies to take photos. (N)		
No. 8	* Use the internet to gain information. (M)			

In grade two students have to use digital skills they have gained in the first class. Besides those skills, they also have to gain information using interactive simulations and have to use digital tools to solve tasks - in order to have faster feedback (table 5.2.). Students evolve two of four digital literacy goals.

Table 5.2. Implemented digital literacy elements in grade two maths' and nature sciences' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (N) * Use digital tools to solve			

	tasks. (M)			
No. 2	* Use the internet to gain information. (M)			
No. 3	* Use interactive simulations. (N)			
No. 4		* Use technologies to take photos (N)		
No. 6		* Use digital tools to draw shapes. (M) * Use technologies to take photos (M)		

Students in Latvia are supposed to discuss the effects of technology development on students' everyday life and health in the natural sciences in grade three. Likewise they have to learn to use GPS devices and use digital maps to gain specific information. As visible in table 5.3. Students are improving their digital skills more in natural sciences than in mathematics.

Table 5.3. Implemented digital literacy elements in grade three maths' and nature sciences' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (N) * Use interactive tasks to memorise a multiplication table. (M)	* List used references. (N) * Use technologies to take photos (N)		
No. 2	* Use the internet to gain information. (N)			* Discuss effects of technology development on students' everyday life and health. (N)
No. 3	* Use digital maps to gain information. (N) * Use GPS devices. (N)			
No. 5	* Use applications to do tasks. (M)	* Use technologies to take photos (N)		

In grade four both in science and mathematics programmes' there are described a very few elements about digital literacy (table 5.4.). Technologies are only used to gain information through internet research or maps in these subjects. Other digital literacy goals aren't implemented in these programmes.

Table 5.4. Implemented digital literacy elements in grade four maths' and nature sciences' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (N)			
No. 3	* Use the internet to gain information. (M)			
No. 4	* Use digital maps to gain information. (N) * Use the internet to gain information. (N) * Use mobile applications to do tasks. (N)			

In grade five students have to make a new content - digital portfolio in natural sciences. As visible in table 5.5. there are few elements included in grade five programmes in mathematics and natural sciences. As previously, there are elements from two digital literacy goals - gaining information and creating content and new information.

Table 5.5. Implemented digital literacy elements in grade five maths' and nature sciences' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (N, M)			
No. 2		* Make a digital portfolio. (N)		
No. 4	* Use the internet to gain information. (N) * Use an application to gain data. (M)			

In grade six only in one topic in the mathematics programme are found elements of digital literacy, moreover to gain information. Students are supposed to talk about healthy habits of technology use in natural sciences in the fourth topic. In table 5.6. It is visible that there are only a few topics with digital competence elements, which mostly sustain from gaining information on the internet or in digital maps.

Table 5.6. Implemented digital literacy elements in grade six maths' and nature sciences' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (N) * Use digital maps to gain information. (N)			
No. 4	* Use the internet to gain information. (N)			* Talk about healthy habits of technology use. (N)
No. 5	* Use the internet to gain information. (M)			

In grade seven natural sciences transformes into separate science field subjects. Biology, geography and maths programmes describe different elements of digital literacy to include in the lessons. As visible in table 5.7. students have to gain information from the internet, maps, simulations, online databases in order to solve given tasks or problems. Students are supposed to create new content by making their own digital maps, photo collages, presentations in science subjects and drawing different shapes in mathematics. There aren't any elements that are related to communication and collaboration or responsibilities and digital identity.

Table 5.7. Implemented digital literacy elements in grade seven biology, geography and mathematics' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use internet information to gain information. (B, M) * Use digital maps to gain information. (G) * Use GPS devices. (G)	* Make digital maps. (G)		
No. 2	* Use internet information to fulfil a table. (B)	* Make photo collage. (B)		
No. 3	* Use the internet to get information. (B, G) * Use internet information to make schemes. (G)	* Take photos and make a presentation. (G)		
No. 4	Use internet information to make models. (B) * Use the internet to get information. (B) * Use digital maps to answer			

	questions. (G) * Use simulations to obtain data. (M)			
No. 5	* Use online databases to gain information. (G)	* Use digital tools to draw and analyse shapes. (M)		

In table 5.8. there are summarised digital literacy elements of four science programmes and maths' programme in grade eight. As in previous years, science subjects mostly develop students' skills to gain information through devices. Mathematics in grade eight is more focused on developing students' content creation skills by making surveys and drawing functions, shapes or diagrammes with digital tools, for example, GeoGebra. In biology students are supposed to make a video on the second topic.

Table 5.8. Implemented digital literacy elements in grade eight biology, geography, physics, chemistry and mathematics' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (G, B)	* Make a survey. (M)		
No. 2	* Use interactive maps to gain information. (G) * Use the internet to gain information. (G, M)	* Make a presentation. (B, G) * Make a video about an experiment. (B)		
No. 3	* Use the internet to gain information. (B)	*Make an infographic. (B) * Make a video about first aid. (B) * Use digital tools to draw functions. (M)		
No. 4	* Use internet information to gain information (B, Ph) * Use simulations to obtain data. (Ph)			
No. 5	* Use the internet to gain information. (Ch)			
No. 6	* Use the internet to gain information. (Ph)			
No. 7	* Use the internet to gain information. (M)	* Use digital tools to draw shapes. (M) * Use digital tools to draw graphics. (M)		

In the last year in elementary school, students continue to acquire skills in the first two blocks of digital literacy aims. Students mostly are using the internet to find necessary information, in the fourth topic of geography students have to work with databases. In the beginning of the grade nine students have to do field work in project work that involves mathematics, biology, geography and physics. That is why in table 5.9. is visible that students have to process research data and results digitally and have to make a presentation about research.

Table 5.9. Implemented digital literacy elements in grade nine biology, geography, physics, chemistry and mathematics' programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (G, Ch) * Use GPS devices. (G)	* Make a presentation. (B, G) *Process digitally research data and results. (B) * Use digital tools to draw shapes. (M)		
No. 2	* Use the internet to gain information. (G, Ch) * Use simulations to obtain data. (Ph)	*Process digitally research data and results. (G) * Make a presentation. (G)		
No. 3	* Use the internet to gain information. (B)	*Make an infographic. (B) * Make a video about magnetism. (Ph)		
No. 4	* Use the internet to gain information. (B, G) * Use databases to gain information. (G) * Use interactive maps to gain information. (G)	*Assess the reliability of internet resources. (B)		
No. 5	* Use the internet to gain information. (Ph)	*Make an infographic. (Ph)		
No. 6	* Use the internet to gain information. (Ph)	* Make a presentation. (Ph)		
No. 7	* Use the internet to gain information. (M)			
No. 8	* Use the internet to gain information. (M)	* Use digital tools to make mathematical patterns. (M)		

High-school students are learning all of the science subjects and mathematics in optimal level in grade ten and eleven. In the table 5.10. are outlined the digital literacy elements in science and mathematics programmes at an optimal level. As visible students have to use digital technologies and tools to find the information on the internet, through simulations, maps and databases. Mostly in mathematics students have to use digital tools and applications to solve problems or to analyse diagrams and functions, also to train skills in solving problems. In geography and physics students have to process and display graphics in spreadsheet programs. Chemistry and geography programmes have outlined media literacy elements - students have to search scientifically accurate information and have to check different information. Students are supposed to make interactive maps and materials, make presentations and draw 3D shapes.

Table 5.10. Implemented digital literacy elements in optimal level science and mathematics programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No. 1	* Use the internet to gain information. (B, Ch, G) * Use interactive simulations. (Ph, M) * Use spreadsheet programs to process and display graphics. (Ch) * Use databases to gain information. (G) * Use applications to train skills. (M)			
No. 2	* Use the internet to gain information. (B, Ph, Ch, G) * Use interactive simulations. (Ph, M) * Use databases to gain information. (G) * Use spreadsheet programs to process and display graphics. (G) * Use applications to analyse information. (M)	* Use digital tools to draw and analyse graphics. (M) * Make a presentation. (G)		
No. 3	* Use the internet to gain information. (B, Ph, G) * Use interactive simulations. (Ph, M) * Use interactive maps. (G)	* Make an interactive material. (M) *Search scientific proof about the topic. (G)		
No. 4	* Use the internet to gain	* Make an interactive		

	information. (B, Ph, G, M) * Use spreadsheet programs to process and display graphics. (Ph) * Use interactive maps. (G) * Use databases to gain statistics. (M) *Analyse statistics using digital tools. (M)	map. (G)		
No. 5	* Use the internet to gain information. (B, Ph, G, M) * Use spreadsheet programs to process and display graphics. (Ph) * Use interactive maps. (G) * Use digital tools to solve functions. (M)	* Make a presentation. (Ph) * Make an interactive map. (G)		
No. 6	* Use the internet to gain information. (B, Ph, Ch, G) * Use interactive simulations. (Ph) * Use databases to gain information. (G)	* Make an interactive map. (G)		
No. 7	* Use the internet to gain information. (M)	* Use digital tools to make graphics. (M)		
No.8	* Use interactive simulations. (Ph) * Use the internet to gain information. (Ch) * Use digital tools to solve functions. (M)			
No. 9	* Use the internet to gain information. (Ph, Ch)	*Analyses reliability of information in media about food additives. (Ch)		
No. 10	* Use the internet to gain information. (Ph, Ch) * Use interactive simulations. (Ph) * Use digital tools to solve functions. (M)			
No. 11	* Use the internet to gain information. (Ph, M) * Use interactive simulations. (Ph) * Use digital tools to analyse 3D shapes. (M)			
No. 12	* Use the internet to gain information. (M)	* Makes 3D models. (M)		
No.		* Make a		

13		presentation. (Ph)		
No. 14	* Use interactive simulations. (Ph)			
No. 15	* Use the internet to gain information. (Ph)			

Part of Latvia's students in high school chooses to take science and mathematics courses in the highest levels. In the table 5.11. are visible digital literacies elements that are included in the biology, chemistry, geography, physics and mathematics programmes. Students in grade twelve are supposed not only use the Internet to gain information and solve tasks and problems, but also use advanced programmes and applications in order to accomplish programme requirements. In mathematics students have to make their own functions and analyse them from various angles. In geography and biology there are implemented demands about scientifically proven information. At the end of the biology and chemistry learning cycle, students discuss technology impact on ecosystems.

Table 5.11. Implemented digital literacy elements in higher level science and mathematics programmes.

Topic No.	Gaining information	Creating content and new information	Communication and collaboration	Responsibilities and digital identity
No.1	* Use the internet to gain information. (B, Ch, Ph, G) * Process and analyse data electronically. (Ph) * Use monitoring programs to gain data. (G)	* Search and select trusted information for research. (G)		
No.2	* Use the internet to gain information. (B, Ph, G, M) * Use GPS devices. (G) * Use applications to solve tasks. (M) * Use digital tools to solve functions. (M)	* Make and analyse graphics. (M) * Make a presentation. (Ph) * Search and select trusted information for research. (G)		
No.3	* Use the internet to gain information. (B, Ch, G, M) * Use interactive simulations. (Ch) * Use monitoring programs to gain data. (G) * Use GIS systems. (G)			
No.4	* Use the internet to gain information. (B, Ch, M) * Use spreadsheets to gain	* Search scientific proof about the topic. (B)		

	information. (B) * Use interactive simulations. (Ch, Ph) * Use monitoring programs to gain data. (G)	* Make an interactive map. (G)		
No.5	* Use the internet to gain information. (B, Ch, G) * Use online databases to gain information. (G) * Use spreadsheet programs to process and display graphics. (B) * Use interactive simulations. (Ch) * Use IT to find the function's formula. (M)			*Evaluates technology impact to ecosystems. (B)
No.6	* Use the internet to gain information. (Ch, Ph) * Use interactive simulations. (Ph)			*Evaluates technology impact to ecosystems. (Ch)
No.8	* Use IT to make and analyse function's graph. (M)			

At least one element of the first aim of digital literacy (gaining information) is implemented in biology programmes from grade seven to twelve in 20 topics from 23 (87%). Second aim (creating content and new information) is implemented in seven of 23 topics (30%). Third aim (collaboration and communication) wasn't implemented in any of 23 topics (0%). Fourth aim (responsibilities and digital identity) was found in one of 23 topics (4%).

There are 14 topics of 25 (56%) in grades eight to twelve in chemistry where students are supposed to improve their skills in the first of digital literacies' aim. Second and fourth aim appeared in one of 25 topics (4%), while the third aim wasn't included (0%).

In physics there are in total 32 topics from grade eight to twelve. First aim was outlined in 20 topics (63%), second in six topics (19%), third and fourth in no topics (0%).

Geography programmes are divided into 21 topics in total from grade seven to twelve. There were 20 topics (95%), where the first aim was implemented. Thirteen topics (62%) included content and new information creation. Third and fourth aim's elements weren't in geography programmes described.

Natural sciences, which are from grade one to six, are divided into 26 topics. First aim of information seeking and gaining is implemented in 11 topics (42%). Elements of second aim are described in seven topics (27%), but elements of fourth aim - in two topics (8%). Third aim wasn't outlined.

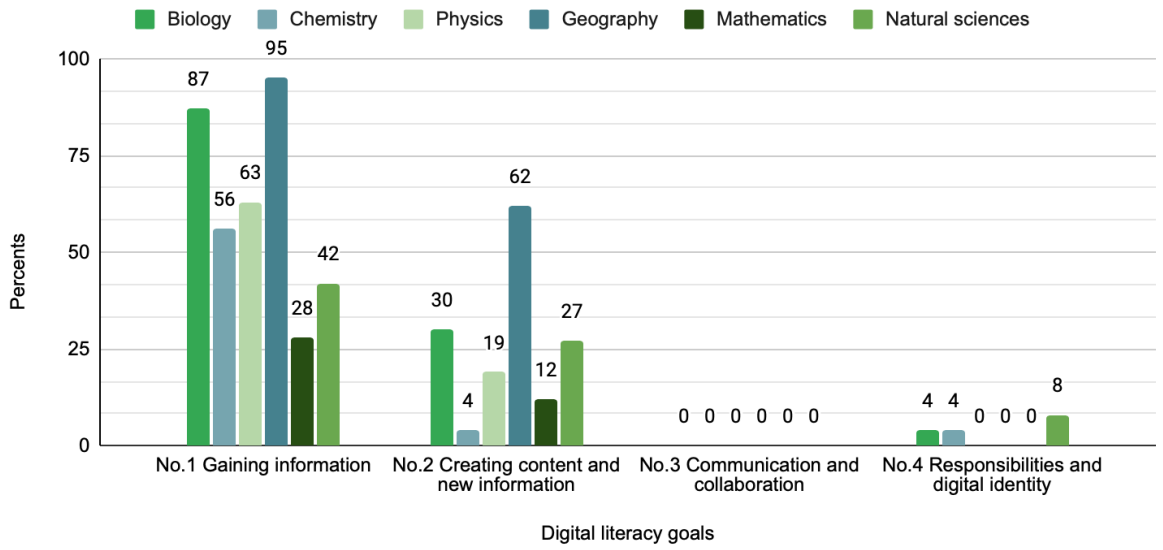
Mathematics is from grade one to twelve. In total there are 95 topics. Students are supposed to gain information using their digital literacy skills in 27 topics (28%), while

creating something new in 11 topics (12%). Mathematics programmes don't anticipate for students to enhance their digital literacy communication and collaboration skills (aim three) or discuss responsibilities that are connected with living in a digital society (aim four).

In Figure 5.1. there are statistics about digital literacy elements in topics of science and mathematics.

In total there are 222 topics in all of the science and mathematics programmes. First aim of successfully gaining information through technologies was implemented in 112 topics or in 50,5%. Second aim of creating a student's own media or information was described in 45 topics (20%). Communication and collaboration through digital technologies (aim three) weren't mentioned in any of the programmes. Creation of digital identity and responsibilities while using technologies was described as an element of the learning process in three topics or 1%.

Figure 5.1. Implemented digital literacy elements in topics in total in science and mathematics programmes.



5.2. Teacher's survey

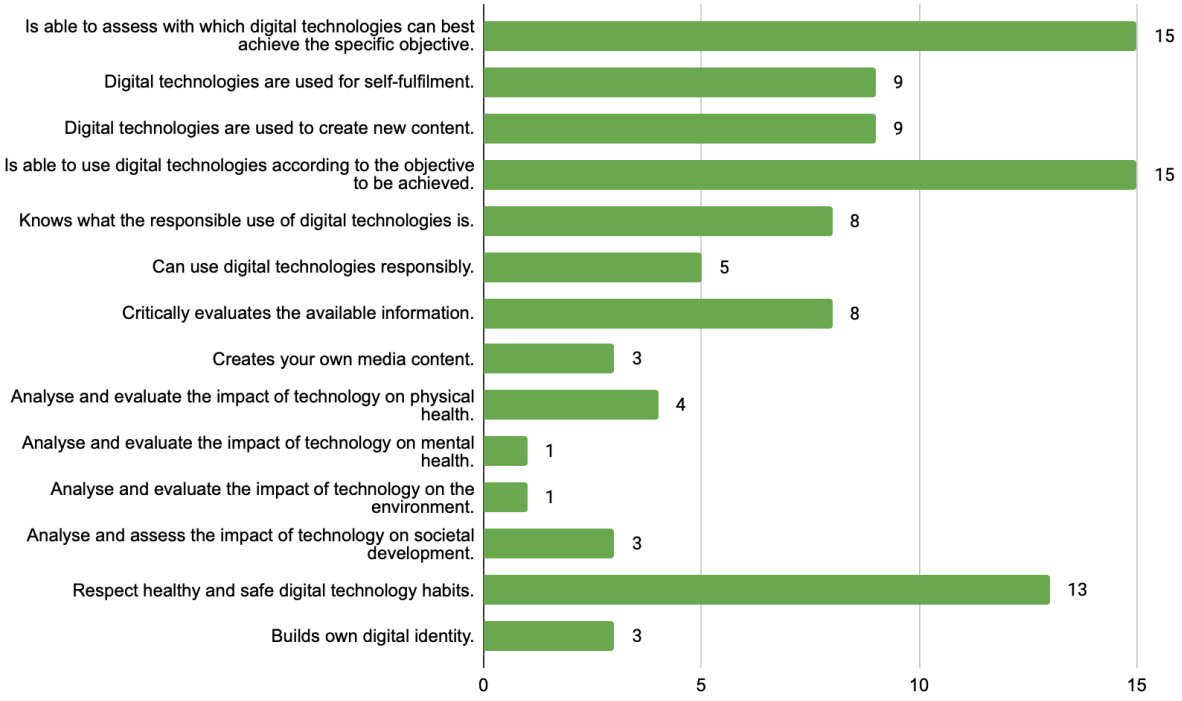
In an online survey in Valka Janis Cimze gymnasium 15 science and mathematics teachers responded. These teachers are working with different class groups, mostly more than one. Six teachers are working with pupils from grade one to three, five teach grade four to six students, with grade seven to nine work seven teachers, the same number of teachers work with the high-school students (grade 10-12).

To the survey responded three biology, two chemistry, one geography, one physics, three natural science and nine mathematics teachers.

In the third question teachers were asked to point out all the skills that, in their opinion, are part of digital literacy. As visible in Figure 5.2. all of the teachers think that the digital literacy element is 1) is able to assess with which digital technologies can best achieve the specific objectives and 2) is able to use digital technologies according to the objective to be achieved. “Respect healthy and safe digital habitats” was the option for 87% of teachers. Only one teacher thought that “analyse and evaluate the impact of technology on mental health” and “analyse and evaluate the impact of technology on the environment” are the skills from digital competence.

In order to understand the teacher's comprehension of the term “educational technologies” , the fourth question in the survey asked to tick all educational technologies. All of the respondents pointed to the computer (laptop or PC), digital learning platforms (in Latvia skolo.lv, soma.lv, uzdevumi.lv, etc.) and interactive feedback applications (kahoot, quiziz, mentimeter, etc.). Fourteen of fifteen teachers ticked internet resources, 13 thought that smartphones are educational technologies. Interactive board chose eleven respondents, but tablet - eight. The least responses were about overhead projector (four answers) and TV (three answers).

Figure 5.2. Responses in teachers survey to the third question: "Which of the skills listed below do you think are part of digital literacy? (Mark all the answers that you think are correct!)"



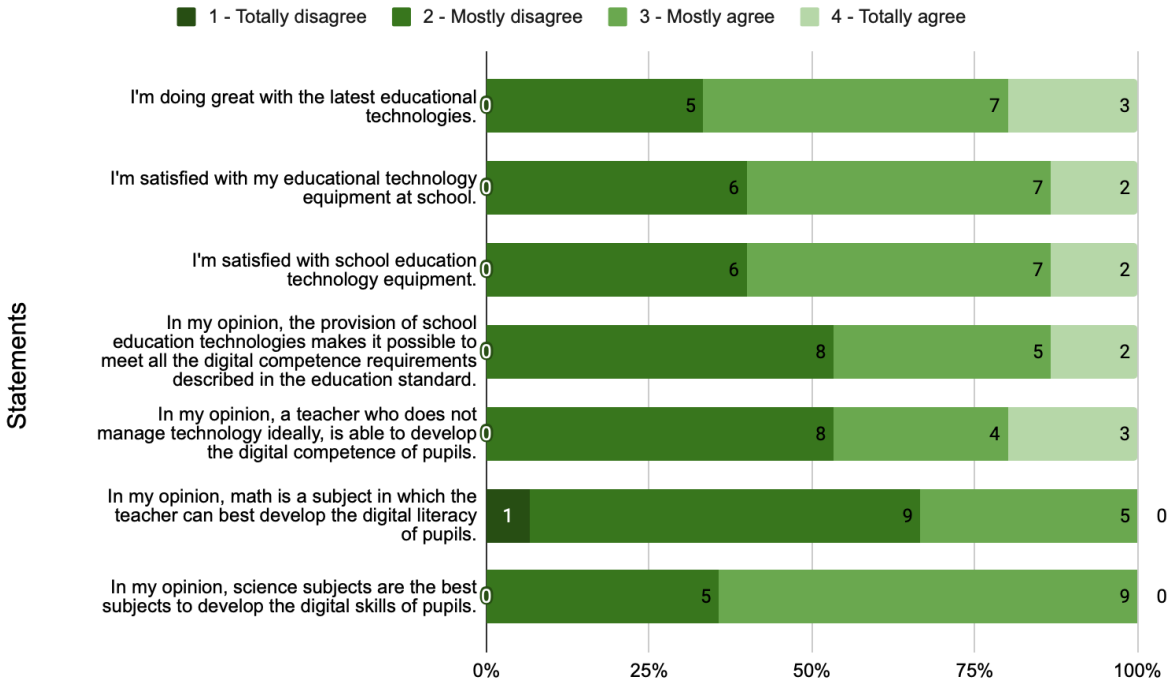
Valka Janis Cimze gymnasium teachers were asked to evaluate their digital skills in scale from one to four, where one is "I don't have any digital skills" and four is "I have a great deal with all the latest technologies". There was no teacher with "no skills". Twenty seven percent of the teachers ranked themselves with two points, 53% with three points, but 20 percent assessed themselves as the person who deals very well with the latest technologies.

Respondents were given several statements in regards to digital literacy. They had to evaluate each of the statements and choose in scale one to four, how much they agree with the statement. In Figure 5.3. it is visible that only two teachers are fully satisfied with their educational equipment at school and also the school's educational equipment. Seven are mostly satisfied with the personal equipment in school and school's equipment, but five teachers mostly aren't pleased with opportunities of personal educational technologies and also school's educational technologies. Fifty three percent of respondents mostly disagree that they can meet all the digital competence criteria in educational standards with current educational technologies in school, 33% mostly agree with this statement, but 13% think that it is a true statement.

In this survey there was a statement “In my opinion, a teacher, who does not manage technology ideally, is able to develop the digital competence of pupils.” Eight teachers mostly disagreed with this assertion, four mostly agreed, two totally agreed.

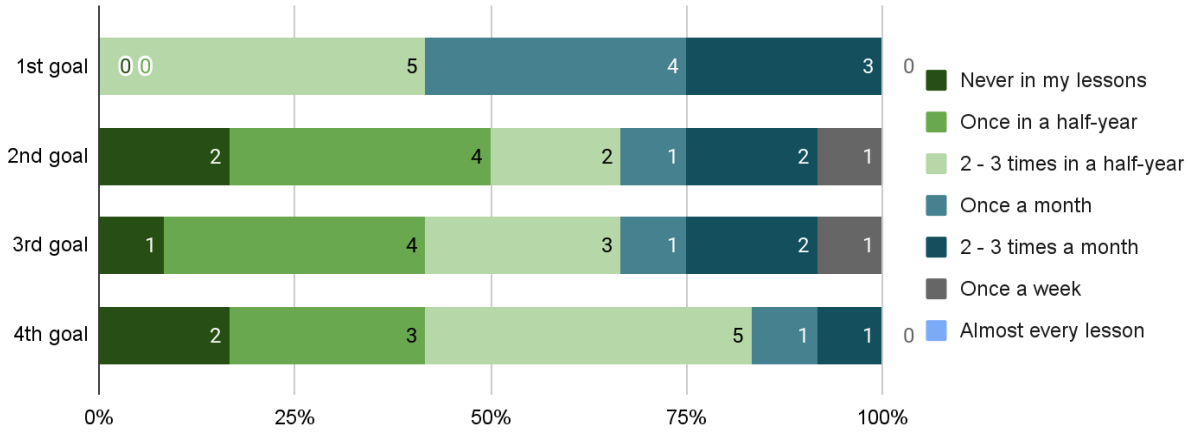
In order to understand if teachers think that science and mathematics subjects are the best subjects to develop digital skills of pupils, two declarations were made. One teacher totally disagreed with the statement about mathematics. There were no teachers who totally agreed about mathematics or science subjects as the best way to develop the digital skills of their pupils.

Figure 5.3. Responses in teachers survey to the different statements about digital technologies and digital literacy.



Teachers were asked to evaluate their lessons and to mark off how regularly they are implementing each of digital literacy goals in their lessons. Figure 5.4. shows the results of these questions. There is no teacher who would implement at least one of the goals in every lesson. One teacher is implementing content/information creation and communication and collaboration once a week in lessons. Teachers mostly improve students' digital skills once or often a month in information seeking and suitable technology choose to do different tasks. The fourth aim is the least implemented digital literacy aims in science and mathematics lessons according to the teachers answers.

Figure 5.4. Frequency of implementation of digital literacy aims in lessons.



Respondents were asked to point out what kind of activities they use in their lessons to enhance students' digital competence. Fourteen of fifteen teachers pointed out that they teach or appeal for students to use different applications, interactive tools to accomplish tasks. Information seeking on the Internet as a method is used by 13 teachers. Sometimes students have to learn to choose digital technologies in order to reach the target, eleven teachers try to include this skill in their lessons. Eight teachers update or recall the rules of the digital environment or the use of digital technologies as healthy habits in the lessons. How to distinguish reliable information from unreliable includes seven teachers in their lesson plans. Six teachers give such kinds of tasks, where students have to create their own digital content. Four educators update or recall the forming of a student's digital identity, the risks associated with it. The least used method is using digital applications for students to interact between themselves - three teachers maintain that they use it in their lessons.

There was an open question about teacher opinion on why students have to learn digital literacy. Their answers were: 1) It is necessary everyday and in the future. 2) For students to critically evaluate and analyse trusted media. 3) Students would be able to find the necessary information, evaluate if the information is reliable. Self-regulated learning using technologies. 4) Students have the opportunity to learn to work with different information sources and tools. 5) It is the 21st century and it is impossible to live without digital skills! In order to learn other skills, students need to have digital skills. 6) Students have to train to seek problem solutions by themselves. 7) In almost every sphere of life digital skills are necessary. 8) Because it is a necessary skill in employment. 9) These students are living in the digital age and it dictates the rules - everyone has to be capable with technologies. 10) Digital literacy is one of the most important future skills. The better these skills are taught to our pupils, the more successful they will be able to enter the future employment. 11) New

opportunities, to be able to act in society. To be able to communicate, collaborate, gather information, address tasks, etc. 12) To be able to more successfully make a working career. 13) If we want for our students to be capable of standing out in the employment market, we have to give a good education with very good digital skills. 14) Digital technologies are the future. We have to grant for our pupils to be successful in the future. 15) Students have to learn about media literacy to be aware of the fake news.

The last question in the survey was about difficulties teachers face in their work in order to improve students' digital skills. Teachers wrote different arguments, which can be grouped in categories: 1) Lack of methodical materials (two teachers emphasised). 2) Lack of educational technologies - every student doesn't have a smartphone, tablets and computers are too short in school, sometimes problems with the Internet (four teachers wrote). 3) Lack of time to cooperate and collaborate with other colleagues (two responses) to create new ideas. 4) Lack of student's critical thinking and creative thinking. Students have very poor basic skills in working with a computer, keyboard, and slow pace of work. Students have unpracticed memories - everything is quickly forgotten (three teachers mentioned). 5) Student families' material situation - some students don't have smartphones or computers to learn at home. Also parents' education and capability to work with technologies, help their children at home (two responses). 6) Lack of skills to conduct such a learning process for students (one reply). 7) Some pupils are unable to orient on Internet resources (one answer). 8) Lack of confidence to work in certain digital learning environments (one teacher wrote). 9) Priority is the mathematical goals, don't have time in lessons to use technologies (one teacher emphasised). 10) There is often no knowledge of what students know and can (one mention).

6. Discussion

The aim of this work is to identify the challenges posed by teachers in implementing the new learning content, improving the digital literacy of pupils in science and mathematics in classes 1 - 12. The researcher collected data and information from teachers in Valka Janis Cimze gymnasium by a survey and analysed Science and Mathematics programmes.

Content analysis of science and mathematics programmes indicates that content creators did not implement all of the digital literacy aims, that are described in the national standards about elementary and secondary education, in the science (natural sciences, biology, chemistry, physics, geography) and mathematics programmes. In 50,5% of all the topics of programmes included the first goal about effective digital tool use in order to gain information. The third goal about technology use to effectively communicate and collaborate wasn't included in any of 222 topics in science and mathematics.

Teachers survey showed that only 20% of science and mathematics teachers in Valka Janis Cimze gymnasium feels comfortable with the newest technologies. Teacher responses also brought out the problems with technological support at school, 33.3% of teachers mostly are not pleased with their personal equipment in school and school's overall technological equipment. It was also stressed out in the open questions about difficulties teachers face in order to improve student's digital skills. Teachers wrote that there are problems with technological support, also with materials about digital literacy implementation in the learning process.

In grades one to three it is visible from content analysis that students are supposed to use technologies very little. Mainly students have to search for some information on the internet or take photos. In nature sciences students use more technologies than in mathematics. From the subject's programme it is not clear if teachers are also teaching about trusted sources. Grade one to three analyses raises the following questions:

1) How can students search for information or take photos, if in the elementary clases only some students have smartphones?
2) How well teachers know what is trusted information? Can they teach it to the students?

In grades four to six students have to use very little technology in order to learn natural sciences or mathematics, also to improve their digital skills. As in the previous learning period, students mainly search for information. In the end grade three and grade six in one

lesson teachers are supposed to discuss with students about technology's impact on their health.

In grades seven to nine there is much more technology use than in the previous six years. Pupils suddenly have to use technologies to use and make interactive maps, to make collages, presentations, in order to gain information through simulations, they have to work with different interactive tools. They have to shoot videos and use spreadsheet programs to process their research digitally. In mathematics students have to use programs such as Geogebra in order to do tasks. There is a huge gap between six grader and seventh in science and mathematics subjects in the regards of digital skills necessary to fulfil programmes requirements.

Grade seven to nine analyses raises following questions:

1) Who is going to teach students how to work with all the digital tools?
2) Do teachers know how to use the programmes they are supposed to work with?
3) Is there enough technical equipment to make the required content?
4) Do teachers talk about students' digital skills at the end of each learning period?

There was a noticeable gap between students' supposed digital skills at grade six and seven, the same gap is visible between grade nine and ten. At the high school level students have to use technologies in their learning process very often. They have to search or gain information through the internet, simulations, spreadsheet programs, databases, applications, interactive maps, monitoring programs. In mathematics there are topics when in almost every lesson they have to use mathematical programs, such as Geogebra, Graph etc. Students are not only supposed in mathematics to create their own graphics or shapes, they have to analyse functions and created content.

Only students who take biology or chemistry in the highest level discuss technology impact on ecosystems. The subjects that are supposed to make sustainably aware students, don't include in their programs such kinds of topics that teach about technology impact on ecosystems.

Content analysis of the high-school programmes in mathematics and science leaves questions:

1) How easy is it to implement technologies in everyday work, if there aren't computers for every student? Do teachers have to go to computer classes every time when they have to use spreadsheet programs or other applications?
2) How do teachers learn to work with data processing programs?

3) Why only in the grade 12 (the higher level, that is optional course) from all the learning years students talk about technology impact on nature and ecosystems?

Survey in Valka Janis Cimze gymnasium shows that teachers only partly understand the term “digital literacy” and what it includes. Almost half of teachers estimate their digital skills as rather good, but 33% say that their skills are rather bad. This data also relates to what teachers said about necessary methodical materials. There are described necessary actions for students in subjects' programmes, but there isn't methodical help for teachers. Eight of fifteen teachers claim that they rather can't improve their students' digital skills if their digital skills are not perfect. This leads to the first challenge of implementation of digital literacy through science and maths subjects in the context of a new curriculum in Latvia - it is necessary to develop teachers' digital literacy in order to enhance students' digital competences.

Four teachers wrote that there were problems in Valka Janis Cimze gymnasium providing computers or tablets for every pupil within lessons. It alongs with problems in Latvia with technologies, because 47% of Latvia's teachers say that if there would be some extra money given to schools, computers or tablets should be bought (Lielvārds, 2022). Only two teachers from 15 are satisfied with their technological supply and school's. Seven teachers say that they are rather satisfied, but 6 are rather dissatisfied. Eight science and mathematics teachers in Valka Janis Cimze gymnasium claim that the provision of the school's educational technologies makes it rather impossible to meet all the digital competence requirements described in the educational standard, five teachers say that mostly standard requirements are achievable with current educational technologies. Survey shows that teachers with educational technologies understand the kind of technologies that students are working with to do tasks. Second challenge for teachers to implement digital competence in their lessons is insufficient provision of educational technologies at school.

There is inconsistency in different project Skola2030 materials about digital literacy implementation in subjects and lessons. On the one hand, transversal skills are supposed to be enhanced through every field. On the other hand, science and mathematics programs show that there are elements of digital literacy, but they aren't linked together and they do not improve every aspect of digital literacy that are postponed in standards. For example, the most frequently described activity is about information search. There are no described technology use to communicate and collaborate with. A lot of activities that are described in the programmes are more the ideas of authors about subject content, not consistent digital literacy implementation. Third challenge that teachers are facing in the context of the new

curriculum is insufficiently and inconsistently implemented digital literacy elements in the science and mathematics programmes.

Two teachers wrote in the survey that there is a lack of time to cooperate and collaborate with other colleagues to create new ideas, one wrote that they often have no knowledge of what students know and can. Educators in the European Commission conference in 2019 about key competences also identified the lack of time and space for teachers to experiment with new technologies as one of the problems in digital literacy. Collaboration is one of the DigCompEdu described competencies educators should have. The fourth issue teachers are having is the lack of time to collaborate with other educators.

The results about the challenges that teachers are facing in order to implement digital literacy through the new curriculum partly support the hypothesis of this work, because difficulties are not only the lack of technologies and teaching aids, but also the lack of time to collaborate and communicate and insufficient programmes.

The contribution of this thesis work is for Latvian education makers. This work exhibits the systematics problems that occur with teachers in order to implement one of the transversal skills in their lessons. It also shows what kind of help and support is necessary for educators and educational facilities. Readers can use content analysis of science and mathematics programs to support discussions between teachers of digital literacy enhancement in their subjects.

It is possible to deepen this research by surveying all of Latvia's science and mathematics teachers. Moreover, this thesis work can be wider by exploring and analysing other field programmes in the order to understand the implication of digital literacy in them.

The aim of this thesis was to identify the challenges posed by teachers in implementing the new learning content, improving the digital literacy of pupils in science and mathematics in classes 1 - 12. The main challenges were examined and described.

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Author’s declaration

I hereby declare that I have written this thesis independently and that all contributions of other authors and supporters have been referenced. The thesis has been written in accordance with the requirements for graduation theses of the Institute of Education of the University of Tartu and is in compliance with good academic practices.

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Appendixes

Appendix 1. Achievable results by pupils at the end of grade three, six, nine and twelve.

	End of grade three	End of grade six	End of grade nine	End of grade twelve
No. 1. Gaining information	Use digital technologies for learning tasks by following instructions.	Use digital technologies for the acquisition, processing, presentation, transmission and supports the need for the use of digital technologies	Choose and use the best digital technology capabilities for the purpose or task, use it for self-implementation and for the creation of a variety of content	In order to implement diverse ideas, purposefully choose or adapt and use appropriate digital technologies effectively;
No.2 Creating content and new information	Recognize images and symbols created and promoted by the media.	Analyse the role of the media in the construction of reality and assess the credibility of the various sources of information, including the sources available in digital form.	Critically analyse the realities and reliability of information generated by the media, create its own media content.	Critically analyse the reality and the reliability of information generated by the media, take responsibility for taking action to eliminate the effects of poor-quality media content and, when creating its media content, respect privacy, ethical and legal conditions.
No.3 Communication and collaboration	Define the types of digital communication.	Define the types of digital communication, their objectives, formats and impact on the audience. Use digital technologies for communication and cooperation.	Use digital communication responsibly for specific purposes, assessing its relevance to the needs of the target group.	Analyse the benefits and risks of digital communication, behave responsibly and communicate in the digital environment in accordance with their own interests and others' interests.
No.4 Responsibilities and digital identity	Explain how digital technologies affect everyday, with the support of an educator develop healthy and safe habits in the use of digital technologies.	Explain their understanding of the role of digital technologies in society and self-realisation. Respects healthy and safe technology habits.	Analyse and assess the impact of technology on mental and physical health, society and the environment. Take into account healthy and safe technology usage habits, justify their need. Design, control and manage your digital identity.	Analyse and evaluate the role of technology in different contexts, evaluate healthy and safe technology usage habits, respect and adapt them to their needs, reflect on their digital identity and their relevance to their and public interests.

Appendix 2. Maths and science teacher survey in Valka Janis Cimze gymnasium.

Hello! I am Līga Lāce-Jeruma, a student of Tartu University's Education Technology Master's Program. As part of my master's work, I study how maths and science teachers in classes 1-12 develop the digital literacy of pupils as one of the six transversal skills of the new basic and secondary education standard.

The survey consists of two parts. The first part contains questions about your personal opinion, knowledge and attitudes to digital literacy. The second part deals with the development of digital literacy in your teaching hours.

Please complete this questionnaire. The results will be used as part of a master's job.

Thank you!

1. Personal attitudes and knowledge about digital literacy.

1.1. At which stages are you teaching pupils? (Mark all the answers that match you!)

- ☐ grade 1 - 3
- ☐ grade 4 - 6
- ☐ grade 7 - 9
- ☐ grade 10 - 12

1.2. Which subject/-s are you teaching? (Mark all the answers that match you!)

- ☐ Maths
- ☐ Natural sciences
- ☐ Biology
- ☐ Physics
- ☐ Geography
- ☐ Chemistry

1.3. Which of the skills listed below do you think are part of digital literacy? (Mark all the answers that you think are correct!)

- ☐ Is able to assess which digital technologies can best achieve the specific objective with.
- ☐ Digital technologies are used for self-fulfillment.
- ☐ Digital technologies are used to create new content.
- ☐ Is able to use digital technologies according to the objective to be achieved.
- ☐ Knows what the responsible use of digital technologies is.
- ☐ Can use digital technologies responsibly.

- ☐ Critically evaluates the available information.
- ☐ Creates your own media content.
- ☐ Analyse and evaluate the impact of technology on physical health.
- ☐ Analyse and evaluate the impact of technology on mental health.
- ☐ Analyse and evaluate the impact of technology on the environment.
- ☐ Analyse and assess the impact of technology on societal development.
- ☐ Respect healthy and safe digital technology habits.
- ☐ Builds own digital identity.

1.4. What do you think is education technology? (Mark all the answers that you think are correct!)

- ☐ Computer (laptop or PC);
- ☐ Tablet;
- ☐ Smart phone;
- ☐ Interactive board;
- ☐ TV;
- ☐ Overhead projector;
- ☐ Digital learning platforms (skolo.lv, soma.lv, uzdevumi.lv, etc.);
- ☐ Internet resources;
- ☐ Interactive feedback apps (kahoot, mentimeter, quizizz, etc.).

1.5. How do you evaluate your digital literacy? Mark on the scale from 1 - 4!

1 - I don't have any digital literacy skills	2	3	4 - I have a great deal with all the latest technologies

1.6. Mark on the scale from 1 - 4 how much you agree with each of the statements!

	1 - Totally disagree	2 - Mostly disagree	3 - Mostly agree	4 - Totally agree
I'm doing great with the latest educational technologies.				
I'm satisfied with my educational technology equipment at school.				
I'm satisfied with school education technology equipment.				
In my opinion, the provision of school education technologies makes it possible to meet all the digital				

competence requirements described in the education standard.				
In my opinion, a teacher who does not manage technology ideally, is able to develop the digital competence of pupils.				
In my opinion, maths is a subject in which the teacher can best develop the digital literacy of pupils.				
In my opinion, science subjects are the best subjects to develop the digital skills of pupils.				

2. Digital literacy in the lessons.

2.1. Please check how often in your lessons there are such activities that encourage students to reach the 1st goal of digital literacy? (The image shows the goal according to the stages of grades. (There was a picture of Appendix 1 in Latvian.))

- ☐ Never in my lessons;
- ☐ Once in a half-year;
- ☐ 2 - 3 times in a half-year;
- ☐ Once a month;
- ☐ 2 - 3 times a month;
- ☐ Once a week;
- ☐ Almost every lesson.

2.2. Please check how often in your lessons there are such activities that encourage students to reach the 2nd goal of digital literacy? (The image shows the goal according to the stages of grades. (There was a picture of Appendix 1 in Latvian.))

- ☐ Never in my lessons;
- ☐ Once in a half-year;
- ☐ 2 - 3 times in a half-year;
- ☐ Once a month;
- ☐ 2 - 3 times a month;
- ☐ Once a week;
- ☐ Almost every lesson.

2.3. Please check how often in your lessons there are such activities that encourage students to reach the 3rd goal of digital literacy? (The image shows the goal according to the stages of grades. (There was a picture of Appendix 1 in Latvian.))

- ☐ Never in my lessons;
- ☐ Once in a half-year;
- ☐ 2 - 3 times in a half-year;
- ☐ Once a month;
- ☐ 2 - 3 times a month;
- ☐ Once a week;
- ☐ Almost every lesson.

2.4. Please check how often in your lessons there are such activities that encourage students to reach the 4th goal of digital literacy? (The image shows the goal according to the stages of grades. (There was a picture of Appendix 1 in Latvian.))

- ☐ Never in my lessons;
- ☐ Once in a half-year;
- ☐ 2 - 3 times in a half-year;
- ☐ Once a month;
- ☐ 2 - 3 times a month;
- ☐ Once a week;
- ☐ Almost every lesson.

2.5. What do you do in your lessons to promote the digital literacy of pupils? (Mark everything that suits you!)

- ☐ I call out students to search for information on the internet.
- ☐ I remind / teach pupils how trusted media can be distinguished from unreliable ones.
- ☐ I call on students to choose digital technologies that can be worked on in the lessons to reach their target.
- ☐ I teach / invite pupils to use digital apps where they can interact with each other.
- ☐ I teach / call out for students to use different apps, interactive tools to accomplish the task.
- ☐ I give such tasks that require students to create their own digital content (presentation, infographic, homepage, etc.)
- ☐ I update/recall the rules in the digital environment.
- ☐ I update/recall the use of digital technologies as healthy habits.
- ☐ I update/recall the forming of my digital identity, the risks associated with it.

2.6. Why do you think it is essential to develop the digital literacy of pupils?

_____

2.7. What obstacles are you facing, which prevents the development of the digital literacy of pupils?

_____

Appendix 3. Number of units in each subject in each year.

	Biology	Chemistry	Geography	Mathematics	Natural Sciences	Physics
Grade 1	-	-	-	8	5	-
Grade 2	-	-	-	8	4	-
Grade 3	-	-	-	7	5	-
Grade 4	-	-	-	8	4	-
Grade 5	-	-	-	8	4	-
Grade 6	-	-	-	8	4	-
Grade 7	4	-	5	9	-	-
Grade 8	4	5	2	8	-	6
Grade 9	4	4	3	8	-	6
Optimal level	6	10	6	12	-	15
In-depth level	5	6	5	11	-	5

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