Navigating Artificial Intelligence in Education: First- and Second-order Barriers to the Implementation of AI in Finnish Classrooms

Eeva Le Bihan

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Department of Teacher Education
University of Jyväskylä

ABSTRACT

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This qualitative study explores the barriers that Finnish primary and secondary school teachers' perceived while implementing AI education in their classrooms. The data used for the study was generated using semi-structured interviews with nine teachers. The participants were all part of the Innokas-network project "Tekoäly nyt!" The analysis mostly focused on explicit mentions of barriers, but some second-order barriers were found within more implicit contexts. The analysis method was an abductive form of thematic analysis.

In the interviews teachers described the barriers they had faced while implementing AI education. The teachers expressed that they had encountered barriers during the project, especially relating to the limited amount of software they could use without issues with information security policies. Lack of time was also perceived as a barrier to the implemention of AI education in the classroom. First-order, or external, barriers were in general more explored in this study, perhaps due to the approach taken. Second-order, or internal, barriers were, however, also somewhat explored in this study, and many teachers did not only have trouble with their work hours and workload, but also with having time to implement everything in the classroom while often prioritizing other content such as mathematics and even referring to AI education in ways that could be interpreted as less important than other content. The results shed light on the areas in which AI education implementation needs improvement, which is especially important in a time where AI proficiency is becoming more important in people's everyday lives.

Keywords: education, artificial intelligence, implementation, teachers, barriers

TIIVISTELMÄ

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Tässä laadullisessa tutkimuksessa tarkastellaan, millaisia esteitä suomalaiset peruskoulun opettajat kokivat toteuttaessaan tekoälyyn liittyvää opetusta luokkahuoneissaan. Tutkimuksessa käytetty aineisto kerättiin yhdeksällä puolistrukturoidulla haastattelulla. Haastateltavat olivat Innokas-verkoston Tekoäky nyt! -hankkeessa mukana olevia opettajia. Analyysi toteutettiin enimmäkseen ilman piilomerkitysten analysointia, mutta joitakin sisäisiä estäviä tekijöitä tunnistettiin myös piilomerkitysten kautta. Analyysimenetelmänä käytettiin abduktiivista sisällönanalyysia.

Haastatteluissa opettajat kuvailivat esteitä, joita he olivat kohdanneet toteuttaessaan tekoälyyn liittyvää opetusta. Esteet liittyivät erityisesti siihen, miten rajallisia heidän mahdollisuutensa olivat käyttää erilaisia ohjelmistoja ilman tietoturvakäytäntöjen rikkomista. Myös ajan puute koettiin esteeksi tekoälyyn liittyvän opetuksen toteuttamiselle luokkahuoneissa. Ensimmäisen asteen esteitä käsiteltiin yleisesti ottaen tässä tutkimuksessa enemmän, mahdollisesti johtuen tutkimuksen lähestymistavasta. Myös toisen asteen esteitä kuitenkin käsiteltiin, ja sen lisäksi, että monella opettajalla oli vaikeuksia tasapainotella työajan puutteen ja työmäärän kanssa, moni myös koki, ettei heillä ollut tarpeeksi aikaa toteuttaa kaikkea luokkahuoneessaan. Opettajat saattoivat asettaa etusijalle muun sisällön, kuten esimerkiksi matematiikan, ja viittasivat tekoälyyn liittyvään opetukseen tavalla, joka antoi ymmärtää sen olevan vähemmän tärkeää kuin muu sisältö. Tulokset kuvaavat opettajien kokemia alueita, joilla tekoälyyn liittyvän opetuksen toteuttamisessa voisi olla vielä parantamisen varaa, mikä on erityisen tärkeää tällä hetkellä, kun tekoälytaitojen merkitys ihmisten jokapäiväisessä elämässä kasvaa jatkuvasti.

Avainsanat: opetus, tekoäly, toteutus, opettajat, esteet

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1 INTRODUCTION

Artificial intelligence (AI) has been an especially topical subject in the past few years, as work environments are using its implementations to transform the nature of many different fields of work (Xu et al., 2021). The medical field, for example, is being transformed by AI-based software (Basu et al., 2020), while image generation AI such as DALL-E have transformed the landscape of digital art (Vartiainen et al., 2023; Vartiainen & Tedre, 2024) and the possibility of large language models such as ChatGPT transforming academic writing is being discussed as well (Lund et al., 2023).

AI is also being used in education (Kahila et al., 2024). For example, AI-powered personalized tutors such as Cognii have been published and, according to the developers (Cognii, 2024), are being used around the world. Using AI as a learning tool could give students an advantage over traditional learners, because it gives students personalized help at a lower cost than by increasing the amount of human educators in the classroom (Kochmar et al., 2020). Additionally, AI literacy could be an extremely sought after skill in many fields of work in the future,. It is therefore also important for children to receive equal opportunities to learn with, and about, artificial intelligence to help close the socioeconomic gap between them as they emerge into adulthood (Dolan, 2016). AI is also present in everyday lives in social media (Gillespie, 2013), video games (Skinner & Walmsley, 2019) and marketing (Mariani et al., 2022), so it is important for every child to learn the appropriate AI literacy to better understand how AI is being used to control for instance the things they are shown in adverts or on social media.

In addition to students being able to use it, AI can also automate manual processes in teaching. If effective and accurate algorithms are developed (Chang et al., 2022), AI-driven automated grading systems such as Gradescope or chatbots with lesson planning capabilities such as ChatGPT could for example lighten the workload of teachers (Hashem et al., 2023), many of whom are experiencing symptoms of burnout (Saloviita & Pakarinen, 2021). AI education

is therefore a topic worth investing in, and learning to use AI in the classroom could prove a vital part in achieving better AI literacy in the future. That said, it is important to note that AI does not come without challenges. AI is being used to make life changing decisions but because it is trained with material made by humans, it can have biases and discriminate against certain people (World Economic Forum Global Future Council on Human Rights 2016-18, 2018). It is therefore important to integrate AI carefully and while keeping these possible biases in mind.

The educational sector is not the only one where ethical dilemmas regarding AI are being discussed. For instance, AI could be used for reading medical images, but biases in the algorithms could harm patients if not studied and corrected (Borenstein & Howard, 2021). As these dilemmas emerge, there is naturally also a need for AI ethics education in schools (Borenstein & Howard, 2021).

This study aims to better understand how different factors affect the implementation of AI in education, to facilitate higher-quality AI education in Finland. The study focuses on this subject because AI has not been widely utilized in primary school education until quite recently (Kahila et al., 2024; Ng et al., 2022), and knowledge about the adjustments that should be made could be a factor in the successful implementation of AI education. However, more research is needed in the field of artificial intelligence in education in general (Crompton et al., 2022), and especially in the Finnish context, as the subject of barriers in the implementation of AI education in primary schools has not been studied in Finland. This study will contribute to filling that research gap.

In this study, artificial intelligence will first be defined in a general sense, and then the focus will be shifted toward AI in education. The link between AI and education will be explored, starting with its concrete integrations and then moving to a more theoretical level to reflect on different theories of technology implementation. After this, the objectives of the study will be shared, and the methods used to gather data and conduct the study will be detailed. In the

study's final sections, the findings of the analysis will be presented and then compared with previous literature.

2 ARTIFICIAL INTELLIGENCE

In this section, artificial intelligence will first be defined using various approaches. Then, the focus will be shifted toward AI in education specifically, examining its uses in the world of education and theories regarding its implementation. Finally, past research regarding AI education implementation will be explored.

2.1 Definition of Artificial Intelligence

Artificial intelligence currently has no clear definition, but it can be described as a technology that imitates human intelligence in some way, such as by mimicking complex human skills (Sheikh et al., 2023) or thinking and acting like humans and having the ability to achieve goals (Akgun & Greenhow, 2022). That said, artificial intelligence is a broad concept with many different approaches. In this section, the definition of AI will be explored from three different perspectives: functionality, approach to learning and application.

If a functionality-based approach is taken, AI can be separated into narrow or general AI (Kaplan & Haenlein, 2019). Narrow AI is designed to only accomplish predetermined tasks such as face and voice recognition (Kaplan & Haenlein, 2019). All currently designed AIs such as ChatGPT, Siri and DALL-E are considered narrow. General AI, on the other hand, is so far a purely hypothetical concept, which would have the ability to understand, learn and apply knowledge across a wide range of tasks that it was not specifically designed to accomplish (Kaplan & Haenlein, 2019). It therefore mimics human intelligence in a way that developers have not yet been able to achieve (Murphy, 2019; Sheikh et al., 2023). Although at first glance large language models like ChatGPT may seem like they would fit the criteria of a general AI, as they appear to mimic human intelligence in this way, even ChatGPT can only accomplish tasks it was specifically designed for (i.e. generating text using a large

amount of data) (OpenAI, 2022), and is therefore not classified as a form of general AI (Kaplan & Haenlein, 2019).

If we, however, look at AI from the perspective of its technological mechanisms, we are able to divide it into a few major categories. Many forms of artificial intelligence are capable of learning in some way, but the approach they take differs. Some AIs use forms of machine learning, which involve algorithms and models that learn from data without explicit programming (Sarker, 2021). Machine learning itself can be split into a few different subgroups: machine learning can, for instance, be supervised, unsupervised or semi-supervised depending on the amount of external guidance the model is given (Sarker, 2021). Supervised learning can be used for example for text classification, while unsupervised learning might be used for identifying meaninful trends and structures, by for instance clustering or anomaly detection (Sarker, 2021). Their combination, semi-supervised learning, on the other hand, can be used for fraud detection, machine translation and text classification (Sarker, 2021). Two other branches of machine learning are reinforcement learning and neural networks. Reinforcement learning is based on rewards and penalties, and it is used to train AI models that can automate tasks such as driving or supply chain logistics (Sarker, 2021). Neural networks, on the other hand, attempt to mimic the way human brains operate (Mahesh, 2020) and can be used for various purposes including agricultural and biological engineering (Huang, 2009).

AI can also be approached through the question of how it is applied in practice. Some AI is designed to interact with humans in much the same way as another human would. These models use natural language processing and can be used as for example chatbots or language translators. (Murphy, 2019). Expert systems on the other hand attempt to mimic human decision-making in a specific area (Sheikh et al., 2023), such as diagnostics or financial advisory systems. Visual data is also used in certain applications. Computer vision applications interpret visual data and can use it for example for facial recognition, object detection or for driving autonomous vehicles. AI robots, on the other hand, are a familiar trope in fantasy, and AI is indeed integrated into robotics in some in-

dustries, such as industrial robots, drones and autonomous healthcare robots (Anderson, 2014).

2.2 Types of AI in Education

As presented in the introduction, new software have been developed for AI education, and some research has been done to prove its usefulness in classrooms (Hashem et al., 2023; Kochmar et al., 2020). This chapter explores the various types of AI applications in education, focusing on two main categories: AI as a teaching tool and AI as a learning tool.

AI-powered virtual assistants such as ChatGPT can be valuable resources for teachers, helping answer students' questions, providing resources and assisting in administrative tasks such as enrollment, scheduling, and student record management (Hashem et al., 2023). The user interface of these applications is often intuitive, mimicking a conversation between two individuals (Murphy, 2019). Certain applications like Kahoot can automatically generate questions for a chosen topic (Kanaris, 2023), possibly reducing the burden on teachers to design quizzes. Tools like Gradescope are designed to automatically grade multiple choice, short-answer, and even essay questions, with the intention of saving teachers time and providing quicker feedback to students (Gradescope, 2024). Other AI-based software such as Turnitin is designed to detect plagiarism to ensure academic integrity (Turnitin, 2024). AI tools like ChatGPT (OpenAI, 2023) and Canva (Wilmot, 2023) can assist in creating educational content, generating quizzes, and even writing educational materials. Resource allocation applications such as Skolaris, on the other hand, can help optimize the use of resources, including faculty scheduling, classroom assignments, and course planning (Skolaris, 2024).

Another approach to AI in education is personalized learning for students. Online learning platforms are not a particularly new development (Dougiamas, 2023; Kahn, 2014; Weller, 2006), but some are beginning to integrate AI into their applications. In addition to serving as virtual assistants to teachers, AI-

powered chatbots such as ChatGPT and virtual assistants like Siri can answer common student queries and provide information. AI can also enhance learning experiences through adaptive learning environments, which adjust game difficulty based on individual student performance. Duolingo and other language learning apps can assist in language learning by providing real-time feedback on pronunciation, grammar, and vocabulary. Translation services help students and teachers overcome language barriers by providing instant translation services, which could be vital especially with the amount of children moving to another country at a young age without a common language with educators. Adaptive learning platforms such as Ville (University of Turku, 2020), and intelligent tutoring systems like the chatbots Duolingo Max (Duolingo Team, 2023) and Khanmigo (Khan Academy, 2023) can use learning analytics to analyze student performance and tailor educational content based on individual needs, pacing, and learning styles. They provide guidance, feedback, and support to students, enabling them to learn at their own pace. However, as with most new technologies, learning analytics comes with its own set of risks and considerations. More specifically, AI analytics comes with a decently researched risk of bias because AI is programmed and trained by biased humans and culturally biased data (Jarke & Macgilchrist, 2021). Concerns about datafication transforming teacher-student relationships (Mertala, 2022) as well as concerns about privacy and data protection issues (Liu & Khalil, 2023) have also been raised in previous literature.

2.3 First- and Second-order Barriers

The current forms of artificial intelligence are fundamentally new technologies that are being implemented into education. While AI implementation is a relatively new topic, technology implementation has been discussed for a lot longer (Baker et al., 1989). Technology in education is an extremely broad and multifaceted issue that can be viewed from many different perspectives, such as from

several technological and educational theories, but this study will focus on perspectives that are related to the research objectives at hand.

In recent research relating the integration technology, barriers have generally been talked about as first- and second-order barriers or internal and external barriers (Bell & Barr, 2023; Hamutoglu, 2021; Tawfik et al., 2021). First-order barriers are defined as external barriers, which are easier to measure and can often be eliminated by allocating enough resources to the implementation project. They include barriers such as access to resources, training and support. Second-order barriers on the other hand, are described as less visible and more internal, such as teachers' beliefs about teaching and learning. These internal barriers are more abstract, personal and deeply ingrained, and might not even be known by the teachers themselves. (Ertmer, 1999; Ertmer et al., 1999). According to Ertmer (1999), the underlying assumption is that once enough resources are available to teachers, technological integration will follow. However, there are often second-order barriers in place as well, which can hinder the actual implementation of technological innovations for reasons such as beliefs about teacher-student roles (Ertmer, 1999). While the original papers relating to this theory are from a time when AI had not emerged in its current forms, it is still utilized as a useful framework for research in the context of technology implementation in education (Bell & Barr, 2023; Hamutoglu, 2021; Tawfik et al., 2021).

2.4 Past Research on Barriers in AI Education

There is no consensus regarding specific barriers to technology implementation, perhaps because there are so many different factors involved. The field of AI education research specifically has been mainly focusing on, for example, suggesting curricula and testing them (Chiu et al., 2022; Su & Zhong, 2022) but some research has been done regarding barriers to implementation as well.

One research paper (Wang & Cheng, 2021), for instance, discovered that the most prevalent barriers that the schools incorporating AI education in Hong

Kong faced were lack of explicit guidelines, time constraints of using non-user-friendly interfaces as well as teachers' indifferent attitudes and their misconceptions about AI. A review study (Crompton et al., 2022) identified perceptions, technology skills, ethics and technology itself to have been challenges to the use of AI in education. The study also discovered that some teachers were negatively biased against the use of technology and rather saw AI as a distraction from meeting learning objectives. Many of the teachers felt that they did not understand AI well enough to teach it, and in addition often had to troubleshoot the technology in use. The teachers also did not think that the software was easy to use and felt that the programs were not designed to cater to students' needs well enough. Some of the students in the teachers' classrooms did not have the necessary understanding, technological skills or sometimes even the required technology to use the AI applications. In some cases, the technology used was not perceived as being capable enough to facilitate deeper student learning. When AI software was in use in classrooms, some teachers had concerns about privacy issues.

While barriers for the implementation of AI education have not been researched as much, barriers to technology implementation in general have been researched as well and may inform about the barriers to AI education. Tawfik et al.'s (2021) study about first- and second-order barriers to online learning is especially relevant to this study as it was used to create the working second-order barrier categories in the analysis. Tawfik et al.'s study also used Ertmer's (1999) constructs as the working categories for their analysis. In the study, Tawfik et al. used Ertmer's (1999) paper to construct the first-order barriers, which were "inadequate technical and administrative support", "lack of access to computers, software and tools", as well as "insufficient time to plan instruction". The sub-themes revealed that there was not enough support and training, district-level decisions were delayed, and policies were nonexistent or not clearly communicated. The second-order barriers in the study were "beliefs about computers and digital tools", "beliefs about teaching when online" and "established classroom practices", with sub-themes such as concerns about an appropriate

level of screen time, difficulties with classroom management and the need to develop structures that make online learning possible.

Another technology integration research paper from last year (Abedi & Ackah-Jnr, 2023), on the other hand, explored first- and second-order barriers to technology implementation and the researchers discovered that limited technological resources, inadequate infrastructure, lack of access to technology and insufficient technical support were first-order factors hindering the implementation of AI education. The paper also explored second-order factors and discovered teacher pedagogical beliefs, skills and knowledge were prevalent barriers in the schools selected for the study.

3 RESEARCH IMPLEMENTATION

In this section, details about the conducted study will be discussed in depth. First the objectives of the study will be set, then the research context, participants, data generation and data analysis will be described, and finally the ethical considerations will be discussed.

3.1 Study Objectives

The research problem of this study is to better understand the experiences of teachers with different aspects of the implementation process, with the aim to explore the different barriers that teachers experience when attempting to implement AI education. The research questions in this study are as follows:

1. What first- and second order barriers have teachers encountered in the implementation of AI education?
2. How do teachers experience these barriers to have affected their implementation of AI education?

To answer the research questions at hand, the study was conducted using qualitative methods, specifically following a phenomenological approach and an interpretive perspective. Qualitative methods were selected because, unlike quantitative methods, they focus on lived experiences and context (Tracy, 2020), and it was therefore the appropriate choice to answer especially the second research question. The second research question also determined the phenomenological approach taken in this study, as it can answer the question of how people experience something (Tracy, 2020). An interpretive (also known as constructivist) approach means that the study was conducted with the assumption of reality as something that is constructed through interaction rather than objective truths (Tracy, 2020). It is an appropriate approach because the study aims to explore experiences and contexts rather than attempting to answer questions with a simple answer.

3.2 Research Context

AI is not yet explicitly present in Finnish curriculums (Finnish National Agency for Education, 2014). Although digital competency and media literacy in general are present in the national curriculum, AI has not been explicitly added (Finnish National Agency for Education, 2014). However, the Finnish National Agency for Education (2024) has together with the Ministry of Education and Culture, made plans to release in-depth recommendations for AI education implementation sometime in the year 2024. In the recent years, the Finnish National Agency for Education has also funded pedagogical innovation projects to support children's AI competencies (University of Jyväskylä, 2024).

This study was conducted as part of AI for early childhood education and primary education projects organized by Innokas (2023), a network of teachers and other educational stakeholders coordinated by the Faculty of Educational Sciences in the University of Helsinki. The network aims to guide Finnish schools toward creativity and innovation through technology education. The AI education project focusing on primary education, "Artificial intelligence now!" (in Finnish: "Tekoäly nyt!"), was launched in 2022 to develop materials and methods for supporting children's AI-related digital competencies. It was funded by the Finnish National Agency for Education and coordinated by the city of Lohja in cooperation with the Innokas network team at the Faculty of Educational Sciences of the University of Helsinki. In practice, several teachers from different regions in Finland participated in the project by co-creating AI related methods for teaching and learning, integrating co-created AI education practices into their teaching, taking part in AI-related professional training, and co-developing materials for AI education. The pedagogical materials produced during the project as well as information on the network and its projects are available on the Innokas website. (Innokas, 2023). The materials include videos for teachers interested in the implementation of AI in their classrooms, as well as instructions for the use of, for example, Teachable Machine and Lego Spike. The website also includes lessons plans, quizzes and inspiration for using AI with students.

3.3 Participants and Data Generation

Due to the nature of data collection in qualitative research as very dependent on the active decisions made by the researcher, calling the data collection process data generation instead of collection is widely seen as more reasonable (Vuori, 2021a) and the term will therefore be preferred in this study.

The data for the study was generated using semi-structured interviews with teachers (N=9) involved in the Innokas project. While structured interviews are advisable when comparing data across large samples, semi-structured interviews are favorable for deeper understanding of the participant's complex viewpoints (Tracy, 2020). Semi-structured interviews were therefore selected over structured ones. The interviews were also respondent in nature, meaning that they were formal and they focused on the experiences of the active members of the project themselves (Tracy, 2020) instead of, for instance, interviewing principals or project leaders on wider structural or cultural topics.

Table 1

Background information about the participating teachers

Experience	**Number of Participants**
Less than 5 years	2
More than 5 years	7
Gender	
Male	8
Female	1
Educational Context	
Grades 1-6	3
Grades 7-9	3
Grades 1-9	3

The data included four interviews with early childhood educators, but as early childhood education is outside the scope of this study, only the remaining

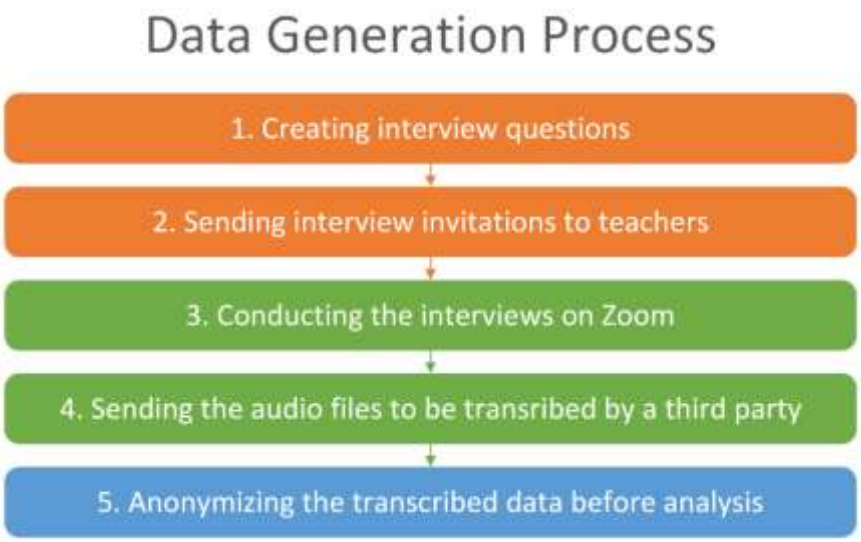
nine interviews with educators teaching 1st to 9th years were included. The interviews were recorded by each interviewer, and a third party hired by Innokas was used to transcribe the recordings. The interviews were designed to last for about an hour, and the interview with the highest word count was 8076 words, while the lowest word count was 4455 words. The median word count was 6146 words and the average 6136 words. The transcribed material was used for analysis (see details in next subsection), and although the interview questions were not all specifically designed with this study in mind, the entire transcribed material was thoroughly explored for answers to the research questions.

The interviews were conducted in November 2023 by Eeva Le Bihan and other members of the Innokas project remotely using online peer-to-peer video chat service Zoom, which was also used to record the interviews. The interview questions were developed together with other researchers in the Innokas network.

The interest for the interview questions was teachers' backgrounds, motivation, barriers and drivers, as well as future plans, and aimed for an interviews lasting for approximately one hour, attempting to explore various issues but without making the interview too heavy. Theoretical links between for the questions were drawn from previous research (Stupurienė et al., 2023) and theories such as KSAVE (Binkley et al., 2012), Intrinsic motivation self-determination theory (Ryan & Deci, 2018), T-PACK (Mishra & Koehler, 2006) and Biesta's three domains of purpose (Biesta, 2020). The questions were then reformatted using Tietoarkisto's guide (Hyvärinen et al., 2023). The data generated from the interviews will be used by other members of the Innokas project as well, so not all of the questions were composed for this study specifically. The translated interview themes and questions can be found in Appendix 1.

Figure 1

Data generation process



The interviewees' responses to all of the questions were analyzed for relevant material but most of the relevant data was in the second and third sections of the interview protocol, (i.e., questions regarding external motivation and social perspective, as well as internal motivation and individual perspective).

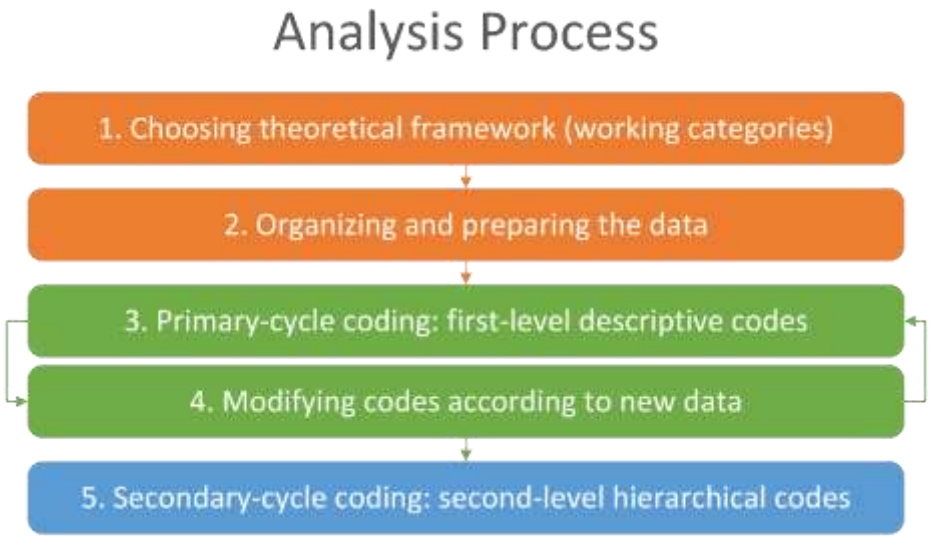
3.4 Data Analysis

Since the background literature provides existing theoretical perspectives regarding barriers to AI implementation, the thematic analysis was conducted using an abductive approach, which combines the characteristics of both an inductive and deductive approach: data is analyzed through the lense of an existing theoretical framework while maintaining an open attitude toward possible results straying from the framework used (Grönfors & Vilkka, 2011). This approach was selected to make sure that the predetermined working categories could still give space to any possible new discoveries. Because of the nature of first-order barriers as concrete resource-based barriers, a more explicit approach was taken when analyzing meanings. Second-order barriers, on the other hand, are more abstract by nature and therefore a more implicit approach was sometimes taken to find them. In other words, hidden meanings that were not explicitly stated were sometimes used to identify barriers that could not have been

found otherwise. The complete thematic analysis process is displayed in Figure 2 and will next be described in more detail.

Figure 2

Analysis process (Tracy, 2020)



The purpose of the analysis was to examine the transcribed data for mentions of barriers the teachers had encountered as well as discussions about how the teachers had experienced them. The interviews were coded and analyzed using thematic analysis. Thematic analysis was selected as the appropriate method because while the first research question could have been answered with content analysis, thematic analysis was required to answer the second research question, to understand the context of the barriers and the experiences of the teachers (Vuori, 2021b). Additionally, since qualitative thematic analysis often focuses on the explicit meanings of the discussion in the data rather than, for instance, implicit ways of expression (Vuori, 2021b), grouping the data into predetermined (working) categories with qualitative thematic analysis was a suitable option. Ertmer's (1999) first- and second-order barrier theoretical framework was selected as the main framework because there was no pre-existing theoretical framework for barriers in AI education implementation specifically. The working first-order barrier categories were "access", "training", "time" and "support" (Figure 3).

Since Ertmer's (1999) interpretation of first- and second-order barriers did not include clear categories for second-order barriers, they were modeled after a more recent study on the implementation of online learning (Tawfik et al., 2021) but the categories were modified to fit the framework of AI in education instead of online learning by removing words relating to online learning or replacing them with similar meanings relating to AI. The working second-order barrier categories were "beliefs about computers, digital tools and AI", "beliefs about teaching", and "established classroom practices" (Figure 3). As this study took an abductive approach, both first- and second-order barriers included subcategories titled "other discoveries" was also added to include any barriers that did not fit into these working categories. The data was coded with Atlas.ti.

The data analysis process was conducted according to Tracy's (2020) instructions for a phronetic iterative approach. Unlike grounded theory, Tracy's (2020) phronetic iterative approach focuses on specific parts of the data to address concrete problems. As this study also focused on a concrete problem (the barriers to the implementation of AI education), the phronetic iterative approach was a fitting one.

Primary cycle coding involves exploring the data and identifying words or phrases that describe their essence (Tracy, 2020). Therefore, after reading the transcribed data to gain an overall understanding of the themes discussed in it, the data was revisited, and all identified barriers were coded with Atlas.ti into more simplified expressions. The aim of this was to make the material more easily readable by summarizing parts of the data into memorable attributes that captured the essence of the data (Saldaña, 2016; Tracy, 2020). Just as Tracy (2020) recommends, the primary-cycle codes were also descriptive first-level codes such as "can't use software that collects information about students" or "students need to log in to use software". The coding process was carried out using the constant comparative method, in which codes are modified to fit new data (Charmaz, 2014; Tracy, 2020), to lessen the risk of definitional drift (Gibbs, 2018; Tracy, 2020). The data was divided into very specific codes in the beginning, as doing so may lead to more insightful interpretations than when broad-

er codes are used (Tracy, 2020). However, as Tracy (2020) instructs, these narrow codes were afterwards grouped up into broader codes such as "issues with information security policies".

Originally the data was coded very broadly, but after further consideration, the codes that did not directly relate to the research questions were discarded, as Tracy (2020) instructs. This meant that for example mentions of not understanding the complex mathematical ways in which AI works (that is, the teacher's personal understanding of AI), with no contextual relation to the actual implementation of AI in the classroom, were no longer included. These mentions might have been indirectly related to the implementation of AI, but studying them would have been outside the scope of this study.

Once the data had been reread multiple times and the broader codes were constructed, the secondary-cycle of coding began (Tracy, 2020). Unlike first-level codes, which emerge from the data itself, second-level codes are constructed using interpretations, first-level codes and theoretical knowledge (Tracy, 2020). The theoretical framework utilized in this study was that of Ertmer (1999) and Tawfik et al. (2021). The codes created in the primary-cycle process were viewed through the lense of the theoretical framework and so codes were categorized according to Ertmer's (1999) constructs and Tawfik et al.'s (2021) interpretations with hierarchial codes (Tracy, 2020), also known as axial coding (Charmaz, 2014). Most of the codes fit into the theoretical framework and were therefore categorized under the framework's constructs.

To better fit the material, the category "training" was renamed to "knowledge". It also became apparent that two of the second-order barrier categories, "beliefs about computers, digital tools and AI" and "beliefs about teaching" were often present together in statements, making it impossible to differentiate between the two categories. Because of this interconnectedness, they were merged into a single category titled "attitude". Finally, to make the categories consistently named, "established classroom practices", was simplified to "routine". However, not all codes could be categorized within the theoretical framework's working categories. Two first-order barrier categories titled

"students" and "curriculum" were added, as well as one additional second-order barrier group "confidence". After the analysis process, the final first-order barriers categories were therefore "access", "knowledge", "time", "support", "students" and "curriculum", and the final second-order barrier groups established were "attitude", "interest", "routine" and "confidence" (see Table 2).

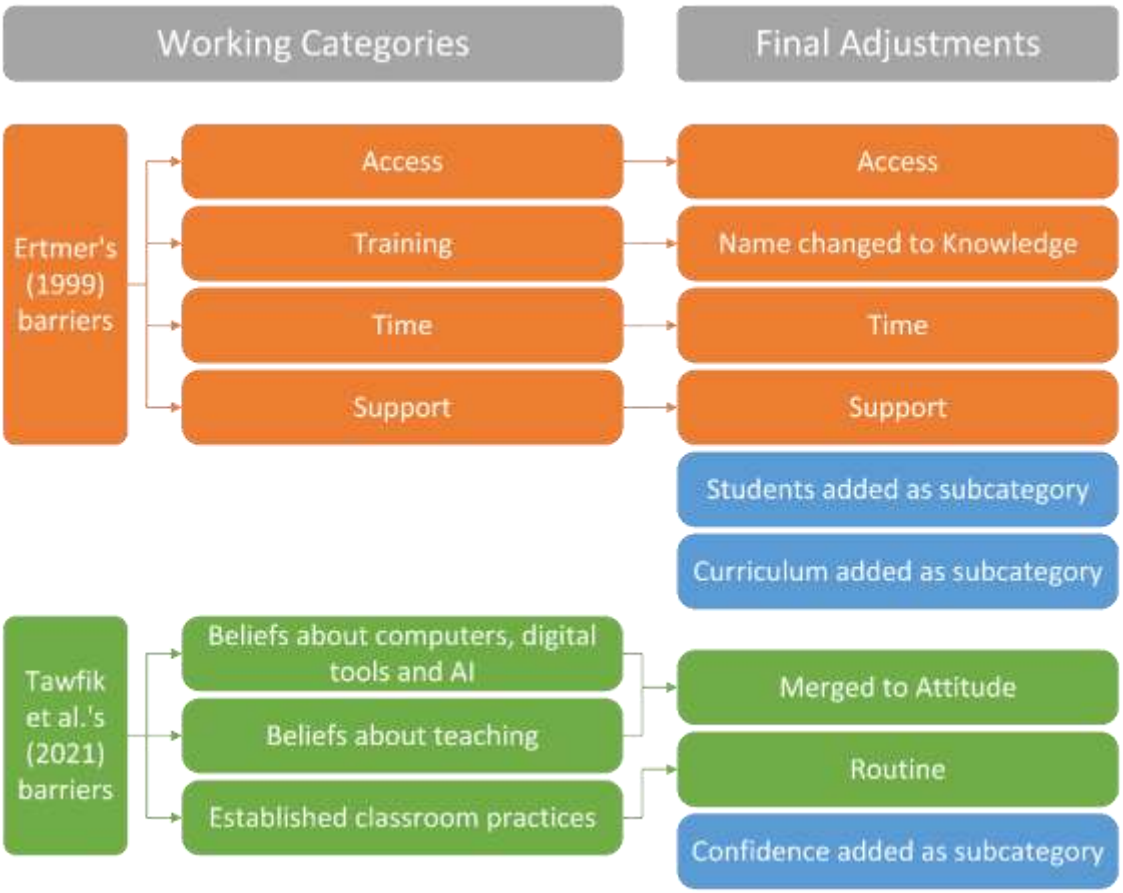
Table 2

Data samples for the final categories of the thematic analysis

	Groups	Data samples
First-Order	Access	T3: "in the context of AI, it is the software and data protection and security issues that are challenging"
	Knowledge	T1: "where I feel there are more shortcomings in my own understanding is related to [knowing] what kinds of applications … could be used."
	Time	T2: "Well, I still have to have time to ski, sail, run and do all kinds of other stuff. Maybe that's what's been holding me back the most."
	Support	T12: "even though this [Innokas] network is here, it would still have been … good to have even more discussions and see people and share their thoughts"
	Students	T8: "of course, it is always a challenge for young people to concentrate"
	Curriculum	T1: "in the curriculum content, this is not really taken into account yet ... it might be there in the 2016 curriculum as a small mention. But it's not a very relevant part of it"
Second-Order	Attitude	T10: "in a way engaging in this kind of hokey-pokey causes some type of student to miss out on something."
	Routine	T1: "I get used to using old familiar systems and that is perhaps the worst enemy here in the end. I work in my own comfort zone, where new things come relatively slowly."
	Confidence	TX: "male teachers … somehow have a stronger identity in that they are able to use microbits with their students more bravely."

Figure 3

Adjustments to the working categories



3.5 Ethical Solutions

This study followed the guidelines for the responsible conduct of research issued by the university and the Finnish National Board on Research Integrity (TENK, 2023). Consent was obtained from participants and data protection principles were followed. Because this study was conducted as part of the Innokas network project, the consent forms and privacy notices were handled by the coordinators of the Innokas AI projects at the University of Helsinki. Sensitive information was not collected and the transcribed data for this study was anonymized by replacing personal information with codes (Teacher 1 = T1, Teacher 2 = T2, etc.). The code "TX" was used in one quote included in the results, as only one female teacher was included in the study, and identifying the quote would have revealed their identity in all the other quotes included in the

results. Some data that didn't have its own code, such as people's names, were deleted and simply replaced with the word "name1", "name2" etc. The quotes for the results section were selected in a way that did not involve any identifying information, and therefore quotes disclosing involvement in specific local (e.g., municipal) projects, for example, were edited for privacy. If the quote would have been unreasonably difficult to understand without the identifying information in it, another fitting quote was selected in its place. The Zoom recordings and transcribed data were stored in the university's secure drive.

4 RESULTS

When reporting the results, some quotes were added as examples. Because the interviews were conducted in Finnish, the quotes were translated with DeepL and then refined by the author. Some quotes that would have been difficult to read and understand with their direct translations were carefully reworded while still maintaining the essence and meaning of the quote. The original quotes can be found under the translated quotes in italics.

4.1 First-Order Barriers

4.1.1 Access

One of the most prevalent themes in the data was the teachers' frustration with the difficult to navigate and often limiting factor of **information security policies**. The teachers expressed that having to follow the information security policies limited their ability to integrate AI into their teaching, as many of the available tools required students to create user accounts and therefore give away information about themselves to a third party.

> T11: We can't access a lot of applications that require logging in. And we won't make students log in because I still don't know if the instructions apply to adults only or if students are allowed to log in to ChatGPT with their school emails … So this kind of uncertainty about information security as well about what we're even allowed to do.

T11: me ei voida moneenkin tällaiseen tai ainakin joihinkin tekoäly, vaikka sovelluksiin niin vaatis kirjautumisen. Ja sit kun me ei oppilaita laittaa sinne kirjautumaan, koska mä en edelleenkään tiedä koskeeko se ohje nyt vaan aikuisia vaan saiko oppilaat kirjautua Roi edulla sinne chat GPT:n …. Niin tällainen tietoturvaepäselvyys myöskin, että mitä me nyt ees saadaan tehä.

T11: The problem is that there isn't really a free application where we would be allowed to log into, or one that we could use without logging in. That's a problem right now. Hopefully students will get Bing soon, so they can then use that.

T11: ongelma on se, että näissä ei ole ehkä ihan sellaista ilmaista mallia, mihin pystys kirjautumaan, tai että mitä pystys käyttämään kirjautumatta. Se on semmonen ongelma tällä hetkellä. Toivottavasti saadaan oppilaille tuo Bing käyttöön pian, niin sitä pystyvät sitten käyttämään.

In general, teachers felt that there were **not enough suitable tools** that could be used without privacy policy issues.

T3: In the context of AI specifically, software, data protection and security issues are challenging. As a teacher I can experiment and understand on some level … But in student use it's challenging. We can't use any service or application that requires logging in. For now it is the biggest barrier, the fact that there aren't really any services that students could use logged in. Recently Microsoft has been promising that perhaps at some point. But always when it comes to these projects when new services come out, students can't use them in school if they save any kind of information at all.

T3: tekoälyyn liittyen nimenomaan ohjelmisto- ja tietosuoja ja tietoturvaan liittyvät asiat on haastavia. Eli opettajana mä voin itse kokeilla ja ymmärrän jollain tasolla. …. Mutta oppilaskäytössä se on haastavaa. Eli mitään kirjautumista palvelua tai sovellusta ei voida käyttää, että me ei voida. Toistaiseksi se on se suurin este siihen, että oppilaille ei oikeastaan tällä hetkellä vielä ole juurikaan semmoisia palveluja mitä voisi käyttää kirjautuneena. Nyt Microsoft on lupaillut, että ehkä tässä jossain vaiheessa. Mutta se oli koko ajan näissä kokeiluissa, että kun tulee uusia palveluita ja muuta. Niin ei voida käyttää mitään sellaisia paleluja oppilaskäytössä, mikä tallentaisi edes mitään tietoja.

Some of the teachers felt that the bureaucratic process of having to get **permission** from administrators for using different applications was too long. One of them saw a positive side to it though, as they felt privacy issues had improved in exchange.

T12: Usually you have to wait too long to get approval for these things. And many times, for example, some specific iPad applications have been requested, but then they have not been approved, and so on. I think this has taken a step backwards in the whole ICT teaching field in the sense that it is not possible to use applications as freely as before. Then again, we have progressed in security issues.

T12: Yleensä joutuu kyllä odottamaan liian pitkään, että saa hyväksynnät näihin juttuihin. Ja monesti on toivottu esimerkiksi joitakin tiettyjä iPad-sovelluksia, niin niihin ei oo saatu sitten lupaa, ja muuta vastaavaa. Tää on minusta sillä tavalla ottanu takapakkia koko tää TVT-opetuskenttä siinä mielessä just, että ei pysty käyttämään sovelluksia niin vapaasti kuin aikasemmin. Toisaalta sitten taas on etumatkaa menty siinä suojakysymyksessä.

Some teachers discussed the barrier they had faced as using third party software required the district to make individual **contracts regarding the students' data**. They suggested that some of the companies developing these applications

might not even have the means to make individual data processing contracts, as their technology is still quite crude.

> T3: But then again, the legislation prevents you from being able to take those services until you have agreements in place about the processing of personal data and so on. And so again, most of these AI companies or services, their data processing is so muddled that you can't make contracts. So it prevents it for the time being.
>
> *T3: Mutta sitten taas lainsäädäntö estää sen, että ei voida ottaa niitä palveluita, ennen kun on tehty sopimukset henkilötietojen käsittelystä ja muusta. Ja sellainen taas tämmöisten, suurin osa näistä tekoälyfirmoista tai -palveluista, niin se on vielä sen verran hähmäistä se heidän tietojenkäsittely, että ei pysty tekemään sopimuksia. Niin se estää sitten sen toistaiseksi.*
>
> T12: the city always has to negotiate these contracts separately with the application developers. And it isn't always possible with everyone. The required processes may not exist with the application developers and so on. It really depends on the case.
>
> *T12: kaupungin pitää neuvotella tavallaan aina nää sopimukset erikseen sovelluskehittäjien kanssa. Ja aina kaikkien kanssa se ei onnistu. Tai ei oo semmosia prosesseja olemassa sovelluskehittäjillä ja näin edelleen. Se riippuu tosi paljon tapauksesta.*
>
> T11: Information security and the lack of clarity about what is and isn't allowed. We are not allowed to give out names or pictures of students to any service. Which is quite understandable. But that's why we need more software that is specifically made, for example for the context of Finnish education.
>
> *T11: Elikkä tietoturva myös ehkä tai se nyt epäselvyydet siinä, että mitä saa tehä ja mitä ei saa tehä. Mihinkään ei saa mennä kuvia ja oppilaitten nimiä ja niin. Mikä on siis ihan ymmärrettävää. Mutta että siks tarttis enemmän sellaisia ohjelmistoja, jotka ois jotenkin tehty sitten vaikka vaan suomalaisten koulujen opetustarkoitukseen rajattuja ympäristöjä.*

Teachers also talked about the **GDPR and Europe's privacy policies** as a barrier to being able to freely experiment with and integrate AI software into the classroom.

> T12: Before, you could kind of like Gyro Gearloose in the wild west experiment freely with all sorts of tools and you didn't have to think about GDPR or Europe's privacy policies. Now you have to really think. So it's a problem now that you really can't use just any tools you want. And these kinds of things always become available for students to use a lot later.
>
> *T12: Aikaisemminhan tässä pystyi tämmösenä pelle pelottomana villissä lännessä kokeilemaan ihan vapaasti kaikenlaisia työkaluja ja ei tarvinnu miettiä GDPR:ää tai Euroopan tietosuoja-asetuksia. Nyt pitää oikeestikin miettiä. Niin sitten se on ongelma, että tosiaan ei pysty sitten käyttämään ihan mitä tahansa työkaluja. Ja oppilaillehan ne tulee aina tavallaan tosi paljon myöhemmin käyttöön nää kaikki kamat.*

Some teachers expressed that they had trouble implementing AI education because there were **not enough ready-made materials and resources** to do so. One of the teachers described materials as for example lego sets that they hadn't acquired yet:

> T1: we haven't even had that much material available yet. By material I mean various robotics kits and things like that, that they're still coming.
>
> *T1: meillä ei ole ollut edes materiaalia vielä kovin runsaasti käytettävissä. Siis materiaalilla viittaan erilaisia robotiikkasarjoja ja jotain tämmöisiä, että ne on vielä tulossa*

Another teacher struggled with coming up with ideas on how to implement AI education, and didn't feel like the videos on the internet were of much help in their teaching context.

> T13: I find it hard at the moment to come up with new fun ideas that would motivate students and really benefit them. I feel that there are a lot of them on the internet, just those How-to PowerPoint videos, or whatever kinds exist. Well, they don't really do me any good with these third graders.
>
> *T13: koen työläänä tällä hetkellä, et keksis niitä uusia hauskoja ideoita, jotka motivois oppilaita ja niistä olis oikeesti hyötyä niille. Tuntuu, että paljon on netissä just niitä Näin tekstität PowerPoint-videot, tai mitä nyt ikinä onkaan semmosia. No, ei niistä oo kyllä mulle mitään hyötyä näitten kolmosluokkalaisten kanssa*

Even with the appropriate technology and software, some of the teachers experienced **issues with the technology** when attempting to implement AI education.

> T1: Well, in this type of thing, the tools, if the tools work or don't work, that has an effect.
>
> *T1: No ainahan tämäntyyppisissä jutuissa välineet, että jos välineet toimii tai ei toimi, niin sillä on merkitystä.*
>
> T2: We always quickly noticed that when they were using Chromebooks and these weren't brand new Chromebooks, that the camera on the Chromebooks was not that great. To get it to work properly, you had to have really good lighting. And as soon as the lighting was a little bit worse it didn't really work anymore.
>
> *T2: Kun me huomasimme aina nopeasti, että kun ne käyttivät Chromebookeja ja ne ei ollut ihan uusia Chromebookeja. Niin se kamera siinä Chromebookissa ei ollut kovin häävi. Jotta saat sen toimimaan kunnolla, niin pitää olla todella hyvä valo, hyvä valo siinä piti olla. Ja heti kun valotus oli vähän huonompi, niin sitten se ei oikein toiminut.*
>
> T7: Ready made materials and working hardware, so that the time we have available wouldn't be wasted on wondering why something is not working. … This kind of challenge we are facing here and hopefully we'll come up with something to overcome it.
>
> *T7: Niin valmiit materiaalit ja semmoiset toimivat laitteet että tavallaan, että se ei menis se aika siihen, että ihmetellään että miks tämä ei toimi tai toimii. … Mut et semmoinen haaste meillä on tietenkin tässä ja toivottavasti siihen jotakin keksitään sitten*

One of the teachers expressed that they had trouble using the software because they were often **only available in English**.

> T11: to be honest, often what makes me a hit a wall is my English language skills, like when I download an application and there are five million different options, how to plan a schedule with the help of artificial intelligence, I do not understand them. For that as well I would need to have time to try them out or just to produce the information, for example only in English.
>
> *T11: niissä mulla siis rehellisesti sanottuna tulee monesti englanninkielen taito vastaan, että kun mä lataan jonkun sovelluksen ja siellä on viis miljoonaa eri vaihtoehtoa, miten ne voit suunnitella jaksosuunnitelman tekoälyn avulla niin mä en ymmärrä niistä. Siinäkin tarttis olla aikaa, et mä voisin kokeilla niitä tai vaan sit tuottaa sitä tietoa, vaikka pelkästään englanniksi.*

4.1.2 Knowledge

One of the teachers expressed that they understood the concept of AI quite well, but they did **not know of enough software** that could've been implemented in the classroom.

> T1: I do think I understand the phenomenon reasonably well. But then where I feel that there are more shortcomings in my own understanding is related to [knowing] what kinds of applications already exist, which could be used.
>
> *T1: kyllä mä luulen, että mä sen itse ilmiön ymmärrän kohtuullisen hyvin. Mutta sitten se missä mä koen, että on enemmän puutteita omassa ymmärryksessä niin liittyy siihen, että minkälaisia kaikenlaisia sovelluksia jo löytyy, mitä voisi hyödyntää*

Another teacher explained in turn that **AI is difficult to grasp** because it is such a wide concept.

> T2: this AI is really challenging to understand because it's so vast. And you have to take a certain part that you know and tell the students that this is now a tiny fraction of AI. So that's what makes it maybe challenging.
>
> *T2: tämä tekoäly on todella haastava ottaa kiinni siitä, koska se on niin valtavan laaja. Ja sun pitää ottaa tietty osa ja sitten sä tiedät ja kerrot oppilaille, että tämä nyt on ehkä 1 promille tekoälystä tai jotain muuta. Niin se tekee sen ehkä haastavuuden.*

One teacher talked about the fact that they did not understand machine learning, which is a technique underpinning how AI works, well enough to explain it in depth to their students.

> T3: Well, it's just the technology behind artificial intelligence, it's certain that it has not yet become clear enough to me to be able to explain it very fluently. I explain on quite a general level how for instance machine learning works.
>
> *T3: No, just se teknologia siellä tekoälytoiminnan taustalla, niin se on kyllä sitä Se ei ole vielä kirkastunut mulle, että mä osaisin kovin sujuvasti kertoa. Aika yleisellä tasolla kerron, että millä tavalla vaikka just se koneoppiminen toimii.*

Another teacher expressed that while there were no technological barriers, the barriers they encountered had to do with **know-how**.

> T10: I don't see that there are any actual technical obstacles or such, but rather the kind where I would do things if I only knew how.
>
> *T10: Mä en näe, että semmosia varsinaisia teknisiä esteitä tai tämmösiä, että tekisin, jos vain osaisin –tyyppisiä esteitä sinänsä on*

As a possible explanation for the lack of knowledge, one teacher expressed that they felt that **all the information regarding implementing AI education** was difficult to conceptualize.

> T11: [it would help to have] a sort of clarification of the fragmented information, that there are so many different things, so what would I even want to or be able to or what I should practice.
>
> *T11: hajanaisen tiedon semmoinen jotenkin selkeyttäminen, että on niin paljon erilaisia juttuja et mitä mä ees nyt haluaisin tai voisin tai mitä kannattais harjoitella.*

One teacher felt that they had not yet grasped how to **explain everyday use of AI to students**.

> T1: But then again, how do we for instance illustrate to the students how our everyday environments use artificial intelligence, for example in programming and robotics, in a way that the students get to do it themselves. That has not yet been very well under control for us.
>
> *T1: Mutta sitten taas se, että miten vaikka me oppilaille havainnollistetaan miten jokapäiväinen ympäristö käyttää tekoälyä vaikka ohjelmoinnin ja robotiikan osalta sillä tavalla, että oppilaat pääsee itse tekemällä tekemään. Niin se ei ole vielä ollut kauhean hyvin meillä lapasessa.*

Some teachers expressed that they did not feel that there were a lot of AI related things that could be directly implemented in the classroom, and felt they were **unable to find uses for AI in their classrooms**.

> T2: of course we tried them out and we thought, what can we do with these tools in the classroom, are they of any use? And to be honest we didn't find much that could be directly transferred to the classroom.
>
> *T2: tietenkin me kokeiltiin niitä ja me ajateltiin, että mitä me voimme tehdä näillä työkaluilla luokkahuoneessa, onko näistä mitään hyötyä? Ja jos mä suoraan sanon sen, niin ei me hirveästi löydetty, että mitä voisi suoraan siirtää luokkahuoneeseen.*
>
> T8: I couldn’t directly think of a direct purpose [for AI] in handicrafts, like how I could add AI to these products and techniques that I teach, and I could not think of anything, it feels a bit too extravagant to think about how they could be directly applied to those products
>
> *T8: suoraan en tähän koulukäsityöhön keksiny semmosta suoraa käyttötarkoitusta, että miten mä näissä mun tuotteissa mitä mä täällä opetan ja tekniikoissa ni miten voi suoraan, miten niihin vois lisätä tekoälyä ni sitä en keksiny, et se vähän oli, että se tuntuu enemmän aikakorkealentoselta tämmönen, että miten ne saissuoraan noihin tuotteisiin*

One teacher named **coming up with pedagogical ideas** as a challenge, and described themselves as quite clumsy in the actual implementation of AI education.

> T13: Developing sensible pedagogical ideas is probably one of the challenges. It seems like I'm never very good at it although ... I can think of more child-level things. But now that I should be thinking a bit bigger scale how to make use of it I can see that with those kinds of things I'm still quite clumsy.

> *T13: Varmaan se niitten järkevien pedagogisten ideoitten kehittely, se on varmaan semmonen haaste. Tuntuu, ettei siinä oo koskaan oikein hyvä, vaikka sit taas toisaalta, että no okei että otetaan tähän meidän, mitä me tehdään nyt oppilaitten kanssa, niin otetaas tähän tällä tavalla tekoäly mukaan. Niin semmosia lapsen tasoisia juttuja keksii. No nyt kun pitäs keksiä vähän isommalla skaalalla, et miten sitä vois hyödyntää, niin huomaa, että semmosissa asioissa on aika kömpelö kuitenkin vielä.*

They also wished that there had been more **concrete examples of ways to implement AI in education**, and talked about the fact that the existing examples were directed toward elementary schools, while examples of implementation with older students weren't as common. This category could have also been included under "access", as having access to more concrete examples might have given the teachers the knowledge they needed.

> T8: maybe [an improvement would have been] that there would have been more examples of how it can be used in teaching, but it would probably have come later in the project, that now it was initially just that we all project participants tried it ourselves and did something like that, and perhaps they were more oriented towards primary school experiments. of course, as I am a subject teacher in secondary school, there may not have been so many examples. So if there would have been more examples of concrete things you could do, it would have been easy to start experimenting.

> *T8: ehkä se, että niitä ois ollu esimerkkejä enemmän, että miten sitä voi käyttää siellä opetuksessa, mutta se ois varmaan tullu varmaan myöhemmässä vaiheessa hankettuu, että nyt se oli aluksi vaan se, että me kaikki hanketoimijat kokeiltiin sitä ite ja tehtiin semmosia ja ehkä ne oli enemmän semmosia alakouluun suuntautuneita ne kokeilut. tietysti kun ite on aineenopettaja yläkoulussa ni tänne ei ehkä ollu sitten niin paljon esimerkkiä. Niin jos ois ollu enemmän semmosia esimerkkejä konkreettisia juttuja mitä voi tehä ni oisollu helppo lähtee kokeilee toteuttaa*

The same teacher also had **difficulties engaging and motivating students** to learn with and about AI.

> T8: Perhaps the most common challenge that comes up in schools is how to get the student excited about the subject, how to motivate the student to do it. When the motivation is there, they will learn.

> *T8: Ehkä se, et miten saat oppilaan innostumaan aiheesta se on yleisin haaste, mikä koulussatulee vastaan, et miten saat motivoitua oppilaan siihen. Kun se motivaatio löytyy, ni sehän oppii.*

Then again, beyond the teachers' knowledge, whether it was pedagogical, content-related, or technological, another teacher talked more generally about the **uncertainty** at the beginning of the project.

> T8: maybe a little bit of uncertainty at the beginning about what they want from us and what we should do now... then because I wasn't quite sure what I should do, it was then easily forgotten, and I thought "I'll look at AI stuff when I have time for it".

> *T8: ehkä vähän semmonen alussa semmonen epätietoisuus, että mitä meiltä halutaan ja mitä meijän kuuluis tehdä nyt… sitten ei oikein ite ollu ihan satavarma, että mitä mun pitäis tehä, ni sit se ainahelposti jäi, että "mä katoin sitten sitä tekoälyjuttuja kun mulla on aikaa niihin"*

4.1.3 Time

Time was another extremely prevalent theme in the interviews, as many of the teachers felt that they **didn't have enough work hours to explore AI implementation** on a sufficient level. Additionally, some teachers talked about exploring AI in their free time, the teachers quoted here felt like their workload was already too large to fit AI education into properly.

> T10: this has been a pretty chaotic autumn for a couple of reasons not directly related to teaching, but we've been exploring the topic again with these new groups, but I haven't been able to, and frankly haven't had the energy to, start working on a longer-term, more coherent project yet.

> *T10: tää on ollu aikakaoottinen syksy paristakin suoraan tähän opetukseen liittymättömästä syystä, mutta ollaan noitten uusien ryhmien kans taas tutustuttu aiheeseen, mutta en oo pystyny, enkä oo suoraan sanottuna jaksanut nyt lähtee semmosta pitemmälle menevää pitkäjänteisempää johdonmukaisempaa projektia vielä työstämään*

> T11: if only there had been time for this kind of technical training, and specifically time so that it would not be something like, "research it yourself, try it yourself", because you really don't have time for it when you have millions of meetings and everything to deal with.

> *T11: jos ois ollu just aikaa tällaiseen ikään, kun tekniseen koulutukseen ja nimenomaan aikaa silleen, että se ei ois jotain, että selvitäpä ite yritäpä ite, koska ei sitten oikeesti oo aikaa siihen, kun on monta miljoonaa kaikkia palavereja ja kaikkia hoidettavana*

> T13: coming up with those new ideas is always a bit [challenging], somehow I feel in my everyday life that I have to spend quite a lot of time on how to get the AI implemented in this job. Images and the such come easily. But then if I would like to try something new, then it becomes something that I find difficult at the moment, to come up with new fun ideas that would motivate the students and would really be useful to them.

> *T13: niitten uusien ideoitten keksiminen on aina vähän, jotenkin tuntuu tässä arjessa, että siihen joutuu käyttään aika paljon aikaa et miten mä sen tekoälyn ottaisin vaikka tähän hommaan mukaan. Tommoset kuvat ja muuthan tulee aika sillai helposti. Mut sitten jos haluis jotain uutta kokeilla, niin se on ehkä semmonen, minkä mä koen työläänä tällä hetkellä, et keksis niitä uusia hauskoja ideoita, jotka motivois oppilaita ja niistä olis oikeesti hyötyä niille*

In contrast to the teachers that used their free time to explore AI, one of the teachers highlighted the need for free time.

> T2: Well, I still have to have time to ski, sail, run and do all kinds of other stuff. Maybe that's what's been holding me back the most.
>
> *T2: No, kun pitää ehtiä hiihtää, purjehtia, juosta ja kaikkia muita juttuja tekemään. Ehkä ne on eniten, mikä on estänyt.*

Some teachers had **other projects** that they were simultaneously working on and for that reason did not feel like they had enough time for implementing AI education.

> T3: On an individual level, I have to balance the fact that I do a lot of other development work and [I have to think about] how much time I spend [on each one]. So maybe you could say that if I had wanted to invest more time in this project, then I would have achieved more too.
>
> *T3: Yksilötasolla mulla on sitten tasapainoilua sen kanssa, kun mä teen paljon muutakin kehittämistyötä, että kuinka paljon käyttää aikaa. Niin ehkä sen voisi sanoa sitten, että jos olisi halunnut panostaa enemmän tähän projektiaikaan, niin sitten olisi saanut enemmän aikaankin*
>
> T12: I have maybe had very little time now. It's a terrible shame that some, a big part of this whole AI hype will pass me by. If it were a normal situation, I would have done much, much more of everything. But now I have this [other project], so it takes so much time that I can't give it my full effort.
>
> *T12: Itellä ehkä nyt on ollu aikaa tavattoman vähän. Harmittaa hirveesti, että menee osa, iso osa tästä koko tekoälyhypestä ohi. Jos olis normaali tilanne, niin mä olisin tehny paljon, paljon enemmän kaikkea. Mutta mulla on nyt tuo [toinen projekti], niin se vie niin paljon aikaa, että ei pysty täysillä satsaamaan*
>
> T8: for me, at least, the time seemed that there were not enough hours in a day for everything, that then the thing that affected my own teaching the most, so it was prioritized then to the top just the [second project] arrangement and everything else took priority.
>
> *T8: mulla ainakin se aika vaikutti, että ei vaan yksinkertasesti riittäny tunnit vuorokaudessa kaikelle, että sitten se, mikä omaan opetukseen vaikutti eniten, ni se priorisoitu sitten kärkeen just sen [toisen projektin] järjestely ja kaikki muu siinä meni edelle*

One teacher had needed to devote a lot of time to **personal issues** and therefore could not focus their time and concentration on the implementation of AI education.

> T10: maybe I won't go into what they are here, but there have been things that have significantly affected my overall burden, so I haven't had the energy or time to spend on this, that I've had to prioritize things strongly here ... I've had to spend time on things like my personal life and family.
>
> *T10: en mä nyt ehkä rupee avaan tässä, mitä ne on, mutta tämmöseen kokonaiskuormitukseen voimakkaasti vaikuttavia asioita, et ei oo vaan ollu sitten paukkuja eikä aikaa käyttää tähän, että*

nyt on joutunu priorisoimaan asioita voimakkaasti tässä … oon joutunu käyttää aikaa ihan tämmösiin lähipiirin ja omaisten asioihin

4.1.4 Support

Some of the teachers highlighted shortcomings in **being able to share thoughts, ideas and discussions** with peers.

> T12: even though this network is here, it would still have been possible, or would have been good to have even more discussions and see people and share their thoughts and a little bit of sharing their visions, where these things are going and what kind of opportunities are shaping step by step. Some sort of sharing and studying and so on, and searching for information

> *T12: vaikka tätä verkostoa on tässä, niin siltikin olis pystyny, tai olis ollu hyvä varmasti vielä enemmän käydä semmosia keskustelujaja nähdä ihmisiä ja jakaa niitä ajatuksia ja vähän niinkun jakaa niitä visioita myöskin, että mihin nämä asiat on menossa ja minkälaisia mahdollisuuksia näistä sitten tavallaan askel askeleelta muodostuu. Semmosta jakamista ja opiskelua ja näin, niin sen informaation hakemista*

> T11: how very unequal it is, too, that if I had my own teaching group, such as a primary school class, we would probably do all sorts of things with them. But the class next door would not necessarily do anything. So somehow we need joint planning, brainstorming and sharing of information. It has been a challenge that this thing has been mostly one's own responsibility in the end.

> *T11: kuinka epätasa-arvoista sekin sitten on, että jos mulla sitten vaikka ois oma opetusryhmä silleen kiinteästi, vaikka alakoululuokka. Niin mehän tehtäis heiän kanssa varmaan vaikka ja mitä. Sitten naapuriluokassa ei välttämättä tehtäis yhtään mitään. Et jotenkin sellaista yhteissuunnittelua, ideointia ja tiedonjakamistakin tässä tarvitaan. Se luo haasteen, et se on vähän silleen ollu kuitenkin aikalailla omalla jotenkin vastuulla tää asia.*

While another teacher expressed frustration with the **communication** between them and IT administration.

> T13: There may have been some momentary fluctuations in the communications with the IT department. It's always like "damn now I threw in the towel for a while" when the matter is not moving forward.

> *T13: Hetkellisiä heilahduksia on ehkä tullu noitten tietohallinnon kanssa käytävän viestinnän suhteen. Aina se, että ei vitsi että nyt heitin kirveen kaivoon kyllä hetkeksi, kun ei asia etene.*

4.1.5 Students

Some of the teachers mentioned their **students having been challenging** in one way or another. One of them talked about their students' excitement as a positive thing, but noted their attitude toward AI as something akin to a magic trick instead of a tool to learn with or about.

> T3: the attitude in some ways was maybe that the AI is doing some kind of magic tricks, like wow, it can do this kind of thing and stuff. And it was not in that way seen as a learning tool or object first. But it was more of a thing that [students] would go look at
>
> *T3: se suhtautuminen jollain tavalla oli ehkä, että tekoäly tekee jonkunlaisia taikatemppuja tai temppuja, että vau, tämä osaakin tehdä tällaisen asian ja muuta. Eikä se sillä tavalla oppimisen välineenä tai kohteena ollut ensimmäisenä. Vaan se oli enemmän semmoinen asia mitä mentäisi katsomaan*

Another teacher discussed the stark differences in students' knowledge and use of technology.

> T11: in this subject, as in any subject nowadays, it seems that you notice the huge difference in the level of knowledge that students have, that some of them are like walking knowledge banks, for example in artificial intelligence, in my opinion. But then most of them do not necessarily know anything about this. And then again, some use different applications and some then do not even have a phone or do not have permission to use, for example, Snapchat or something.
>
> *T11: tässäkin aiheessa kuten missä tahansa aiheessa nykyään tuntuu, että huomaa sen valtavan osaamistasoeron mikä oppilailla on, että osa on semmoisia kävelviä tietopankkeja vaikkapa tekoälyyn liittyen mun mielestä. Niin sitten suurin osa ei täst taas tiedä välttämättä mitään. Ja sitten taas osa käyttää erilaisia sovelluksia ja osalla sitten ei edes ole puhelinta tai ei oo lupa käyttää, vaikka Snap chatia tai jotain.*

A third teacher talked about difficulty for students to concentrate, especially when working with complex concepts such as AI.

> T8: of course, it is always a challenge for young people to concentrate. perhaps the fact that for some people, artificial intelligence may already be a word that they do not understand and it feels heavy to start thinking about. It is easier to use wood as a material because it is familiar. And then when there is artificial intelligence, it seems like such a fancy technology that you may not immediately understand it or not be able to start thinking about it.
>
> *T8: ainahan se tietenkin on nuorille haaste keskittyä. ehkä se, että joillekin saattaa olla se tekoäly jo sanana jo semmonen, että ei hahmota sitä ja tuntuu raskaalta alkaa miettimään on helpompaavaikkamiettiä puuta materiaalina kun seon tuttu. Ja sitten kun onkin tekoäly, ni se tuntuu jotenkin niin hienolta teknologialta, että ei välttämättä heti hoksaa tai ei pysty alkaa miettimään hahmottamaan sitä*

Some of the teachers also discussed the challenges they faced as a result of not having one permanent classroom and instead **teaching many groups of students**.

> T10: classroom teachers have much greater freedom to do and try things and link it to different things, but as a subject teacher the perspective and viewpoint is quite small on the subject compared to the classroom teacher's stuff, there are far fewer lessons and they are always related to one topic, while the classroom teacher is able to look at it as a whole and then think about the different subjects and in general if only at the weekly level thinks about how things are handled.
>
> *T10: luokanopettajalla on paljon suurempi vapaus tehdä ja kokeilla juttuja ja nivoa sitä eri asioihin, mut sitten tälläi aineenopettajana ni se näkökulma ja katsantokanta on aika pieni siihen aiheeseen verrattuna luokanopettajan juttuun, että tunteja on paljon harvemmin ja sitten ne liittyy*

aina siihen yhteen osa-alueeseen, sitten luokanopettaja pystyy kattoo sitä kokonaisuuttaja miettiin sitten eri aineiden osalta ja ylipäätään sen koko heidän vaikka pelkästään jo viikkotasolla miettii, että mitenkä siinä asioita hoidetaan.

T11: If I had my own class, if I was a classroom teacher, I would somehow dare to build the school year in a way that would be more daring and look more like the lives of today's children ... I don't have a kind of permanent group. In a way, the information that I have been able to spread has been pretty fragmented and kind of scattered here and there and sometimes there and sometimes there and with this [student] and with that [student].

T11: jos mul ois oma luokka. Mä oisin luokanopettaja, että mä jotenkin uskaltaisin rakentaa siitä kouluvuodesta jotenkin silleen rohkeammin silleen nykylasten näköisen … ei oo semmoista pysyvää ryhmää. Et tavallaan se tieto mitä ikään, kun on pystynyt levittämään on ollu aika silleen pirstaleista ja sellaista hajanaista siellä täällä sinne tänne ja välillä tuolla ja välillä tuolle ja tuon kanssa ja tämän kanssa

4.1.6 Curriculum

The Finnish national curriculum does not acknowledge AI education outright, and one of the teachers indeed felt that **AI education was not properly acknowledged in the curriculum**.

T1: in the curriculum content, this is not really taken into account yet ... it might be there in the 2016 curriculum as a small mention. But it's not a very relevant part of it

T1: opetussuunnitelman sisällöissä tätä ei hirveästi vielä huomioida … se on ehkä siellä vuoden 2016 opetussuunnitelmassa pienenä mainintana. Mutta se ei sinne kuulu kovin olennaisesti

Another teacher was concerned about the **change in curriculum**, where the previously taught ICT-education was replaced with the assumption that all subjects would be integrated with technology use. On the other hand, this barrier could have been categorized under second-order barriers with the perspective of teachers who are not willing to integrate technology into their teaching.

T11: I cannot overemphasize how big of a problem it is in my opinion …, that while in the past there used to be a separate ICT subject, now perhaps it is thought that it isn't needed because it's in all subjects all the time. But it is not ... for such teachers [that have trouble integrating technology] perhaps it would help that ICT would then be a separate subject in which there would be a separate subject teacher.

T11: sitä ei voi liikaa korostaa sitä, että kuinka iso ongelma se on minun mielestä …, että kun ennen ehkä on ollu se joku TVT oppiaine tai muuta ja nyt ehkä ajatellaan, et sitä ei tarvita, koska se on kaikkialla kaikissa oppiaineissa koko ajan niin ei se oo … semmoisille opettajille ehkä auttais se, että siinä ois sitten oppiaine, jossa sitten vaikka ois joku aineenopettaja

4.2 Second-Order Barriers

4.2.1 Attitude

Many of the teachers talked about their attitude toward technology and AI. One such teacher contemplated the **essential skills that should be focused on** and talked about the risk of AI education becoming pointless busywork that wouldn't actually help advance students' skills.

> T1: I am also a teacher who is constantly thinking about what are the basic skills that students need to learn no matter what. So that this phenomenon doesn't turn into a kind of pointless tinkering … which doesn't necessarily advance the children's skills terribly much.
>
> *T1: mä olen myös opettaja, joka koko ajan pohdiskelee sitä, että mitkä on semmoisia perustaitoja, jotka oppilaille täytyy joka tapauksessa opettaa. Ettei käy niin, että tästä ilmiöstä tulee ikään kuin semmoinen puuhastelu, osa puuhastelua, joka ei sitten välttämättä vie lasten taitoja hirveästi eteenpäin*

The same teacher also talked about their **perception of AI as dangerous** and something that doesn't advance humanity.

> T1: all in all, when we talk about AI, we see a lot of threats. And those threats perhaps also color our own attitude ... it involves some kind of avoidance, as if this does not bring humanity forward. Somehow in this way, that it is an unfamiliar environment, which we must of course deal with and of course adopt in some way. But then, this idea that humanity is something other than immersion in the world of artificial intelligence.
>
> *T1: kaiken kaikkiaan tekoälykeskustelusta kun puhutaan, niin nähdään paljon uhkia. Ja ne uhkat ehkä värittää sitä omaakin suhtautumista … siihen sisältyy jonkunlaista välttelyä ikään kuin, että tämä ei edistä ihmisyyttä. Jotenkin tällä tavalla, että se on vieras ympäristö, johon on ilman muuta suhtauduttava ja ilman muuta otettava se jollakin tavalla käyttöön. Mutta sitten kuitenkin ajatus siitä, että ihmisyys on jotakin muuta kun uppoaminen tekoälyn maailmaan.*

Another teacher thought that AI was **not a relevant topic in their own subject**, and felt that it was more relevant in other subjects.

> T10: I have not been able to bring the actual content to the teaching of mathematics in such a way as to make artificial intelligence proper content, because I know that, for example, it is much more relevant in humanities and natural sciences or in Finnish.
>
> *T10: varsinaisia sisältöjä en oo kyenny tähän matematiikan opetukseen sillä tavalla tuomaan sitä tekoälyä lihaksi tähän, että tiedän, et esimerkiks reaaliaineissa tai äidinkielessäkin on ihan paljonkin relevantimpi tekijä*

Similarly, they also discussed their opinion regarding AI education having to form a concrete connection with other topics in the subject at hand.

> T10: [it should] be linked in some way to the actual subject of ours. [If it's] a completely unrelated thing, I don't [make exceptions with] artificial intelligence either ... Yes, teaching something like [skills related to artificial intelligence] is valuable in today's world, but it's not related to teaching mathematics alone in the same way, that it's more like multiliteracy in any case.
>
> *T10: [se pitäisi] nivoo jollakin tavalla kiinni siihen varsinaiseen meijän aiheeseen, että semmonen ihan irrallinen juttu, niin en mä tekoälyopetustakaan … Kyllähän semmosen [tekoälyyn liittyvien taitojen] opettaminen on nykymaailmassa arvokasta, mutta se ei taas juuri sillä tavalla liity matematiikan opetukseen yksistään, et se on semmosta monilukutaitoo kuitenkin.*

The same teacher also expressed that they expected AI education to bring value as a tool into their teaching and didn't want to implement it if it **did not bring value** to their teaching practices.

> T10: I have not yet seen that it would really have been of great added value to the normal teaching ... I do not want to force anything, so that it is then through the added value. ... I'm a little averse to the idea that something is done just for the sake of doing it, [I think] it should also bring some added value to the subject, not just for the sake of doing it, ... more perhaps because I haven't yet seen that it would really have had a great deal of added value to standard teaching.
>
> *T10: en oo vielä nähny, et ihan tohon normi opetukseen siitä ois oikeesti ollu kauheesti lisäarvoa … en halua väkisin tuoda mitään, et se on sitten sen lisäarvon kautta. … vierastan vähän semmostakin ajatusta, että jotakin tehdään vain sen takia, että tehdään, et kyllä se pitää sitten jotakin tuoda myös sitten lisäarvoa sille hommalle, et ei vain tekemisen vuoksi, … enemmän ollu ehkä kiinni siitä just, et en oo vielä nähny, et ihan tohon normi opetukseen siitä ois oikeesti ollu kauheesti lisäarvoa.*

Another teacher's attitude toward AI being an important subject for students to learn about was revealed as they talked about the importance of using technology as a tool for learning instead of having the tools be important to learn about and with by themselves.

> T12: in this situation you have to balance, in a way, kind of whether you go technology first or pedagogy first. In a way, I think it is justified to start a little bit with technology first in these new things. But then, when it comes to 95% of the school's work, it must be absolutely pedagogy first and go in the way where the tools serve the learning. But some time can be spent on wild experiments too.
>
> *T12: tässä pitää tasapainotella tavallaan sitä, että lähteekö ikään kuin teknologia edellä vai pedagogiikka edellä. Tavallaan musta on perusteltua näihin uusiin juttuihin lähteä vähän teknologia edellä. Mut sitten se, että mitä on se 95 prosenttia siitä koulutekemisestä, niin sen pitää olla ehdottomasti pedagogiikka edellä ja mennä sillä tavalla, että ne työkalut palvelee sitä oppimista. Mutta jonkun verran voi käyttää semmosiin villeihin kokeiluihinkin aikaa.*

Two teachers also felt that their current classes of third grade **students would not benefit from AI education** much. On the other hand, this attitude might have also been due to a lack of knowledge about the subject.

> T12: For example with third graders, who can barely read and write, it does not make sense to [explore AI education]. They do not yet have the appropriate schemas, or the

> appropriate world of experiences, that they would necessarily benefit from very far-reaching experiments or even understanding it. Or relating to, for example, artificial intelligence in text production. I don't think it's essential at this stage to actually use it yet. Perhaps with older students who produce or who have to deal with larger text masses and produce larger text masses, then it's be more justifiable to use these.

> *T12: vaikka nyt kolmasluokkalaisten kanssa, jotka nyt hädin tuskin osaa lukea ja kirjoittaa, niin ei oo järkevää välttämättä lähteä, tai he ei, heillä ei oo olemassa vielä semmosta… semmosia skeemoja, semmosta kokemusmaailmaa, että he välttämättä hyötyisivät semmosista kovin pitkälle menevistä kokeiluista tai edes siitä ymmärryksestäkään, että jotenkin vaikkapa tekoälystä tekstin tuottamisessa. Niin ajattelis, että ei oo oleellista tässä vaiheessa varsinaisesti sitä vielä käyttää. Se ehkä sitten isommilla oppilailla, jotka tuottaa tai jotka joutuu käsittelemään isompia tekstimassoja ja tavallaan tuottamaan isompia tekstimassoja, niin se on perustellumpaa käyttää näitä.*

> T13: they are of no use to me with these third graders. On the other hand, [I have] kind of a critical attitude to everything new, to find the sense in it for these young students.

> *T13: ei niistä oo kyllä mulle mitään hyötyä näitten kolmosluokkalaisten kanssa. Se semmonen toisaalta vähän kriittinen suhtautuminen kaikkeen uuteen, että löytäs sen järjen näitten pienten oppilaiden kannalta, mikä siinä on.*

Some teachers showed their attitude in more subtle ways, such as by emphazising the importance of other curriculum content. Sometimes even if teacher work hours had sufficed, teachers felt that they did not have enough time to implement AI education in their classrooms due to the amount of priorization they had to do with the available time. One of the teachers talked about technological curriculum content being seen as **less important than other topics**.

> T11: everything else in the book is compulsory but then the programming section, which I think is somehow related to artificial intelligence too, those kinds of sections are skipped

> *T11: kaikki muu siellä kirjassa on pakollista mut sit se ohjelmointiosio mikä jollain tavalla liittyy mun mielestä tekoälyynkin, niin on semmoinen, että sen yli hypätään*

Many of the teachers expressed that they often did not feel like they could **fit AI education into their teaching**, and talked about or implied the importance of prioritizing other content.

> T7: So it was then again, especially in seventh to ninth grade, it became so complex that it's hard to imagine that these grade levels could have time for it unless it would be a separate optional subject.

> *T7: Niin se oli sitten taas varsinkin yläkouluun, niin se meni hyvin tai meni jo oikeastaan heti alussa niin ihan niin vaikeaksi, että ei vois kuvitella, että yläkoulun tämmöisen perusopetuksessa niin riittäis siihen aikaa, ellei se ois sitten joiku valinnaisaine erikseen.*

> T10: mathematics is a difficult subject for many and there are a lot of things to do and the schedules are tight, so in a way engaging in this kind of hokey-pokey causes a type of student to miss out on something.

T10: matematiikka on monelle vaikee oppiaine lähtökohtasesti ja asiaa on paljon jaaikataulut tiukkoja, ni tavallaan semmonen tietynlainen kikkailu on sitten aina jonkun tyyppiseltä oppilaalta pois.

T12: of course, it is always a bit tricky in this kind of substance-divided comprehensive school, like where should I shove these in then

T12: se on tietenkin tämmösessä ainejakoisessa peruskoulussa aina vähän hankala se, että no mihin väliin näitä asioita nyt sitten jotenkin tunkisi

4.2.2 Interest

One of the teacher described the widely used materials as **uninteresting** to them, while discussing AI in social media felt more interesting.

T11: I mean, quite frankly, I wasn't even motivated by the microbits. I can see many reasons for it. I haven't had the skills to be able to use them enough. But then another thing is that it didn't seem that interesting to me. So I've gradually found my own approach to artificial intelligence, so that we talk a lot with the students about just this social side of it and social media.

T11: Siis ihan suoraan sanottuna mua ei ole edes motivoinu, vaikka ne mikrobitit. Näen varmaan montakin syytä. Mä en oo osannu tarpeeksi käyttää niitä. Mut sit toinen juttu taas. Se ei oo tuntunu musta niin kiinnostavalta niin sitten mä oon löytäny pikkuhiljaa tavallaan tähän tekoälyynkin semmoisen oman tulokulman jotenkin, että just tän yhteiskunnallisen puolen tässä ja sitten sosiaalisen median siitä me tosi paljon oppilaitten kans puhutaan.

4.2.3 Routine

One of the teachers had **trouble remembering to include AI education** in their teaching routines.

T1: I should have it on the wall of my classroom all the time, "remember to pay attention to AI" and things like that. I have a very kind of intuitive way of teaching. Of course, a reasonably long teaching experience affects the fact that I quickly discard things ... Often I get used to using old familiar systems and that is perhaps the worst enemy here in the end. I work in my own comfort zone, where new things come relatively slowly.

T1: mulla saisi olla … luokan seinällä koko ajan, että muista huomioida tekoäly ja tämäntyyppistä. Se on, mulla on hyvin semmoinen intuitiivinen tapa opettaa. Tietysti kohtuullisen pitkä opettajakokemus vaikuttaa siihen, että mä polkaisen nopeasti niitä asioita … Usein urautuu käyttämään vanhoja tuttuja systeemeitä ja se on ehkä tässä se pahin vihollinen kuitenkin. Toimin omalla mukavuusalueella, johon uudet asiat tulee verrattain hitaasti.

Another teacher felt that certain things should be learned the old way.

T12: You have to learn the basics somehow with the traditional model in a particular way.

T12: On pakko ne perusasiat jotenkin oppia perinteiseen mallin tietyllä tavalla.

One of the teachers also brought up **textbook reliance** in several different instances.

> T11: as long as there is no AI in the teaching materials, it is as if it is not important. Instead, there may be several hours in the environment and nature studies of the third grade, there are several hours worth of material on beaver feeding behavior and sleeping and other things. And then it is studied and fish parts are studied like crazy and then they have to know them in the test and the assessment is based on that. But the knowledge that the kids would need in the future. No one will ask them what the fish parts were. "Just quickly list them by heart", so that in a way I can see that there's a really big problem now with the kind of learning materials we have.

> *T11: niin kauan kun siellä oppimateriaaleissa ei näy nyt vaikka tää tekoäly niin se on yhtä kuin ei tärkeä asia. Sen sijaan siellä voi vaikka kolmosten ympäristöopissa olla useammankin tunnin verran materiaalia majavan ruokailusta ja nukkumisesta ja muusta. Ja sitten sitä tankataan ja kalan osia tankataan hullunlailla ja sitten ne pitää kokeessa osata ja se arviointi perustuu sille. Mut sit se osaaminen mitä ne lapset tarttis tulevaisuudessa. Ei niiltä tuu kukaan kysymään, että mitkä ne kalan osa oli. Luettele ne nyt äkkiä ulkoa, et tavallaan jotenkin et mä näen tosi ison käpin nyt sen kanssa, et minkälaisia oppimateriaaleja meillä on.*

4.2.4 Confidence

One of the teachers discussed teachers' attitudes of not daring to teach certain subjects if they **did not feel proficient** in them in advance. This contrasts with another possible attitude, which would be to learn with and about AI together with students instead of having to feel proficient enough to teach students about it.

> T11: the idea is that "I as a teacher should first know this thing so that I can teach". But it should be turned the other way around, "I do not need to know but now I should just give time for us learn this thing together". It also relates to a kind of bigger school-related issue somehow. That teachers don't want to teach about this subject, because they do not feel like they know enough about it.

> *T11: se ajatus on se, että mun pitäisi opettajana ensin osata tämä asia, että minä voin opettaa ja tässä pitäiskin nyt kääntää se toisinpäin, että ei tarvi osata vaan nyt mun pitäis vaan antaa aikaa sille, että me yhessä opetellaan tätä asiaa, niin se on kans semmoinen liittyy. Semmoiseen isompaan kouluun liittyvään kysymykseen jotenkin, että niin. Että tästä aiheesta ei haluta ikään, kun välttämättä opettaa, koska siitä ei koeta, että tiedetään*

One of the teachers teachers expressed that they were not as sure about their skills when teaching AI education with technology, contemplating about a possible **divide between male and female teachers**.

> TX: male teachers may. They somehow have a stronger identity in that they are able to use microbits with their students more bravely. I don't know where it comes from. But they have more experience with them and so on

> *TX: miesopettajat saattaa. Heillä on jotenkin semmoinen vahvempi identiteetti siinä, et he pystyy oppilaitten kans käyttään vaikkapa mikrobittejä silleen rohkeammin jotenkin. Mä en tiiä mistä se tulee. Mutta et heillä on enemmän kokemusta niistä ja näin*

5 DISCUSSION

5.1 Comparison with Previous Research

The objective of this study was to explore the barriers that Finnish school teachers had experienced in the implementation of AI education. Security policies were regarded as one of the most prevalent barriers because a lot of the applications used for AI education were mentioned to require students to log in to use them. This was challenging for teachers, because they could not carry out AI education lessons in a way that would have engaged students to experiment and learn with AI, but rather had to carry out lessons dominated by teacher presentation. The applications would also collect data about students, which was an ethical and administrative problem for many of the teachers. These findings align with Crompton et al.'s (2022) review, since in Chung and Lee's (2019) study regarding the use of predictive analytics, student privacy concerns were raised as well. Tawfik et al. (2021) also aligns with these findings, as in their study, the participants showed a need for clear policies and the communication of those policies. Wang and Cheng (2021) had similar findings, as they identified "practical complications in privacy, ethical data collection and data protections" as one of their first-order barriers. Also, even outside the context of education specifically, information security issues are a broader concern with AI ethics that has now been discussed for several years (Borenstein & Howard, 2021).

Sometimes teachers also felt that there weren't enough resources available to them. This might have meant physical resources such as a lego spike set they were planning on acquiring, or simply ready made lesson ideas or plans that they could have used. Sometimes the teachers did have the materials they needed, but the technology did not work quite well enough, or there was a language barrier between the user and the software. Similar concerns were identified by studies reviewed by Crompton et al. (2022), as participants talked about the cost of purchases required to implement AI education.

In addition to not necessarily having adequate access to resources, some teachers expressed that their lack of knowledge was a barrier to implementing AI education in their classrooms. For example, teachers might not have known about software they could be utilizing in the classroom, or they might not have been able to understand AI well enough to know how to teach about it. Some of the teachers had trouble coming up with ideas on how to use AI in their classrooms (which could have also been at least partially due to a lack of resources) or felt that they would have needed more concrete examples on how to do it. Other studies confirm that teachers lack understanding and knowledge about AI (Crompton et al., 2022; Wang & Cheng, 2021), but the discovery of a lack of pedagogical knowledge about how to implement AI could be new. Additionally, a lot of these barriers could possibly be removed with the appropriate training, and Tawfik et al. (2021) indeed confirm that a lack of training is seen as a barrier in the implementation of AI education.

Similarly to in Wang and Cheng's (2021) study, time constraints, whether relating to work or school hours, were also discussed. A lot of the teachers felt that there were not enough hours in the day to explore different ways of implementing AI education in their teaching. Some teachers admitted that they did a lot of the work outside of their work hours, cutting the difference from their free time. Other teachers expressed that they could have done more, but they valued their free time over the project's objectives. With teachers having expressed more stress and burnout than other professions (Kauppinen et al., 2010), it could be argued that innovation projects such as these should take teachers' workload and right to free time outside of work into consideration, although to understand how this could be done in practice, more research would need to be done on the topic. On the other hand, for some teachers, this project was not the only one they were working on, and they expressed that they had not given as much attention to this particular project due to the fact that they were working on several projects at the same time.

In addition to insufficient time to prepare and explore AI education, teachers often felt that there was not enough time in a school day to cover eve-

rything important, including AI education. Although the project funded substitute teachers so the teachers part of the project could receive training, the teachers often felt that the substitutes did not lighten the workload much, as they still had to plan the lessons for the substitutes. Many of the teachers also expressed, either outright or more subtly, that AI education was not a priority for them. One of the teachers suggested this might be because of many teachers' heavy reliance on textbooks, which do not yet include AI education. This, too, aligns with Crompton et al.'s (2022) review results, as some of the studies part of the review discovered that teachers saw AI education as a distraction from meeting the learning objectives. Perhaps the culture around teaching is yet to develop into being more open to technology, and teachers used to teaching a certain way are not as open to change as might be expected of them.

Just as Ertmer's (1999) constructs predict, some teachers also expressed the need for more or better quality support either in a school community engagement or an administrational support perspective. Tawfik et al. (2021) also found that more technological support was needed in the implementation of AI education. However, the mentions of support needs were surprisingly low in this study, perhaps due to knowledge being more discussed as a concept than its possible solution, which could have been support and training. Two other relatively rarely, but still occasionally, discussed topics were students and curriculum. More specifically, this included, for instance, the stark differences in the AI knowledge students started with, and concerns about the AI not being a large enough part of the curriculum. Tawfik et al. (2021) also reported classroom management as a barrier to technology implementation, and Wang and Cheng (2021) reported a lack of curriculum guidelines as a barrier to AI education implementation.

The teachers' attitudes toward AI education might have also been a barrier to the implementation process, at times calling AI education "busywork" or "pointless tinkering". Some teachers felt that AI did not bring enough value to their teaching and was therefore not worth implementing. In the results, one of the teachers expressed their thoughts that AI was not a relevant topic in math-

ematics. This might have also been a first-order barrier depending on the perspective: perhaps AI is truly not as relevant in mathematics as it is in other subjects, thus rather creating a first-order barrier of incompatibility with subject. While this is a possibility, other studies have demonstrated that AI can serve as an effective tool in facilitating mathematical learning (Dabingaya, 2022). This suggests that the belief about AI as irrelevant is more likely to be a second-order barrier relating to attitude than a concrete first-order barrier. This kind of negatively biased attitude toward AI was also noticed by Crompton et al. (2022) and Wang and Cheng (2021).

Sometimes it was not entirely clear whether a barrier was a first- or second order barrier in nature. For instance, not having enough time to explore everything in the classroom can be seen as a first-order barrier, but a teacher might be struggling with prioritizing content due to internalized attitudes towards different subjects, such as believing that certain subjects and themes are more important than AI education, and therefore not making time for it and instead leaving it out with the explanation that there was not enough time. For this reason, prioritization and insufficient school hours were closely intertwined in the results, and the decision was made to include them under second-order barriers instead of first-order barriers, while still discussing it from the first- and second-order perspective.

In addition to possibly having a negative attitude regarding AI education, some teachers did not have enough interest, were stuck in routines or lacked the confidence to implement AI education. For instance, textbook reliance and not remembering to include AI education were discussed, as well as a feeling of not being proficient enough either relating to gender or something else entirely. Lack of confidence was also present in Wang and Cheng's (2021) results.

5.2 Study Evaluation

This study utilized semi-structured interviews, a method that offers flexibility and depth, allowing for a comprehensive exploration of the teachers' experi-

ences and perceptions (Tracy, 2020). However, due to time constraints, the interviews were conducted by different interviewers. This use of different interviewers may have introduced some variability in the data generation process since although all of the interviews were conducted using the same protocol, they were semi-structured in nature and each interviewer had a unique interviewing style, which might have influenced the responses of the interviewees. Therefore it is possible that the same information was not consistently obtained from all interviewees.

On the other hand, a strength of this study was its focus on educators of school-aged children. Interviews with early childhood education teachers were excluded from this study because analyzing them would not have contributed to the research questions at hand. Partially due to this exclusion of interviews the study was conducted with a relatively small sample size of nine interviewees. While this may have limited the generalizability of the findings, it is important to note that in qualitative research, it is often more important to explore the phenomenon at hand deeply than it is to have a large sample size (Vuori, 2021a). Thus, the small sample size does not necessarily undermine the value of the study.

One of the key strengths of the research method used in this study was its ability to provide an understanding of the phenomenon at hand beyond quantification. The methods allowed for the investigation of the context surrounding the barriers faced by the teachers instead of simply counting and naming them. Qualitative research, as utilized in this study, allows for the exploration of questions that cannot be easily reduced to numbers (Tracy, 2020). It provides a means to understand human experiences in their richness and complexity. By studying important questions, qualitative research helps answer questions in a more in-depth manner and contributes to our understanding of the nature and characteristics of the world.

Another strength of this study was the relatively unbiased author, as the subject of AI education was relatively new to the author and most of the first

impressions regarding AI education were through scientific research papers read for this study.

5.3 Practical Applications and Further Research

The research may not be one that can be applied widely to the field of AI implementation in education because the focus group in question is a very particular set of teachers enthusiastic enough to join the project. That said, it may still give the Finnish education administration some valuable insights on how to best support the implementation of AI into education, and perhaps act as a stepping stool for future research on the topic. These results could, for example, be used to inform school administrative staff, create training programs or decide where to allocate resources when attempting to implement AI education.

For instance, this study was only conducted using qualitative data. Quantitative data has also been collected using an online questionnaire form, and it would be beneficial to use both datasets to explore the barriers of AI education further and deeper than can be achieved through using only qualitative analysis methods. For example, in this study teacher characteristics were not compared to the barriers encountered. It might, for instance, be discovered that different kinds of educators expressed different kinds of needs. Especially as of the participants brought up gender in their interview, it would be interesting to compare background information, such as gender, to these results. On the other hand, some studies have already suggested that teacher characteristics such as gender, teaching experience and qualification do not affect their intentions to use AI applications in teaching (Al Darayseh, 2023). Moving forward it would be interesting to explore AI education implementation further, especially with objectives to practical applications such as the development of new platforms. One of the teachers in the study suggested the need for applications specifically for the Finnish educational context, to make using applications easier without fear of breaking any information security policies. This could be the next step to making AI education implementation more accessible to all classrooms.

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APPENDIX

Appendix 1. Translated Interview Themes and Questions

Translated Interview Themes and Questions

Theme	Question	Possible Prompts
1		
Background	Which school do you work at?	
	How long have you been a teacher for?	
	How would you describe your thoughts on what interests you in teaching?	
	What kind of background do you have in the use of digital technology in teaching?	
	What kind of background did you have in AI in relation teaching before the project?	
	What got you to join AI project?	What encouraged or helped you to join? Were there any challenges or brakes in joining?
	Could you recount on a general level how you started out on the project at your school?	What did you do after that? Where are we now?
2		
Societal Perspective	How would you describe which factors have enabled or driven forward AI related teaching?	School administration Curriculum Information security policies or other administrative policies Staff at your school People outsdide the school Resources, facilities, infrastructure Teaching group students
	Which factors have challenged you or slowed you down?	… *same as above* How did you overcome the challenges?
3		
Individual Perspective	Could you describe a little what kind of AI education practicer and developer you are in your opinion?	
	And if we dig a bit deeper, is there something special about AI education that mo-	What about the subject interests you or brings joy to you specifically?

Translated Interview Themes and Questions

Theme	Question	Possible Prompts
	tivates you on a purely person level?	Can you take a guess, why these kinds of things motivate you?
	Do you recognize something in the subject that might have decreased the amount of motivation you have for it?	
	How would you describe your own knowledge about AI as a phenomenon or as a subject?	Do you recognize some areas in which you feel you have a strong competence? Do you recognize some areas in which you might still need improvement or learning? Which factors do you overall feel that have brought you more competence? Do you feel that there are factors that have prevented you from gaining competence?
	How would you describe your own preparedness to include AI in teaching?	*… same as above*
	How would you describe your own technical competence related to AI education?	*… same as above*
	What do you think students should be taught about AI?	Could you please elaborate on why these are important things to learn?
	How have you taught these things to students in practice?	
	What kinds of challenges have you faced when teaching these things?	
	If we imagine a situation where you had only a little bit of time to teach a student group about AI, which learning and upbringing objectives would you prioritize?	
4		
Future Plans (Extra)	How are you planning on continuing AI education from here on?	
	What advice would you give a teacher that is trying to grasp AI?	
	Is there anything else you would like to say about the subject?	