An investigation of barriers for elementary school teachers in South Korea introducing Artificial Intelligence (AI) education

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Problem statement

As technology advances, Artificial Intelligence (AI) is being used in various fields of our lives (Paek & Kim, 2021). Governments around the world have made the gradual introduction of AI education a priority in schools (Steinbauer et al., 2021). Following this trend, South Korea is preparing to introduce AI education as a national curriculum from elementary schools to high schools by 2025 (Ministry of education in South Korea, 2020). Prior to South Korea, an increasing number of K-12 schools are planning or piloting their AI education in Hong Kong. However, progress in introducing AI education to public schools in Hong Kong is reportedly slow because of several physical and perceptional barriers considering Ertmer's barrier framework to teachers' technology-integration. (Ertmer, 1999; Wang & Cheng, 2021). Likewise, a full understanding of barriers South Korean teachers may encounter while preparing for AI education implementation is needed but the research on AI education is still in the early stage and lacking because AI education has been actively studied since 2018 worldwide (Paek & Kim, 2021). In particular, elementary schools in South Korea do not yet have a mandatory and separate subject for implementing AI education, and further research related to the barriers is needed. Therefore, it is essential to identify the expected barriers to elementary school teachers previous to the implementation deadline of 2025 considering prior frameworks and practices, allowing the government to develop a successful approach (Wang & Cheng, 2021).

Purpose Statement

The purpose of this study is to identify the overall barriers to elementary school teachers who are implementing AI education as a pilot program in South Korea. Considering Elmer's framework of teachers' barriers to technology integration, there may be several barriers including the physical and perceptual environments teachers may face to introducing AI education. Therefore, this study aims to identify the barriers for elementary school teachers who are working in selected schools to gain insights and references for future progress in AI education rather than a generalized phenomenon.

Research Question

RQ1: What are the elementary school teachers' perceived barriers that are related to the physical environment who are implementing a pilot program in South Korea to introduce AI education in their schools?

RQ2: What are the elementary school teachers' perceived barriers that are related to their perception who are implementing a pilot program in South Korea to introduce AI education in their schools?

RQ3: What are the elementary school teachers' perceived other barriers that are not related to the physical environment or their perception who are implementing a pilot program in South Korea to introduce AI education in their schools?

Literature Review

Artificial Intelligence (AI) Education

The term Artificial Intelligence (AI) was first defined at the Dartmouth Conference in 1956. AI was defined as the engineering and science of creating intelligent machines (McCarthy et al., 1955). As technology is advancing rapidly, AI is being used in many fields. Accordingly, in the research of the definition of AI, researchers defined AI as a technique in the computer science field that uses the principles of human intelligence to solve problems related to cognition and learning (Ma et al, 2014; Wang, 2019). According to research compared and analyzed the definitions of various studies, AI is

defined as a computer system that performs tasks that require human intelligence and is an activity dedicated to making machines intelligent (Chassingnol & Khoroshavin, 2018). Although there is still no clear agreement upon the definition of AI, several implications can be found. The first is that the definition of AI is gradually expanding. This means that the implications of AI education can also be gradually expanded. The second is that AI relates to cognitive task skills for problem-solving. This means that cognitive tasks for problem-solving can be considered in further AI education.

As technology advances, the use of AI in our daily lives and AI literacy will become just as important as classical literacy skills like reading and writing. Since literacy is a fundamental ability to solve high-level problems, it becomes more important to give students with opportunities to become familiar with the basic principles of AI (Kandlhofer et al., 2016; Long & Magerko, 2020; Ng et al., 2021). Long and Magerko (2020) defined the term AI literacy as the competencies to utilize AI well for purposes, communicate with AI to utilize it properly, and collaborate with AI when they use AI to solve problems in life. Current K-12 students will be exposed to more AI as technology advances, and more AI literacy may be required of them in the future (Long and Magerko, 2020; Zawacki-Richter et al., 2019). However, when the students use AI in their daily life, they may not be aware that they are interacting with AI. These may occur misconceptions to AI and limit future students' ability to understand, interact effectively, and use AI (Fast & Horvitz, 2017). Therefore, there is a need for AI education, as this would improve AI literacy. Students can learn to understand, utilize, and evaluate AI through learning about AI. In response to this need, there have been efforts to develop an AI curriculum in formal and informal education for K-12 students and adult learners (Knox, 2020; Steinbauer et al., 2021). Although many researchers have focused on AI utilization in the educational system since 2014, research about AI education for enhancing AI literacy has started to be focused on (Chai et al., 2021). Druga and Ko (2021) verified the improvement of AI literacy through customized machine learning education with mixed research. They found that the AI learning program was helpful in improving AI literacy overall. In

addition, Kong et al. (2021) argued the need for AI education by proving the effectiveness of AI education to enhance AI literacy. In view of the previous research, AI education can be defined as education for AI literacy improvement.

Barriers for Teachers to Introduce AI Education

Even though governments, organizations, and researchers are making efforts to implement AI education for K-12 students, there are barriers teachers can face when adjusting to an AI education initiative. Recent several empirical studies on barriers to teachers introducing technology have been based on Ertmer's framework (Cenk, 2020; Contreras et al., 2022; Hunt, 2022; Wang & Cheng, 2021). Ertmer (1999) divided the barriers encountered in teachers' technology-integration education into first-order and second-order barriers. First-order barriers correspond to physical considerations such as insufficient access to resources, insufficient time, insufficient support, and insufficient policies. Second-order barriers correspond to perceptional considerations such as teacher attitudes, beliefs, and self-confidence. Wang and Cheng (2021) investigated the barriers to incorporating AI education for K-12 schools in Hong Kong based on Ertmer's barrier framework. The authors conducted qualitative research by conducting ten semi-structured interviews for teachers in two different schools in Hong Kong. They found that there were physical and perceptional barriers to introducing AI education for teachers in two schools. Therefore, expanding Wang and Cheng's research, physical and perceptional considerations that teachers can face when introducing AI education can be analyzed based on Ertmer's barrier framework for overall K-12 teachers.

First, Heintz (2021) and Vazhayil et al. (2019) conducted research about physical considerations for introducing AI education to teachers. The authors pointed out the need to improve professionalism through teacher training. Heintzs (2021) interviewed three experts in AI education from the United States, Singapore, and the European Union. The three experts acknowledged the efforts of the government and individuals to introduce AI education in each country but pointed out that the efforts to

enhance the professionalism of teachers were insufficient. This means that a teacher training program is needed to improve teachers' expertise in AI education, indicating that the AI4K teacher education program in Singapore can be referred to. Vazhayil et al. (2019) conducted semi-structured interviews with 34 teachers for investigating barriers to introducing AI education. The author found less than 25 percent of in-service teachers have empathized with the need for teacher training and pointed out that teacher training for AI education was necessary as a result of the interview. The study of Kim et al. (2021) supports the need for teacher training based on the frameworks of Technological Pedagogical Knowledge (TPK) and Pedagogical Knowledge (PK). The authors analyzed the curriculum and resources for AI education in the United States, Australia, China, India, and South Korea. Based on the analysis, they proposed the competency that teachers should have to implement AI education. The authors suggested that teacher training for AI education needs support for increased teacher professionalism considering not only the content elements of AI but also the pedagogical elements. Wang and Cheng (2021) conducted qualitative research by ten-times semi-structured interviews with the teachers in two different schools. They pointed out that there have been insufficient curriculum guidelines, insufficient learning tools, insufficient meticulous systems and manpower, insufficient time, and low user-friendliness of AI education platforms for physical considerations to introduce AI education for teachers.

To introduce AI education to K-12, it is necessary to consider physical considerations, but perceptional considerations cannot be omitted. Fast and Horvitz (2017) performed text corpora analysis through crowdsourcing method on public perception of AI that appeared in New York Times articles from 1986 to June 2016. They found that the discussion of AI has grown steadily and that optimism over pessimism prevails. However, they argued that fears from AI-induced loss of control and lack of ethics still exist in public perception. Teachers who teach artificial intelligence can be the same as this analysis. Preconceived notions such as negative perceptions or fear of AI cannot lead to proper AI education for

K-12 teachers and may account for the difficulties teachers face. Lindner and Berges (2020) conducted semi-structured interviews with 23 teachers to analyze teachers' preconceived notions about AI and their impact on education. The authors discovered that preconceived notions could interfere with proper AI education. Sanusi et al. (2021) conducted semi-structured interviews with 12 African computer science teachers and found that the teachers agreed on the necessity for AI education but had preconceived notions about the concept. Since the participants did not have opportunities to get proper AI, they had preconceived notions about AI. These preconceived notions interfered with teachers' confidence to teach AI to their students. In addition, teachers were not perceptually prepared for AI education to their students because they met AI from media and tended to understand AI superficially (Lindner et al., 2019). Wang and Cheng (2021) pointed out the perceptional considerations in their qualitative research that there have been misconceptions of AI and low confidence in AI education for K-12 teachers in two different schools in Hong Kong. Chiu and Chai (2021) conducted semi-structured interviews on AI education with self-determination theory with 12 teachers with AI education experience and 12 teachers without AI education experience. The authors found that the teachers had a motivation for AI education because they sympathize with the need for AI education, which can be continuous to integrate them into professional development activities. This suggests that efforts to reduce perceptional considerations for K-12 teachers would be effective to introduce AI education.

Conceptual Framework

Ertmer (1999)'s framework is widely used as a framework for recognizing teachers' barriers to technology integration. Her framework takes into account not only individual barriers for teachers but also systemic and institutional factors as a whole. The first-order barriers encompassing physical barriers include the physical environment surrounding teachers, such as the lack of access, resources, and time. The second-order barriers encompassing perceptual barriers can help teachers to comprehensively understand the barriers they may face in technology integration and contribute to a holistic

consideration of their improvement that is related to the perceptual environments such as beliefs and attitudes and self-confidence within teachers. Since AI education is still in the early stages of research, it is necessary to consider these barriers as a whole, so Ertmer's framework can serve as a lens for a holistic perspective in this study as following Fig. 1.

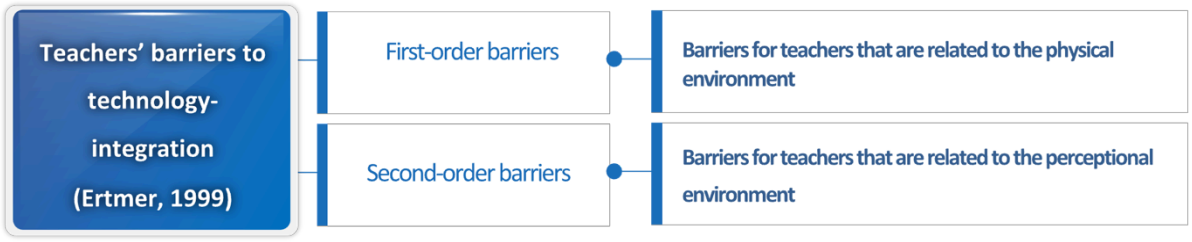

Figure 1. Conceptual framework

Methods

Research Design

This study will employ a qualitative case study. Miles, Huberman, and Saldaña (2014) describe the case as a kind of phenomenon that occurs in a limited context (p. 28). Accordingly, this study will consider a few cases in which schools are piloting AI education. In addition, researchers have to purposively select cases from which they can learn the most (Creswell, 2014). Therefore, case studies will be conducted with elementary schools that are implementing pilot programs for AI education considering the context that a few schools have been selected as pilot schools for AI education by the government and are operated in South Korea.

Context

In this case study, two criteria were established to select the appropriate cases for AI education. The first criterion is the public elementary school in South Korea because the public schools are following the national curriculum. The second criterion is identifying elementary schools that are implementing AI education as a pilot program, and are selected as a pilot school for AI education. Since the pilot schools

have been selected by the government, the list of the schools is open to the public. Considering these two criteria, a peer-recommendation strategy was employed to select for appropriate cases.

Two elementary school in South Korea, named School A and B, was selected for this study. School A was established in 2016 as a public elementary school and has been operating an AI education pilot program for the second year under the topic of operating an AI education activity model. This school has a history of operating various pilot programs such as software (SW) education and digital textbooks since its opening. Therefore, this school can be an appropriate case to focus on the barriers to operating AI education itself rather than the difficulties of operating a pilot program.

School B was selected as additional appropriate case for this study. School B was established in 2021 as a public elementary school and has been operating AI education pilot program for the first year under the topic of establishing an information education lab for AI education. This school has started to pilot the EdTech modeling continued with the AI education pilot program. Therefore, this school can be appropriate for this study in terms of implementing AI education in a pilot school.

Participants

Data will be collected from the two different schools with a total of four individuals in Spring 2022. All four will be elementary school teachers teaching their students including AI education. The description of the interviewee will be followed in Table 1.

Table 1. Demographic of the interviewee

No.	School	Gender	Teaching experience in years	Teaching discipline
Teacher 1	School A	Male	11	All
Teacher 2	School A	Male	11	All
Teacher 3	School B	Male	12	All
Teacher 4	School B	Female	5	All

Data Sources

For this research, semi-structured interviews will be conducted for individuals. All interviews will be conducted virtually by researchers using video conferencing tools, taking into account physical distance between the United States and South Korea. Each interview will last approximately 30 minutes. With the participant's permission, a video interview will be recorded, and every process will be saved in the encrypted drive. Since the language used in the interview will be the local language, Korean, the interviews will be transcribed into a word processing program and translated into English. Guiding questions will be about difficulties and barriers to conducting AI education they may perceive. The follow-up interview will be followed by additional questions about parts that need further clarification from the previous interview.

After interviewing the participants, additional data will be collected by teachers' reflection papers. Teachers will be requested to submit their reflection papers on their overall experiences of AI education. This data can be collected in the form of online survey with open-ended questions. This data also can be translated into English.

Data Analysis

The researchers will use the strategies of open coding and axis coding for data analysis. This analysis is fundamentally based on Ertmer's framework of teachers' barriers to technology-integration. The transcriptions of the interview and reflection papers will be sorted and organized in a spreadsheet software to analyze the data according to the following steps.

Step 1

Considering the participants' first language, the transcribed interview data and reflection will be translated to English. The translation process will be peer-reviewed and double checked by the co-researcher. Both versions of the transcripts will be organized in a spreadsheet. After reading all the transcripts and papers, if there will be any ambiguity part in the meaning, additional interviews will be

conducted to clarify the meaning. After that, the annotated note will be left to each part for the next step.

Step 2

The open coding techniques will be used to group and categorize each annotation by criteria. The criteria is based on Ertmer's framework. If additional barrier elements that are not classified in the framework will be found, a separate standard will be able to be established. This coding analysis goes through triangulation with other researchers, cross-reviewing each other until satisfied. The coding scheme for axial coding is elaborated on following Table 2.

Table 2. Coding scheme for axial coding.

Framework	Code examples	Description
First-order barrier	Infrastructure	The lack of lab or classroom environment such as lab and devices.
	Curriculum	The lack of the curriculum
	Resources	The lack of the teaching materials including teacher's guide, textbook, tools, and so on.
	Time	The limited time to teach
	Access	The limited access
	Etc.	Barriers that are related to the physical environment.
Second-order barrier	Confidence	Lack of confidence
	Misconception	Having a misconception of AI
	Burden	Having a burden to teach new thing
	Etc.	Barriers that are related to the perceptional environment.
New criteria	If additional barrier elements that are not classified in the framework will be found, a separate standard will be able to be establishment.	

Step 3

After every code has been analyzed and classified, barriers will be identified by similar themes. In this process, researchers review each other for barriers that are not classified as first-order barriers or second-order barriers. This review will allow the researchers to incorporate codes into existing criteria or create a new one. After this classification will be complete, it will be discussed in the next chapter, the findings and discussions.

Credibility & Trustworthiness

This study will consider both credibility and trustworthiness. First, when selecting an appropriate case, the researchers will exclude competing for financial interests or personal relationships that could affect the research. Second, all interviews and data analysis will be conducted with co-researchers and the triangulation will be processed iteratively. In terms of the triangulation, researchers will conduct methodological data triangulation by collecting and analyzing both interview data and teacher's reflections. In addition, investigator triangulation will be conducted when translate the interview transcripts in Korean to English and conducting open-coding processes. Fourth, all data sources including the transcripts as an audit trail, and the results of classified axes coding will be provided as a thick description to the appendix after anonymized to protect the privacy of the participants.

Limitations

This study may have the following two limitations in research on AI education considering it is still in the early stages of research even though a lot of governments, organizations, and researchers are making efforts to implement AI education in K-12 worldwide. First, AI education is still in the stage of preparation for 2025 in South Korea, and it has limitations as it is not a study on the completed and confirmed curriculum of AI education. Nevertheless, this study can contribute to expanding the understanding of the future direction for AI education led by the limited number of cases of AI education pilot schools. Second, this study is a qualitative case study to identify the barriers derived from the

operation of an AI education pilot school, and it is difficult to generalize to other pilot schools operating in other contexts. Therefore, in future quantitative research, it will be possible to conduct research related to whether the barriers identified in other schools are consistent or correlated based on the barriers identified in this study.

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