DEVELOPMENT OF PRESERVICE MATHEMATICS TEACHERS' AI LITERACY: "I'M A MATH TEACHER, SO WHO ELSE IS GOING TO TEACH ALSO ABOUT THIS?"

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Preservice secondary mathematics teachers' AI literacy is important because they can help secondary school students develop effective AI literacy. This study investigates how preservice secondary mathematics teachers have developed their own AI literacy for their future career throughout a Master's level course in Finland that focuses on AI-related mathematics, coding, ethics, teaching implementations and attitudes. Interviews with 4 preservice secondary mathematics teachers revealed that participants benefitted from the course experiences and enhanced their AI literacy, and built connections between different components of the course. Findings indicate that training preservice mathematics teachers for AI should address their AI literacy and mathematics-specific elements that could be brought to the mathematics classrooms.

AI LITERACY AND (PRESERVICE) MATHEMATICS TEACHERS

As the Artificial Intelligence (AI) continues to develop at a notable pace, its usage in education has gained increasing attention. Research indicates that AI has been used in mathematics classrooms in order to improve students' learning outcomes and its effect increases as the students' school level increases (Yi et al., 2025). In addition to mathematics learning outcomes, it is important that secondary school students develop an effective understanding of key AI concepts and some technical AI elements, which are parts of AI literacy, to support their future studies (Ng et al., 2024). This, in return, requires preservice teachers to develop their own AI literacy (Carillo et al., 2025), which is essential for navigating in the rapidly evolving AI landscape (Laru et al., 2025). Yet, research on how preservice teachers develop AI literacy to ensure their own and their students' effective engagement with AI remains limited (Ng et al., 2023a), particularly in the context of preservice secondary mathematics teachers.

AI literacy in teacher education is a comprehensive, dynamic and contextual concept with interdependent dimensions and disciplines of *understanding of AI* (having the technical and critical knowledge of AI and its use); *pedagogical integration* (employing AI to design and implement teaching effectively); *affective readiness* (holding favourable attitudes, confidence and resilience about AI); and *ethical awareness and advocacy* (having the critical understanding of implications of AI for teaching and society) (Carillo et al., 2025). AI literacy is widely regarded as critical AI tools are more embedded into society, requiring individuals to develop the knowledge and skills needed to engage with AI responsibly and effectively (Laru et al., 2025).

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Teaching about AI literacy requires teachers to learn more about machine learning and natural language processing (Ng et al., 2023a). They should also be aware of the use of AI as a tool as well as the ethical concerns that AI brings into education and everyday life (Ayanwale et al., 2024; Laru et al., 2025). However, training preservice teachers for AI literacy is a complex process because each subject has its own literacy which may interact with AI in different ways (Stenberg et al., 2025). Thus, utilizing AI does not necessarily result in preservice teachers' recognizing and creating meaningful AI implementations (Ayanwale et al., 2024) especially within specific subject areas.

Recent studies indicate that preservice teachers have several concerns about the use of AI in teaching (e.g., Gamlem et al., 2025). Although AI literacy courses aim to address these concerns, many preservice teachers are still worried that AI may replace teachers and harm students' critical thinking even after participating in structured AI literacy training (Hur, 2024). Given that many in-service teachers also lack the technical, pedagogical and ethical knowledge and skills to use and teach AI effectively (Ng et al., 2023b), training preservice teachers for AI literacy is important, not only for preparing AI-literate teachers but also fostering broader twenty-first century skills relevant to both future teachers and students Therefore, well-designed AI literacy courses are essential for equipping preservice teachers with these skills.

The "AI for Teachers" (AI4Teachers) course was the first teacher training initiative in AI in Finland and–even one of the earliest of its kind globally–developed and offered at the Department of Mathematics and Statistics at the University of Turku in Spring 2022, right at the beginning of the AI literacy era (Ng et al., 2023a). It was designed as a master's level course for preservice teachers which introduced them a wide range of technical elements of AI to help them employ and use AI effectively and creatively in their careers. The course targeted the AI literacy components with a more foundational approach and in a more data-driven way by focusing on: (i) mathematical foundations of key modern machine learning methods; (ii) coding and training machine learning models both of which aimed to increase the *understanding of AI*; (iii) ethical dimensions of AI to help preservice teachers develop *ethical awareness and advocacy*; and (iv) strategies for teaching about/with AI in the classroom to help them develop ideas for *pedagogical integration*. The course aimed to develop preservice teachers' *affective readiness* by discussions and providing them with experiences of building and training models and deal with concrete problems. The course language was flexibly English, Finnish and Swedish allowing all course students to ask questions to the instructor in the language they felt comfortable and the instructor to answer in different languages to make sure all students have understood the question and the answer.

The present study focuses on preservice secondary mathematics teachers' AI-related experiences and aims to provide insights for the courses designed to enhance preservice teachers' AI literacy by answering the following question: How does AI4Teachers course help preservice secondary mathematics teachers build their AI literacy?

METHODS

The study was designed as a case study (Creswell & Poth, 2018) which explored how preservice secondary mathematics teachers developed their AI literacy in the AI4Teachers course. The course was offered in Spring 2022 and Spring 2024 at the time of the study, and the data were collected in Fall 2024.

The course instructor (second author) sent emails to former course students (N=13) who took the course in 2022 and 2024 and asked if they would like to volunteer for a study exploring their experiences of the course. A total of 8 former course students volunteered and the study focused on 4 preservice secondary school mathematics and physics teachers (all males, referred to as P1, … , P4) who took the course in 2024. P1 was doing his master's degree on optimization, P2 and P3 on mathematics, and P4 on physics. Participants were working as substitute teachers at high schools when needed.

Data were collected by a semi-structured interview protocol of 28 main questions about participants' background, experiences and opinions about AI before, during and after the course, their experiences about specific course components, their AI skills, and views about AI at schools, prepared by the first and second authors. Follow-up questions were asked based on responses. In-person or remote one-on-one interviews were conducted based on participants' preferences. They were sent consent forms and information about the study via email, and they all consented for the study and recording of interviews. Interviews were conducted by the first author and lasted about 40-100 minutes. The communication and interviews with the participants were in English, which was not the mother tongue of the researchers and participants.

All interview recordings were transcribed verbatim. Then, the first author read the data set once to understand what the participants emphasized and noted potential codes. She developed a draft list of codes in the next reading. Then, she refined these codes in the third reading and used them to code the data set. The first and second authors discussed the codes and coded data by focusing on specific course experiences (such as training machine learning models) and how these experiences might have developed participants' AI literacy throughout the course. The findings documented participants' AI-related experiences and resulting ideas before, during and after the course.

FINDINGS

Before the course

Participants had limited experience with AI and coding before the course. In addition to the basic IT courses as part of their studies, P4 took an introductory course in AI; P1 reported using AI in daily life; and P1 and P3 had some prior coding experiences. Participants expressed varied ideas on AI and its usage. Some perceived AI as a useful tool and emphasized that it is important to learn about (P1, P3); whereas others viewed AI as potentially misleading (P4) or as a complicated and even mysterious phenomenon (P2). Overall, they all used AI mostly in their daily lives.

Participants enrolled in the course for multiple reasons, including a desire to understand "*the mathematics behind AI*" (P2), intentions to use AI in teaching in the future (P1, P4), general interest in the topic (P1) and practical considerations such as alignment of this course with their schedules and studies (P2, P4). In addition, some participants expressed a specific interest in teaching about AI:

> I want to know more because, well, again, I'm a math teacher, so who else is going to teach also about this? (P3)

> I think we as teachers should really talk more about it, how to use this, what it is. (P1)

Overall, participants were interested in AI and its use in teaching before the course despite having limited experience with AI. They were expecting that the course will help them teach about/with AI and understand what is behind AI (P2, P3, P4).

Course experiences

Participants experienced the four course components in different ways and they often highlighted two components as particularly useful. P3 noted that the course was effective with all its components. They also emphasized that in-course discussions supported their understanding of key concepts and development of their ideas. P1 and P2 addressed the mathematics and teaching components of the course useful:

> In the eyes of a teacher, I think [...] the most important thing when teaching about AI, like what it is and how we should use it in our classrooms. (P1)

The coding component was described as important to learn by P2 and P4.

> The programming was the most important. The first programming exercise was the most important because then you really got the feel… that it's actually just math. (P2)

> I feel like the coding part was the most fun part. [...] I feel like it was also the most useful because now I have something, hands-on experience of simple demos about AI. (P4)

Ethical considerations were also emphasized by some participants. P2 stressed ethics several times during the interview in relation to teaching about AI.

> And then as soon as the course started, I have also become very invested in the ethics behind AI and the applications. (P2)

Yet, the same course components were not experienced as equally useful by all participants. P4 perceived the ethics component as brief and not providing new ideas. In addition, P1, P2 and P3 considered the coding component was necessary at a basic level to learn more about AI, but not very useful at a more advanced level.

> I think the coding part is really necessary to make this understandable as a whole thing. […] I did all [assignments] and I understood everything, but it's not really necessary for school teachers to have this big coding machine learning part or like unsupervised learning and supervised learning and things. (P1)

Participants experienced difficulties with some of the components. P4 had some difficulties in the mathematics component, whereas P1, P2 and P3 had difficulties in

the coding component in line with participants' differences in prior experience or background. In addition, they indicated that there should be more of the teaching component to help them with the ideas and tools to teach about/with AI.

> It would be really useful if we had more classroom stuff, like basically planned lectures that we later could use in our classrooms. Like, I would love to see a gymnasium course in AI, which would implement mathematics, philosophy. (P1)

> It would be quite useful to have more of this didactic stuff. But like, to actually plan a course around this topic, that would, in my opinion, be something that would be very useful. (P3)

Participants benefited from different course components depending on their interests and prior experiences. P2 expressed that it was good to have multiple components because it was possible to focus on the component of interest. They indicated that their expectations about what to learn from the course were largely met and they would like to learn more about teaching about and with AI.

After the course

Participants were more interested AI-related topics after the course. Understanding the nature of AI was eye-opening for them. They indicated that their AI-related knowledge and skills increased after the course.

> Seeing just how this stuff works in practice and seeing the math behind it […] that this is quite simple math but with a lot of iterations and a lot of calculating power. (P3)

> I think I have quite a good understanding of the mathematics behind it. I'm still not very good at coding and creating my own algorithms or machine learning but that was never for me the point. The point was to understand the mathematics behind it and to have the skills to teach about how this works. (P3)

However, they were cautious and critical about its use in general and at schools.

> I think people are starting to realize that maybe AI has specific uses, whereas you can't use it for everything, or it creates problems if you try to use it for everything. (P2)

P1, P2 and P4 stressed that they could use AI to produce ideas and teaching materials, such as preparing quizzes for the students. P1 suggested using it as an assistant.

> If I have this class with, let's say, 35 students, and I can't help everyone at the same time, like if they are struggling with some tasks, and I think they could ask the AI, maybe it helps, maybe they understand something. (P1)

Participants also had ideas about how to integrate teaching about AI to other courses. For P4, "*help[ing] the students use it efficiently and in a proper way that helps their learning*" was a key priority, emphasizing the importance of responsible and pedagogically grounded use. Participants had several ideas regarding what should be taught about AI to the students. While the connection to mathematics was mentioned, ethical considerations were also strongly emphasized.

> I still see that there would be so much room for us to teach people how this thing actually functions and what could be the applications and what definitely are not the applications for this kind of stuff. [...] And it could also be a very good gateway for people to learn math. That is also something where I see the potential, because once you kind of connect the AI and the math, you kind of get this very clear picture of both of them. (P3)

> I mean, how to use it isn't that difficult, but knowing what's going on, that's the thing that they should learn from someone or from somewhere other than the tool itself…they should also be aware of how the information is being gathered or formed. (P4)

P1 and P2 planned and taught a lesson about AI at the high school where they worked as substitute teachers. They used an idea from the AI4Teachers course and developed it into a lesson where they guided students to train an AI by using everyday objects and develop conclusions. Their lesson illustrates how participants translated course ideas into concrete classroom practice by integrating conceptual understanding, ethical considerations and hands-on student activities.

> The basic understanding of AI and then some different situations where AI is used, both in everyday and in society as a whole. And then, a discussion on where it could be used, potentials and a lot of risks with AI and then, we ended the lecture with the students getting to train an AI on their own. So, like the discussion part where [we] talked about the [...] self-driving cars, computer games, social media, and like. And then we tested ChatGPT in different ways, where it is very good and where it has some flaws. And basically, just talked about machine learning, very short. (P1)

DISCUSSION

The study investigated how AI4Teachers course helped preservice secondary mathematics teachers build their AI literacy by exploring their AI-related experiences. Participants' experiences prior to the course were mostly limited to everyday uses of AI, but they were primarily motivated to learn about the mathematics behind AI rather than its use for teaching. This motivation seemed to be maintained throughout the course and contributed to the development of their *understanding of AI*. Although coding tasks were challenging, they helped strengthen participants' understanding of AI. Participants also developed ideas about the *pedagogical integration* of AI for teaching about/with AI. Their understanding of AI seemed to be related to the mathematics-specific pedagogical integration of AI, addressing the subject-specificity in AI literacy (Stenberg et al., 2025), not only in terms of using the appropriate AI tools for teaching but also in connecting the nature of AI and mathematics. It seemed that the more they developed an understanding of AI and learn about the mathematics behind it, the more favourable attitudes they developed to teach about/with AI as they were curious about learning more and utilizing it, addressing the *affective readiness*. They also developed *ethical awareness* and more critical views on using AI and articulated ideas about how to reflect this awareness to teaching about AI.

These findings also address that AI literacy components are interdependent (Carillo et al., 2025) and should be addressed in teacher education and research in relation to each

other, where subject-specificity should also be acknowledged as an important element within these components. In the case of the AI4Teachers course, participants benefited from the course components addressing AI literacy in different ways reflecting their background and interests. They were curious about the mathematics behind AI, addressed the advanced coding tasks as difficult, wanted to learn more about classroom applications and asked critical questions about ethics in different ways. Yet, they thought that all components were necessary at least to some extent. Therefore, it is important that courses targeting preservice mathematics teachers' AI literacy should balance these course components and targeted course experiences should explicitly support connections across components, given their interdependent nature.

The importance of AI literacy for secondary school students (Ng et al., 2024) and the connections between the nature of AI and mathematics emphasized by our participants raise questions about whether mathematics teachers should teach *about* AI in secondary mathematics classrooms to develop students' AI literacy and how preservice mathematics teachers' AI literacy should be enhanced for this task. Our participants viewed AI literacy elements suitable topics of secondary mathematics lessons and P1 and P2 even designed and implemented a related lesson at a school where they worked as substitute teachers. This suggests that the connection between AI and mathematics may have motivated them to design such instruction. Additionally, participants' mathematics background enabled them see AI both as a context to teach mathematics and an application of mathematics concepts. Thus, secondary mathematics classrooms could be important spaces for advancing students' AI literacy in the near future. It should be kept in mind that the issues of secondary mathematics teachers' workload and the curriculum constraints are beyond the focus of this study. However, we can argue that preservice secondary mathematics teachers should be prepared not only to utilize AI for teaching but also to address AI literacy components in their future career. On the other hand, enhancing AI literacy of secondary school students may require a more multidisciplinary approach (Ng et al., 2024), for which preservice secondary mathematics teachers should be prepared to collaborate with teachers of other subjects.

The findings of this study are limited to the scope of the interview protocol, participants' reported experiences and the language used in the interviews. Future studies should investigate preservice and inservice secondary mathematics teachers' AI literacy with larger samples and in relation to additional knowledge and affect constructs which were not addressed in this study. Although the course instructor is one of the authors, we believe that his observation of the students' experiences during the course together with the first author's critical questioning about these observations from an external perspective helped strengthen the credibility of the findings. Meanwhile, the third author, who enrolled in and completed the course in 2025 after the study was conducted, provided an internal view that supported a deeper exploration of participants' course experiences.

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