Instructors' perceptions about teaching machine learning in high school: a first step

Salsuhaida Sulaiman[1], Halida Yu[1], Norshila Shaifuddin[1], Faten Najwa Zamani[2], Mohd Norazmi Nordin[3]

[1]Universiti Teknologi MARA, Malaysia

[2]The University of Sheffield

[3]Faculty of Education, Universiti Kebangsaan Malaysia

Article Info
Page Number: 1667-1684
Publication Issue:
Vol. 71 No. 3 (2022)

Article History
Article Received: 12 January 2022
Revised: 25 February 2022
Accepted: 20 April 2022

Abstract
In today's world, schools all around the world are beginning to see the need of including machine learning curriculum. Teachers' understandings of machine learning remain largely unexamined, despite the growing interest in the topic. Twelve in-service teachers were asked to provide their early thoughts on how to approach teaching machine learning. We used phenomenographic methods to analyze teachers' perceptions about teaching machine learning in K-12 settings. Twelve high school (grades 1–12) computer science teachers from selected countries participated in semi-structured interviews. There were five main themes that came out of the semi-structured interviews: supporting students in developing their technical knowledge; understanding the concept; focusing on professional development practices; contextualizing instructional resources; and ensuring the sustainability of development goals. Techniques, strategies, and long-term sustainability connected to classroom implementation are all a part of the package here. This study's results suggest that existing machine learning approaches should be taught to in-service teachers. As a key component of integrating machine learning in the classroom, creating resources with teachers and students is critical. When teachers assist students in putting machine learning into context, it may have a tremendous impact on society.
Keywords: Instructors, machine learning, high school

Introduction

Machine learning research trends and gaps

There are several opportunities, problems, and potentials in teaching and learning that have been opened up by the rapid advancement of technology (Chen & Tsai, 2021). Emerging technologies like Artificial Intelligence and Machine Learning have created new problems in comprehending its usage, application, and inner workings (ML). Human decision-making is increasingly supported by AI algorithms and systems, which have begun to automate routine jobs. There are many new responsibilities that come with AI, such as the development of new ways to produce future knowledge workers that can engage successfully with AI and ML technologies, which will need a new set of skills. Researchers, practitioners, and educational stakeholders have made a concentrated effort to produce tools for teaching machine learning (ML) to K-12 students.

The American Association for Artificial Intelligence Advancement and the Computer Science Teachers Association created an AI curriculum for K-12 pupils (CSTA). Growing numbers of tools and activities assist people understand AI and machine learning. This includes curriculum and tool design, implementation, and evaluation. Only a few research have focused on instructors' roles in teaching and learning using AI/ML. Only a few research, such as Edwards et al., have examined how AI knowledge may aid computer science professors in Germany (2019). Also, Sanusi et al (2022) studied German teachers' AI preconceptions. Di Vaio et al. (2020) and Tatar et al. (2021) studied teachers' opinions on AI education and co-designed AI curriculum. But these studies can't show how AI and ML are viewed globally. AI has been explored in various subsets and applications, but ML has been the focus. Only one study (Su et al., 2022) looked at Machine Learning with K-12 instructors, assessing an ML tool for teaching ML. This study tries to explore how high school teachers interpret machine learning (ML). Not many research have been done on what teachers believe and do. Without teacher buy-in and understanding of their own situations, implementing the course would be challenging (Tatar et al., 2021). In computer education, context affects teaching and learning, adding relevance and meaning to concepts. Article presents phenomenological study on computer science teachers with diverse teaching backgrounds. In prior study, phenomenography was utilized to investigate instructors' views on mobile learning (Chen & Tsai, 2021), e-learning, online teaching, cloud-based applications, and ICT integration (Scherer et al., 2018). In this work, phenomenography is utilized to compare teachers' machine learning assumptions and opinions.

Educators' views on how students learn in computer education

Teaching and learning conceptions have long been seen as critical to effective methods of instruction. To put it another way, research has shown that instructors' views of the world may have a major impact on their teaching methods. (Yin et al., 2020). Teachers' concepts and techniques have also been connected, showing a functional link between conceptions and actual teaching practices. There is also evidence to support the idea that instructors' ideas about certain topics have a significant impact on their classroom practices and the effectiveness of their instruction. Teachers' conceptions, as stated by Yin et al. (2020) and others, are a multilayered construct that may have difficult or even conflicting effects on their teaching methods. As a result, it is critical to investigate how instructors see machine learning as an independent topic (Tatar et al., 2021) or as part of a national curriculum. Computer-based learning subjects and cognitive approaches that are likely to influence teachers' decision-making should be included in teachers' concepts of students, class, society, and emotions (Yin et al., 2020). There has been a considerable lot of investigation into how instructors see their own teaching methods.

It's imperative that instructors' perceptions about teaching machine learning be examined in a research study for many reasons. It is clear that machine learning cannot be omitted from the development and integration of machine learning into the mainstream educational curriculum based on the rapid spread of machine learning in recent years. This is exemplified by earlier studies, which show that the available teaching materials for machine learning are generally used in conjunction with or as stand-alone courses that are difficult to adapt to different educational settings (Tatar et al., 2021). This means that adopting an international or western-centric approach may not be sufficient. Teachers must first believe in the importance of teaching ML to young pupils and understand the same as Tarchi et al. (2022) asserts, that the engine of beliefs is the one that drives instructional pedagogy.

Teacher education is affected because teachers have ideas about teaching ML. As ML education is new to K-12, teachers' biases may impair their ability to teach ML concepts. These lecturers' prior thoughts must be studied. In the fourth industrial revolution, computer science and engineering will be vital. Despite the importance of AI and machine learning, computer science has a gender gap, low minority student participation, high dropout rates, and poor retention. Complexities in computer science teaching need distinct strategies and methodologies to comprehend and assist students learn. Computer science is believed to be harder than other learning sciences, hence teachers' judgments will differ. The ideas that students develop while studying computer science are important, but the ideas that teachers develop should not be overlooked in computer science education. We also need to understand more about our teachers and their expertise with machine learning. A phenomenographic approach within an interpretative paradigm was used to get a better understanding of instructors' preconceptions about machine learning and the impact it has on classroom instruction. Interventions may be developed or changed to address individual requirements and context awareness with a better knowledge of educators to drive the teaching and learning process of the growing idea in schools.

Specifically, this study seeks to answer the following research question:

What are the perceptions of instructors in the field regarding teaching technology in schools?

The importance of researching the viewpoint of educators cannot be overstated. Teachers in K-12 computer science (CS) have too frequently been forced to teach CS subjects without enough consideration for their viewpoint. Even though their knowledge of machine learning is currently limited, getting these educators' perspectives on the newly developing machine learning idea can help it be used in schools practically. Contextual influences may be expected on teachers' assumptions about machine learning in schools, since instructors' behaviors are impacted by elements such as setting. Technologies of Information and Communication (ICT) have seen rapid development (ICT). There is a significant disparity in Internet availability and use throughout Africa. In the same way that ICT is gradually being included into the fundamental educational level in schools, the ML idea will soon be adopted since it is a worldwide project. Machine learning courses will soon be required for certain CS professors, so be prepared. For many years, schools have struggled to teach computer science or ICT due to a lack of resources, including infrastructure and equipment, competent instructors and permanent technical support workers, among other issues. Because of the current status of computer science education, instructors' perceptions of a novel computing paradigm will be affected.

The theoretical foundation as well as the relevant research

Technical pedagogical subject matter expertise (TPACK)

Technology-enhanced teaching methodologies have been addressed since Seufert and colleagues (2021) established the phrase "Technological Pedagogical Content Knowledge." TPACK also describes instructors' capacity and knowledge to use technology in the classroom. According to Lachner et al. (2021), TPACK is a seven-factor concept that describes instructors' use of ICT in the classroom. Schmid et al. (2020) suggest TPACK integrates technical, pedagogical, and topic knowledge to incorporate ICT into the educational process. To utilize ICT to teach K–12 machine learning, instructors need three new constructs: technical content knowledge, technological pedagogical knowledge, and pedagogical content knowledge.

An educational program's ICT curriculum may be structured in accordance with the framework of TPACK. Secondary computer science teachers' professional development on teaching using technology is also supported by this research. As Seufert and colleagues (2021) found, the TPACK framework may be used to evaluate what teacher competences are needed to teach AI using technology successfully. The research suggests that instructors who teach AI to kids in grades K-12 need TPACK in order to build, prepare, and manage project-based lessons that use AI technology to solve issues. TPACK is more effective when used in context, according to Lachner et al. (2019). Researchers used past results to develop a framework for exploring how instructors perceive machine learning. It has been proposed by Lachner et al. (2021) that instructors' perceptions of themselves as highly adaptable professionals with pedagogical values of technology in regards to teaching new ideas or topics are crucial and may impact their methods as teaching progresses.

Lachner et al. (2021) suggested seven TPACK constructs that are appropriate and may be utilized in the context of teaching machine learning:

1. Knowledge of how to use computers and associated machine learning technologies is known as "Technological Knowledge."
2. The second is pedagogical knowledge, which is the ability to educate students about machine learning while also addressing their unique learning styles.
3. Subject-matter expertise in machine learning and related ideas in artificial intelligence (AI)
4. For example, utilizing a web-based application on a computer to do machine learning is an example of technological content knowledge.
5. Pedagogical Content Knowledge is the ability to convey and explain machine learning in a manner that others can comprehend.
6. Technical Pedagogical Knowledge: knowing how technology, such as asynchronous discussion boards, may support cooperative learning. TPACK is knowledge about how to teach machine learning using pedagogy and technology.

Seven TPACK components highlight the professional abilities needed to teach machine learning using technology. Since machine learning is data and ICT-intensive, educators must comprehend and apply TPACK. This research examines in-service teachers' views on machine learning.

Artificial Intelligence and teacher education

Machine learning may help solve society's toughest problems. Machine learning can be taught in classrooms, despite AI's scary mechanics. ML helps kids build confidence and passion in computers. ML isn't widely recognized across nations, despite increased demand. It's in Israeli high school computer science curriculum (Haenssle et al., 2018). Teacher candidates teach any K-12 topic. Teacher education includes elementary and secondary school curricula. Teacher education strives to generate adaptable instructors.

K-12 machine learning education is evolving and extensively employed in higher education, but most teacher education programs haven't kept up with instructor training. Machine learning is unusual in K-12 teacher education. Some schools teach machine learning in their standard technology integration course or in a separate course. An Israeli university's MTCS programme now includes machine learning. The machine learning curriculum teaches methodology and content, reports said (Haenssle et al., 2018).

No pre-service machine learning program exists, say the authors. Machine learning may be made more accessible via workshops and boot camps. This workshop teaches 34 computer science professors in Kerala, South India, AI (Chen et al., 2020). Two-day training provided instructors AI abilities (AI). Tatar et al. (2021) organized a two-day co-design workshop with 15 instructors to integrate AI into the core curriculum. Teachers and researchers created an AI-based lesson plan for math, science, and humanities. Su et al. (2022) investigated an ML tool (SmileyDiscovery) for K-12 STEM teachers. Two-week study periods occur twice. The platform supports educators with ML-enabled scientific discovery (SD), curriculum-aligned SD lesson planning, and k-means clustering.

Attempts are being undertaken worldwide to integrate machine learning into state and national curricula, although it may take a while. All states must train K-12 teachers on AI and machine learning. Thus, pre-service instructors will be able to teach AI and ML at any level. Previous studies on K-12 teachers and AI discovered certain flaws. According to Edwards et al. (2019), AI educators lack relevant teaching materials and best-practice examples and tools. A global comparison of teachers' AI ability was offered to provide intriguing insights on teachers' AI knowledge and develop recommendations to aid computer science instructors (Edwards et al., 2019). Also, computer science teachers have a weak knowledge of AI and its prospective social consequences.

Context and approach

Publicly subsidized schools were used to perform the study. While nations like the United States, Canada, Europe, and certain parts of Asia may not have to deal with problems like a lack of dependable technical infrastructure, a lack of access to scholarly knowledge, or an uneven modernization and inequality, others, like some developing countries, do. All of these factors have an impact on economic growth and development in general. There is a rising interest among scholars and practitioners alike in learning more about the potential benefits of ICT and how to help governments accept and make use of it for the benefit of their citizens, even though countries are embracing it with enthusiasm (Alhassan & Adam, 2021). According to Alhassan & Adam (2021), the situation is unusual in that it contains some of the world's fastest-growing nations as well as some of the poorest people. According to the authors, advances in information and communications technology (ICT) have made it possible for certain nations to achieve a mobile phone adoption rate greater than 100%.

Allen (2021) argues that the inevitable spread of networks, sensors, AI, and automation will lead to a continent-wide upheaval. With so many new technologies, it's appropriate to teach machine learning in schools. ICT unleashes people's creative and intellectual potential. In developed countries, especially North America and Europe [6,2], the need for K-12 machine learning teaching has surged. This research collects teachers' expectations about machine learning since beliefs govern pedagogy. It'll help schools teach machine learning.

Participants

One of the most important requirements for conducting a phenomenography research is to collect as many different perspectives on a phenomena as possible, or to exhaust the spectrum of possible viewpoints. Purposive sampling was used to ensure that the in-service teachers' experiences were reflected in the data collected. Consequently, each participant was required to teach computer science and have a degree linked to computers, as well as teaching experience that varied among schools. Because of this, it is expected that the results of this study would accurately reflect the variety of interpretations in the intended population (Brennan et al., 2019; Chen & Tsai, 2021). All participants were assigned the letter T, "teacher," with the associated number, in order to maintain their identities.

A sample size of 10–20 individuals is suggested for phenomenographic investigations, according to Sanusi et al. Murillo & Hidalgo (2020) similarly recommends between 15 and 20 participants and finds that 10 to 15 is the minimum for a decent likelihood of discovering variance. Interviews were conducted with a total of twelve (12) instructors, two of whom were female and ten of whom were male. Teachers from 12 high schools in three of the five areas attended the meeting. A total of 12 computer science instructors were interviewed in each of the six nations covered. Each country or area was chosen in an effort to have a better understanding of how people felt about this new hot subject. Even though the goal was to cover all five areas with a higher sample size, re-sources and scheduling restricted the scope. This study should be considered a preliminary discovery, not a full grasp of teachers' machine learning beliefs. While all teachers were computer science professors, they varied in teaching experience, academic degrees, and age:

• Gender: 2 girls, 10 boys;

• Age range: mid-30 s – late 50 s;

• Teaching grades: 10 – 15 grades; Teaching experience: 3 – 10 years;

• Bachelor's in Computer Science, IT, or EdTech.

Because machine learning is a new idea in K-12 education, we purposefully sought out computer science instructors who were already well-versed in the field. Aside from that, the instructors all had a degree in computer science, one in pedagogy, and all affirmed that they regularly attend government-sponsored courses for teacher development.

The gathering and analysis of information

Semi-structured interviews were employed for phenomenography research. Semi-structured interviews are adaptive and provide the interviewer leeway in how to ask questions. Semi-structured interviews are best for small-scale research projects where the interviewer is directly involved in the research process, such as phenomenography.

Interview questions were based on a pre-determined set of pre-conceived notions about how instructors should approach teaching machine learning. We utilized teachers' pre-conceptions and prior knowledge to extract their thoughts on K-12 machine learning instruction, as well as the long-term viability of such instruction for students' overall growth. Sample questions for instructors' pre-conceptions about machine learning are included in Table 1, which includes an interview schedule.

It was necessary to probe the instructors further with follow-up questions throughout the interviews in order to get further insights. Asking for further information, "Could you supply instances," and "How do you mean." This is how it works. Prospective interviewees received notification of the interviews in September 2020 by email and WhatsApp. You will learn about the research's purpose and the pre-conceptualizations of teachers in K-12 educational settings in your interview invitation. Through the research team's colleagues in the nations they studied, the volunteers were approached. The interviewee has just had informal WhatsApp or Skype conversations and phone calls to agree to participate. November and December 2019 saw in-depth interviews. Each professor was interviewed for 30 minutes on Zoom, Skype, and WhatsApp. Having set the interview date and time, we could organize the session around each participant's availability and online platform. English-language interviews were conducted. All participant-permitted interviews were filmed and transcribed. Using interview transcripts, teachers' machine learning teaching assumptions are investigated.

Table 1. Interview schedule to discover teachers' machine learning views.

Introduction
1. Interviewer introduced themself and stated interview purpose.
2. The interviewer guarantees anonymity and secrecy.
3. The interviewer requests permission to record.
Main body of the interview
(follow-up questions were utilized to investigate each question until the subject had been exhausted)
1. Is there a formal definition for machine learning that you could give?
2. What are your thoughts on the value of teaching machine learning in high schools?
3. What do you think about the materials available to teach machine learning?
4. Teach machine learning as a teacher, what are your main worries and concerns?
5. Is it a good idea to use machine learning?
Prior to the finalization of the transaction (summary)
Is there anything else you'd want to add to the list of questions? Summarize the most important things that may have been discussed throughout the interview.
1.The interviewer appreciates that the participant took the time to answer the questions.
2. The interviewer makes notes if the participant has further comments when the interview is not being recorded.

Data analysis

The transcribed teacher interviews were broken down by participant and analyzed using the Phenomenography approach. The transcripts were examined iteratively in the same way as Brennan et al. (2019). Several readings of the transcripts were required so that the authors could get acquainted with the professors' points of view. In the transcript, lines that primarily illustrate the instructors' viewpoint on teaching machine learning were included to emphasize the core theme. We compared and contrasted the replies to see whether there were any commonalities or discrepancies. The discrepancies made it easier to pick out recurring ideas and specific statements within the text. Teachers' thoughts on teaching machine learning were revealed by the following remark.

Despite swift technical developments, AI and machine learning will be around. Even though I only took one ML course in college, high schoolers should study it. Teaching machine learning satisfies tech-savvy students.

An "supporting student technical knowledge" annotation has been placed above this sentence to better convey its meaning. Another teacher's response: I believe that given the pace at which new technologies are becoming a part of our daily lives, we cannot avoid learning at least the fundamentals, particularly for our youngsters. Students will benefit from mastering machine learning, as the world continues to become more technologically advanced.

In the second statement, one of the instructors used the phrase "relevant for students' learning" to describe the key point. There were a lot of parallels and variances in instructors' ideas about how to teach machine learning to pupils. Teaching machine learning is relevant and satisfies the requirements of students, as shown by the two examples given above and others published as snippets in the conclusions. "Supporting student technical knowledge" became a new subcategory. The above indicated method was used to construct additional sets of pre-conception categories. Figure 1 summarizes the findings from the interviews with the instructors.

Students, teachers, and society were all important considerations in this study.

1. Focused on the teacher's needs: what are the key ideas to be learned? What resources and tools are available? Professional development possibilities may be found in many places.
2. Student-centered: a focus on the needs of students.
3. Sustainability is a societal issue.

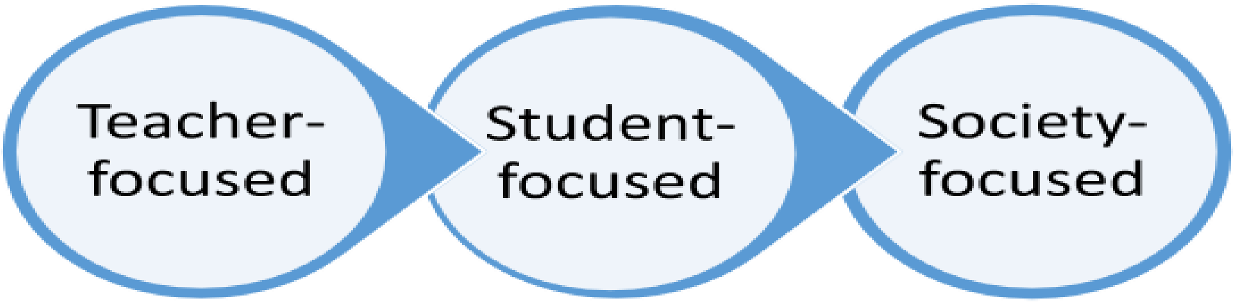

Figure 1. Summary of instructors' assumptions.

Preconceptions about teaching may be broken down into three main categories: narrow (the instructor's personal requirements), medium, and wide (teacher, students, and society).

Emerging themes were developed by keeping an open mind and listening intently to transcripts as we analyzed the data. In order to comprehend the context and significance of the developing themes, we are constantly returning back to the original transcripts. This also proves that the explanations were derived from the facts, which is a good sign. To end the process study, a pre-existing set of instructors' beliefs on teaching machine learning was gathered. Based on Chen & Tsai, (2021), a communication check was requested from an experienced researcher. As a consequence of the input obtained, the data's preconcept categories were refined. On the basis of our interviews, we were able to derive certain generalizations about instructors (see Figure 2).

Results

Teacher perceptions of machine learning in the classroom were divided into five distinct groups using a phenomenographic analysis technique (as presented in Figure 2). Teaching materials and tools are contextualized, students are supported technically, they understand the idea, they concentrate on professional growth, and they are sustainable for long-term development objectives, according to the categories of experiential learning identified. This part outlined the five categories and extracts from the interview with the instructors, followed by the allocation of the five categories.

Assisting students with their technical expertise

Students' technical knowledge was explored in this area since machine learning helps them build their mental models and talents. Children and teens nowadays are well-versed in technology, thanks to the proliferation of cutting-edge gadgets that include artificial intelligence (AI) and machine learning. These gadgets are widely utilized by them, and they regularly engage with the technology they use. Learning about how machine learning works and how it impacts society is essential for preparing K-12 students for a profession where humans and AI work together on a regular basis. One of the core principles of machine learning is teaching students about computing ideas and developing technologies in order to help them build their personal and professional skills.

T2: The pace of technological advancement is accelerating. How they function must be taught.

T5: I believe schools should teach students about machine learning, since it is unavoidable in today's environment**.**

T7. I believe that machine learning must be taught. In light of today's widespread use of ML-powered gadgets, it would be beneficial to include the foundations into classroom instruction.

Machine learning techniques are relevant to today's tech-savvy students.

Teaching machine learning to high school pupils has a significant impact on the pre-concept pronounced in this subgroup. Many teachers were concerned about the impact that artificial intelligence (AI) algorithms and the broader society would have on their children because of the present widespread use of machine learning applications. This is why the instructor insisted that pupils be taught these principles.

The ability to understand and apply machine learning concepts

They thought they had a basic understanding of machine learning because of the classes they took in their computer science degree program. Because of the premise that a system may learn from data and make decisions with as little human input as possible, machine learning was formerly considered a subset of artificial intelligence (AI). Teachers' phrases in this area varied in their degree of reference to machine learning.

T2. On the basis of preexisting techniques and datasets, a computer system may learn on its own how to perform tasks like recognize photos.

T8. The term machine learning refers to a system in which computers are able to learn on their own, without any human involvement. Using robots and artificial intelligence, it's a common occurrence in a variety of industry.

T9. As I understand it, machine learning gives a computer the capacity to analyze patterns and anticipate outcomes based on the patterns that machine researched over time.

T5. I've learned how machine learning works or generates models based on experience.

Using definitions and examples, instructors in this area explained their knowledge of how students learn using technology. The terminology and examples in the passages above show that the professors have a basic understanding of machine learning. However, this does not imply that professors may use machine learning algorithms or have the authority to instruct students on the subject.

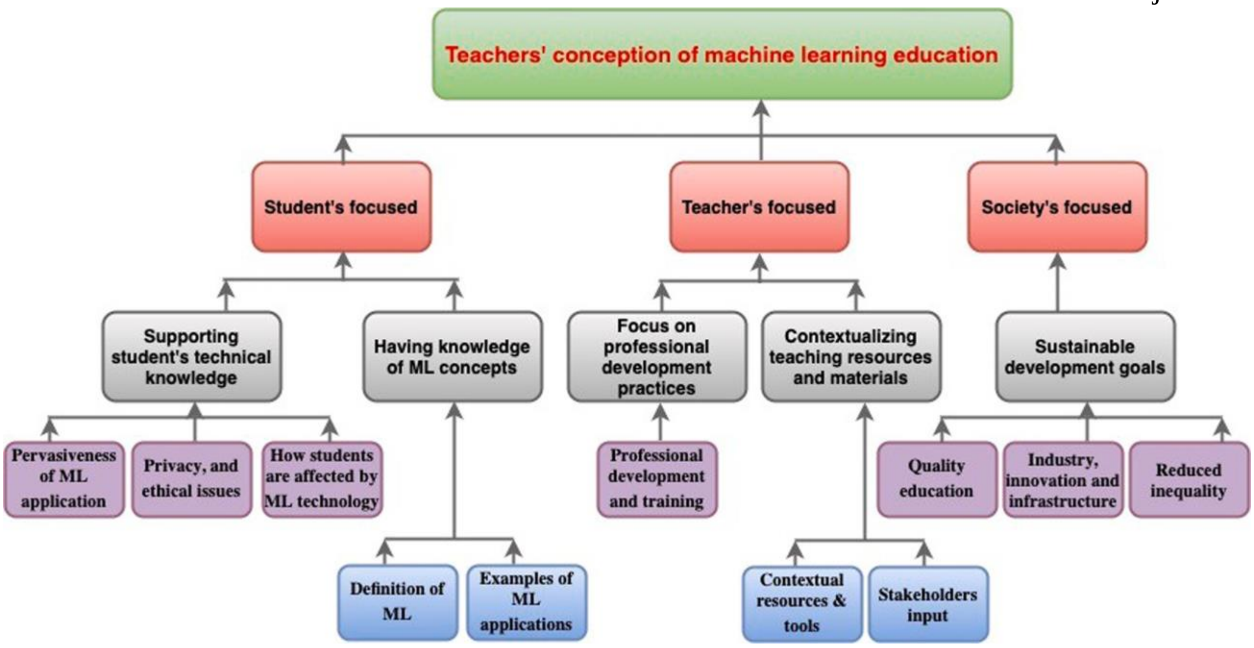

Figure 2. Categorizing professors' machine learning views.

Instructional methods for teaching machine learning that promote professional growth

Teachers' discourse in this area focused on the lack of training and understanding to teach machine learning in schools. Teachers who want to teach machine learning to their students should get continuing education credits.

T8. Teaching machine learning in high school will need a guide, since it is an unfamiliar idea to the students.

T10. It is impossible to deploy machine learning in the classroom without first providing instructors with appropriate training.

T3. Teaching machine learning to students requires more than a bachelor's degree in the subject.

T8. Despite my knowledge of what machine learning is, I lack the expertise necessary to instruct students in its use.

Teacher expressions make it clear that they are in need of some kind of training or development program for their careers. The teacher is intended to be the "knowledge source" that unravels the notion or guides the pupils to the road of discovery at the K-12 level.

However, all instructors surveyed indicated a lack of pedagogical understanding to promote the notion in schools, particularly in their own area.

Contextualization of training materials and tools for machine learning Using contextualized materials and technologies for teaching machine learning in schools is the instructors' pre-conception. Teaching materials, materials, and tools that take contextual aspects into account are highly valued by educators. Materials, tools, activities, or educational aids used to help students learn were claimed to be known to them as an emergent notion. This would be a good approach to learn effectively.

T8. In order to teach machine learning, there must be a curriculum. Afterwards, a curriculum authorized by the government.

T2: We cannot begin teaching machine learning in our schools until the ministry of education issues an official mandate. For one thing, we need to generate our own material rather than just copying ideas from other places.

T7. I believe the greatest strategy to take in promoting this notion in school, which is entirely new to me as a teacher, is to use tactics that are most successful in our nation.

T10. Students will have a thorough understanding of how machine learning utilizes well-known resources**.**

To make classes interesting and learning simple, it is necessary to include an idea into the teaching and learning materials and tools. Machine learning resources and technologies are relevant to the introduction of the ideas in schools, particularly when considering contextual considerations, as mentioned by these instructors in the extracts above. In order to develop curricula and tools that would help raise children who are machine learning literate, a lot of emphasis was placed on gathering feedback from stakeholders.

The use of machine learning to achieve long-term societal objectives

Teachers' preconceptions regarding the incorporation of technology in high school are characterized by the four categories listed above. Teaching machine learning is relevant, instructors' understanding of the subject, the requirement for professional training, and adequate resources are all directed toward successful machine learning education. Teacher perspectives on teaching machine learning in relation to sustainable development objectives set this subcategory apart (SDG). Teachers emphasized the link between teaching machine learning in classrooms and the SDGs. As a result, mastering machine learning techniques may be used to achieve the Sustainable Development Goals.

T1. Yes, it has to do with the caliber of instruction. Learning how to teach machine learning is a step toward creating a high-quality education that is open to all students, regardless of their background or socioeconomic status.

T3. I believe that integrating machine learning to classrooms will encourage pupils to be creative.

T5. Pupils will be more prepared for the future if they are taught how to use machine learning.

T12. Identifying and addressing inequalities in machine learning is addressed in T12. When, for example, all pupils are given the opportunity to develop innovative and marketable abilities, Inequality, in whatever shape it takes, will be reduced as a result.

To achieve SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, & Infrastructure) and decrease inequality, introducing machine learning to children in schools should be executed properly.. Teaching students how the world works and using technology to learn about the world is an important part of an effective education system. Intriguingly, machine learning technologies are increasingly driving both of these processes today. Education that is high quality should lead to new ideas. As a result, learning about the inner workings of things might help youngsters develop the principles of innovation so that they can begin experimenting with it at a young age. This will enhance the number of studies and help the development of domestic technologies. Education that prepares students for a future where AI is ubiquitous will be even more critical when a whole generation of youngsters comes of age surrounded by it. The next generation of artificial intelligence (AI) researchers and software developers will be inspired if the fundamentals of machine learning (ML) are taught.

The distribution of categories

Because the instructors' preconception categories were provided apart from their own personal knowledge, their opinions may be dispersed among categories. When analyzing instructors' expectations about teaching machine learning, Table 2 shows how often each of the teachers' preconceptions about machine learning occurs throughout the various categories. According to the method used by Chen and Tsai, (2021), the preconceptions of teachers are compared to the frequency of each category in the responses from the teachers' interview. Teachers' interviews on teaching machine learning fall into one of four categories, with the third most often cited topic in Table 2 (see Figure 1). (13). Furthermore, as can be shown in Table 2, the frequency of occurrence is greater in the category of professional growth than in the other categories. For teaching machine learning, there is a pressing demand for relevant teaching resources and tools.

Discussion

12 high school teachers' opinions regarding teaching machine learning were investigated. Supporting student technical knowledge, having a working grasp of the idea, concentrating on professional development practices, contextualizing instructional materials and tools, and guaranteeing development objectives' sustainability were discovered via phenomenographic

analysis of teachers' interviews. This study's results show how high school teachers evaluated machine learning and how to teach it successfully.

Pupils were not the primary focus of the superficial preconceptions category. To guarantee that students are getting the most out of their education, the emphasis has shifted from teacher-content to teacher-pedagogy notions. It doesn't matter where the instructors studied come from; their ideas about teaching ML and its applicability to the K-12 population are all on the same page. ML instructors' assumptions center on how to properly teach the subject, with an emphasis on the need of professional development. According to a research by Chassignol et al. (2018), educating teachers is essential. Because instructors require topic expertise such as problem-solving, reasoning, learning, perception, applied mathematics, cognitive/psychological/ethical artificial intelligence (Chassignol et al., 2018), teacher training is essential. Even if instructors have a basic understanding of machine learning, their preconceptions are shallow and lack technical depth. By Sanusi and colleagues (2022), instructors must display much more advanced knowledge than their pupils if they want to effectively teach a subject matter.

To reiterate, the importance of rigorous training by professionals cannot be overstated. The focus of this research is on machine learning patterns and misunderstandings, not on instructor definitions.

Teachers' preconceptions about machine learning as seen via the TPACK framework

To have a better grasp on how to teach machine learning in K-12, the classifications made in this research might be compared to the TPACK (technological, pedagogical, content knowledge) integration framework (Schmid et al., 2020). Teacher ability and knowledge are conceptualized in the framework (Schmid et al., 2020). With a foundation of technological, pedagogical and content-related information. In the domain of technical knowledge, the focus is on the ability to utilize digital tools that are suitable for the lesson or subject being taught. A teacher's emphasis on pedagogical knowledge is on the teaching methods necessary to suit both their students' needs and those of the lesson. What to teach and how to teach it are two aspects of content knowledge.

Table 2. Teachers' ideas about teaching machine learning were surveyed (Frequency).

	1	**2**	**3**	**4**	**5**
	Supporting the student's understanding of technical concepts	**The ability to understand the ideas**	**Investing in professional growth**	**Contextualizing instructional materials/resources**	**Goals for a better future**
T1	4	4	9	9	3
T2	5	4	14	7	1
T3	2	3	7	6	2
T4	0	2	6	2	3

T5	4	4	10	3	1
T6	3	3	5	4	1
T7	2	6	6	5	2
T8	7	6	7	5	9
T9	2	4	5	2	1
T10	2	3	7	3	3
T11	0	3	7	3	2
T12	3	3	5	6	5

Table 3 shows teachers' misconceptions regarding ML and TPACK. Category 1 includes IT help for pupils. Even though children are digital natives and use ML-powered devices, teachers assume they are aware of the technology and will meet their needs and train them to become ML developers, engineers, and researchers. Machine learning content knowledge is under category 2. As part of their bachelor's degree program, teachers will study about machine learning and how technology may be used to improve the lives of their students and the community. Teaching in schools requires more than a grasp of machine learning; it also requires a command of the subject matter. This category focuses on teaching students how to use machine learning and how to use it in their own work. As instructors acknowledged lacking pedagogical skills to teach machine learning in schools, this research recommends a focus on professional development methods. Under topic knowledge, category 4 focuses on teaching machine learning successfully through contextualized teaching tools or materials. Category 5 illustrates the transforming force of comprehending the essential and inner workings and their applications, and it is the last category. It helps in preparing for the future. SDGs like improving educational quality and reducing disparities can only be achieved with the help of instructors who are well-versed in the latest technologies, as well as in pedagogy and subject matter.

According to Table 3, we discovered that the most common preconceptions of the instructors participating were grouped into Categories 3 and 4. A key finding of this research is the absence of a TPACK framework in machine learning, which implies that pedagogical and content knowledge are both missing from the technology. The responses of the instructors reveal that, despite their apparent familiarity with machine learning concepts, the conversation focussed on professional development and teaching resource options. No, this study's goal isn't to determine whether or whether professors are capable of teaching machine learning. Educators may need to develop more nuanced preconceptions about machine learning if the new notion is widely implemented in classrooms.

Table 3. Teachers' perceptions of machine learning and the TPACK framework.

Teachers' misconceptions on machine learning	**Technology Integration Framework**		
	Technological Knowledge	**Pedagogical Knowledge**	**Content Knowledge**
1. Assisting students with their technical knowledge	*		
2. Understanding the notion.			*
2. Understanding the notion.		*	
4. Contextualizing educational tools and materials			*
5. Sustainable development is essential to achieving the stated aims.	*	*	*

Academics, politicians, and practitioners may all benefit from this work. First, it shows the need for machine learning training and growth in schools. That AI and ML teacher education program is basically nonexistent. As a result, we suggest a hands-on training curriculum that teaches AI and ML. In-service teachers and researchers may work together to develop lesson plans and discuss ideas in co-design workshops. The instructors' discourse indicates that contextualized materials and tools are necessary for successful ML education in the classroom. As Cruz-Jesus et al. (2020) and Tatar et al. (2021) have shown, it is challenging to adapt already-developed resources to new situations. Teacher participation in the development of ML curriculum and tools is critical for success. As a result, the instructor will be better equipped to help pupils learn the foundations of machine learning, which will open up new doors for innovation and long-term growth.

Validity and trustworthiness of the study

Teachers' views on a novel topic like machine learning may be too subjective for an objective evaluation of the validity of qualitative research, which is much more problematic in phenomenography studies of this sort. Researchers in this field are more concerned with whether or not the findings coincide with instructors' perspectives on machine learning education than they are with how closely the findings match up to actual classroom activities for teaching and learning machine learning principles today. Incorrect or inadequate data is a hazard to phenomenography study validity. To ensure credibility, all interviews were captured using internet media platforms and a cell phone voice recorder. In this research, the structural relationship between categories confirms the study's credibility. Researchers can't misinterpret phenomenography data due to their collective structure.

Limitations and new research

Much remains unexplained despite the contributions this work has made in terms of teaching computer science principles. As an example, despite the relatively modest sample size, this study does not invalidate since interviews might restrict the number of individuals interested in a research topic. A high sample size may be achieved by the use of a survey methodology; however, this method does not give the possibility for a full and open-ended description of complex topics. Methods other than interviews and surveys are needed to get a complete picture of the situation. ML, for example, might benefit from an approach known as the "draw-a-picture" to better comprehend instructors' thoughts of teaching new topics. Because of the small sample sizes in each nation or location, we could not be certain that our findings and conclusions would be relevant to other instructors. The results of this study are hampered by the fact that the sample size is too small to adequately reflect a wide range of academic disciplines. Because of this, it is difficult to draw conclusions based on the gender distribution of participants (Female: Male 1:5). To better understand how instructors with expertise outside of computer science think about incorporating machine learning into the classroom, further study like this is welcomed. It may be more intriguing to look at individuals from private schools since they are believed to be of higher quality than public institutions. There should be more comparative study on the attitudes of preservice and in-service teachers in different countries/regions and kinds of schools about ML ideas in the future. In addition, future study might examine how instructors' and students' perceptions of machine learning are aligned to detect and rectify the possible gaps in their understanding of machine learning.

Conclusion

Teachers' assumptions about teaching machine learning are examined in this study, and we identify basic preconceptions and variants that are relevant to the application of ML for K-12 in the setting. Our next discussion revolved on instructors' ideas about teaching mathematics (ML). Phenomenography was used as a method to get insight into the assumptions of K-12 computer educators. Teachers are often in charge of deciding how to incorporate a new subject into the curriculum. As a relatively new field of study for students in grades K-12, instructors' perceptions of machine learning's learning, application, and instruction are critical to better comprehend. Teacher education and professional development efforts that promote machine learning instruction in K-12 settings should benefit from the results presented in this research. Because of this, the findings presented in this study provide light on the complexities of teaching Machine Learning to students in environments with less established technical infrastructure and pedagogical perspective. Professional training efforts aimed at helping teachers in K-12 schools find teaching approaches that will help them overcome contextual challenges and engage students in higher-level learning experiences need to be studied further. Due to the immaturity of machine learning education, the results serve as a basis for future research and give constructive insights for the growth of the field.

References

1. Alhassan, M. D., & Adam, I. O. (2021). The effects of digital inclusion and ICT access on the quality of life: A global perspective. Technology in Society, 64, 101511. https://doi.org/10.1016/j.techsoc.2020.101511
2. Apuke, O. D., & Iyendo, T. O. (2018). University students' usage of the internet resources for research and learning: forms of access and perceptions of utility. Heliyon, 4(12), e01052. https://doi.org/10.1016/j.heliyon.2018.e01052
3. Brennan, L., Cusack, T., Delahunt, E., Kuznesof, S., & Donnelly, S. (2019). Academics' conceptualisations of the research-teaching nexus in a research-intensive Irish university: A dynamic framework for growth & development. Learning and Instruction, 60, 301-309. https://doi.org/10.1016/j.learninstruc.2017.10.005

4. Chassignol, M., Khoroshavin, A., Klimova, A., & Bilyatdinova, A. (2018). Artificial Intelligence trends in education: a narrative overview. Procedia Computer Science, 136, 16-24. https://doi.org/10.1016/j.procs.2018.08.233
5. Chen, C. H., & Tsai, C. C. (2021). In-service teachers' conceptions of mobile technology-integrated instruction: Tendency towards student-centered learning. Computers & Education, 170, 104224. https://doi.org/10.1016/j.compedu.2021.104224
6. Chen, X., Xie, H., & Hwang, G. J. (2020). A multi-perspective study on artificial intelligence in education: Grants, conferences, journals, software tools, institutions, and researchers. Computers and Education: Artificial Intelligence, 1, 100005. https://doi.org/10.1016/j.caeai.2020.100005
7. Cruz-Jesus, F., Castelli, M., Oliveira, T., Mendes, R., Nunes, C., Sa-Velho, M., & Rosa-Louro, A. (2020). Using artificial intelligence methods to assess academic achievement in public high schools of a European Union country. Heliyon, 6(6), e04081. https://doi.org/10.1016/j.heliyon.2020.e04081
8. Di Vaio, A., Palladino, R., Hassan, R., & Escobar, O. (2020). Artificial intelligence and business models in the sustainable development goals perspective: A systematic literature review. Journal of Business Research, 121, 283-314. https://doi.org/10.1016/j.jbusres.2020.08.019
9. Edwards, C., Edwards, A., Stoll, B., Lin, X., & Massey, N. (2019). Evaluations of an artificial intelligence instructor's voice: Social Identity Theory in human-robot interactions. Computers in Human Behavior, 90, 357-362. https://doi.org/10.1016/j.chb.2018.08.027
10. Haenssle, H. A., Fink, C., Schneiderbauer, R., Toberer, F., Buhl, T., Blum, A., ... & Zalaudek, I. (2018). Man against machine: diagnostic performance of a deep learning convolutional neural network for dermoscopic melanoma recognition in comparison to 58 dermatologists. Annals of oncology, 29(8), 1836-1842. https://doi.org/10.1093/annonc/mdy166
11. Lachner, A., Fabian, A., Franke, U., Preiß, J., Jacob, L., Führer, C., ... & Thomas, P. (2021). Fostering pre-service teachers’ technological pedagogical content knowledge (TPACK): A quasi-experimental field study. Computers & Education, 174, 104304. https://doi.org/10.1016/j.compedu.2021.104304
12. Lioutas, E. D., Charatsari, C., & De Rosa, M. (2021). Digitalization of agriculture: a way to solve the food problem or a trolley dilemma?. Technology in Society, 67, 101744. https://doi.org/10.1016/j.techsoc.2021.101744
13. Murillo, F. J., & Hidalgo, N. (2020). Fair student assessment: A phenomenographic study on teachers’ conceptions. Studies in Educational Evaluation, 65, 100860. https://doi.org/10.1016/j.stueduc.2020.100860
14. Neto, R. D. C. A., Rodrigues, V. P., Stewart, D., Xiao, A., & Snyder, J. (2018). The influence of self-efficacy on entrepreneurial behavior among K-12 teachers. Teaching and Teacher Education, 72, 44-53. https://doi.org/10.1016/j.tate.2018.02.012
15. Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. Computers and Education: Artificial Intelligence, 2, 100041. https://doi.org/10.1016/j.caeai.2021.100041
16. Sanusi, I. T., Oyelere, S. S., & Omidiora, J. O. (2022). Exploring teachers' preconceptions of teaching machine learning in high school: A preliminary insight from

Africa. Computers and Education Open, 3, 100072. https://doi.org/10.1016/j.caeo.2021.100072
17. Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2018). The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge: Comparing structural equation modeling approaches. Computers in Human Behavior, 80, 67-80. https://doi.org/10.1016/j.chb.2017.11.003
18. Schmid, M., Brianza, E., & Petko, D. (2020). Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK. xs) and comparing the factor structure of an integrative and a transformative model. Computers & Education, 157, 103967. https://doi.org/10.1016/j.compedu.2020.103967
19. Seufert, S., Guggemos, J., & Sailer, M. (2021). Technology-related knowledge, skills, and attitudes of pre-and in-service teachers: The current situation and emerging trends. Computers in Human Behavior, 115, 106552. https://doi.org/10.1016/j.chb.2020.106552
20. Su, J., Zhong, Y., & Ng, D. T. K. (2022). A meta-review of literature on educational approaches for teaching AI at the K-12 levels in the Asia-Pacific region. Computers and Education: Artificial Intelligence, 100065. https://doi.org/10.1016/j.caeai.2022.100065
21. Tarchi, C., Brante, E. W., Jokar, M., & Manzari, E. (2022). Pre-service teachers' conceptions of online learning in emergency distance education: How is it defined and what self-regulated learning skills are associated with it?. Teaching and Teacher Education, 113, 103669. https://doi.org/10.1016/j.tate.2022.103669
22. Tatar, C., Yoder, M. M., Coven, M., Wiedemann, K., Chao, J., Finzer, W., ... & Rosé, C. P. (2021). Modeling Unstructured Data: Teachers as Learners and Designers of Technology-enhanced Artificial Intelligence Curriculum. In Proceedings of the 15th International Conference of the Learning Sciences-ICLS 2021.. International Society of the Learning Sciences. https://repository.isls.org//handle/1/7539
23. Yin, H., Shi, L., Tam, W. W. Y., & Lu, G. (2020). Linking university mathematics classroom environments to student achievement: The mediation of mathematics beliefs. Studies in Educational Evaluation, 66, 100905. https://doi.org/10.1016/j.stueduc.2020.100905