Exploring K-12 Teachers' Confidence in Using Machine Learning Emerging Technologies through Co-design Workshop (RTP)

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Abstract

Artificial Intelligence(AI) and Machine Learning (ML) touch every aspect of modern life and will continue to influence us more than ever in the future. Schools and teachers should be prepared to let the children explore ML to help them understand how the world around them functions. It has been shown that children as young as three years old can not only interact with ML technologies but also produce ML data sets and models[1].

In this paper, we explore factors influencing the growth of teacher confidence in implementing emerging ML technologies within engineering educational settings. Five teachers from St. Louis, USA, engaged in a co-design workshop to explore an emerging ML toolkit and to consider ways of structuring classroom activities to integrate technology into their teaching. Using video and post-interview data, we report on how engagement in the workshop activities influenced their confidence. We claim that educators' confidence grew when they were provided with hands-on opportunities to explore and understand emerging technologies. Moreover, our analysis underscores recognizing and validating teachers' unique insights and perspectives in fostering their confidence. Additionally, we highlight the significance of involving educators in the collaborative design of curricula and activities centered around these innovative ML tools. By shedding light on these critical elements, our research offers practical guidance for fostering a supportive environment that encourages educators to embrace and effectively integrate ML technologies into their engineering teaching practices.

Machine Learning in K-12 Education

Machine learning (ML) is one of the branches of Artificial Intelligence that describes the capability of computer systems to perform complex tasks by using algorithms and statistical models without explicit instructions. The concept of ML in computer science was developed in the 1950s, but it has seen rapid growth in recent years thanks to the advancement of computing systems and the abundance of data [2]. The pervasiveness of ML can be inferred through its widespread integration into a diverse array of fields: from agriculture [3] to manufacturing[4] and medicine[5] to economics[6]. As technologies get more affordable and algorithms get more robust ML is most likely going to be more integrated into our daily routines. This will make having a working knowledge of AI and ML a desired skill set for everyone and, more importantly, for the future workforce.

The rapid advancement of machine learning (ML) has sparked a surge of interest in its integration within engineering education environments as well, with some initial strides made

towards this endeavor [7]. The K-12 educational sphere has witnessed the emergence of ML technologies designed to augment various aspects of teaching and learning [8]. As teachers explore this unchartered territory of teaching AI and ML and integrating them into their classrooms there is a growing need for supporting teachers to demystify and bring concepts of AI and ML into classrooms [9].

Teachers' confidence is central to the integration of technology in the classroom in general, the higher a teacher's self-efficacy with technologies in their class, the more positive their attitude, which leads to a higher level of confidence and technology use[10]. This aligns with Ajzen and Fishbein's Theory of Reasoned Action (TRA), which predicts teachers' behavioral intentions, which lead to technology decisions, with high accuracy by understanding their attitude toward the behavior [11]. Evidence also shows that the exploration and use of available technology tools relevant to the teachers' subject matter during professional development training results in positive changes in their attitudes toward technology, which eventually leads to increased confidence and desire to continue using technology in the classroom[12] [13].

While teachers may need a boost in confidence in specific hardware and software regarding emerging technologies, they come with a plethora of existing pedagogical knowledge that must be considered in conversations about technology integration. Interaction between technology and pedagogical knowledge can be achieved by leveraging teachers' existing knowledge[14], through the joint effort of teachers and experts together in a co-design workshop[15]. There have been efforts to bring teachers and experts together through co-design workshops to develop a curriculum on AI [16]. However, implementing ML technologies to teach engineering while learning about ML concepts is still novel. There is relatively little research on upper elementary teachers' confidence in teaching ML-related knowledge and using emerging ML tools in their classrooms.

In this study, we explored how teachers' confidence in using emerging ML technology evolved in a co-design workshop. We drew on the evidence from studies that showed how training leads to an increase in confidence and subsequently results in an increase in technology adaptation in classrooms[17]. We also drew inspiration from the Technology Acceptance Model (TAM), a widely used Information System research model [18] [19], which asserts (teachers') attitudes are impacted by (their) sense of utility and usability[11]. We expanded on the ideas on technology adaptation to ML-related technology space through an introduction to an emerging ML toolkit called Smart Motors.

Smart Motors [20] are low-cost robotics kits developed at the Center for Engineering Education and Outreach at Tufts University, designed to be used in engineering design workshops in elementary and middle schools[21]. Smart Motors teach the concept of training datasets which is a core concept in Machine Learning. The nearest neighbor algorithm used in these devices makes it possible for the users to teach the motors to move in specific ways through a series of training. The users can train the motors to move to the user-define positions based on changing sensor inputs. First, the users train the motors by selecting sensor values and their corresponding motor positions in the training mode. Subsequently, the motor determines the position based on the sensor input using a nearest neighbor algorithm in the running mode.

Methods

Research Question: What makes teachers' confidence in using and teaching ML emerging technology tools shift?

Background: Several participants in this co-design workshop had taught in the machine-learning workshop in the summer of 2022 with upper elementary school students[22]. Based on their feedback and reflections we learned that they were confused about the curricula and activities design, and they didn't have enough confidence to teach emerging technologies without professional training. They suggested we improve the students' activities and organize some teachers' professional training sessions.

Co-design Workshop: We ran a 2-day, 8-hour co-design workshop at St. Louis in April 2023 to collaborate with K-12 educators to design the ML activities for an upper elementary school summer workshop. There were 5 participants, they were K-12 STEM-related teachers. Three of the five were scheduled to teach an upcoming summer ML workshop. The purpose of the co-design workshop was to get the researchers and K-12 teachers to collaboratively design suitable ML activities for upper elementary school students and help participants explore how to use the emerging ML tools - Smart Motors.

On the first day, we focused on learning participants' backgrounds, their attitude to AI/ML and teaching emerging technologies in their classroom, and supporting participants in exploring the emerging ML tools - Smart Motors via several hands-on projects. On the second day, we focused on brainstorming the ML activities through several rounds of hands-on activities using Smart Motors, reflecting and iterating, and decided to design the final activities together.

Data Collection: All workshop sessions were video and audio recorded, and transcripts were generated of these meetings. In addition, field notes were generated from observation notes. Participant-generated artifacts were collected in a shared notes document (Google Slides), where we could track specific ideas and thoughts raised in the workshop. The three teachers scheduled to facilitate the summer workshops were interviewed on Zoom following the workshop which was also transcribed. The interviews invited teachers to share their reactions to ML integration, feelings and feedback about the co-design workshop, their understanding of AI/ML, and how their positioning and confidence in teaching AI/ML and using emerging technology tools changed.

Data Analysis: We conducted a comprehensive analysis, including transcriptions, from both the co-design workshop and post-interviews, participants' notes on Google Slides, and researchers' reflections on the co-design process and participant behavior documented in field notes to find the evidence to support teachers' confidence in teaching AI/ML and using emerging technology tools increased during the whole co-design process. From video data and participant notes from the co-design workshop, we compared the differences in teachers' attitudes toward ML, their perceptions of emerging ML tools, and their willingness to integrate ML into their classrooms before and after every activity during the co-design workshop. We used participants' direct statements of their confidence change as evidence. We also identified circumstantial evidence, such as participants' willingness to incorporate ML into their teaching practices and the

behavior and emotion they expressed regarding the use of ML tools. In post-interviews, we asked specific questions about how participants felt their confidence changed when their confidence changed, and what caused their confidence to change.

Findings

Teachers' confidence shifted when: 1) they completed the hands-on projects; 2) their perspectives got positive feedback 3) they collaborated on curriculum design, and 4) they saw a chance to integrate ML/AI into their classroom.

1. Hands-on projects provide opportunities for participants to engage in emerging technologies, and understand and use emerging ML tools.

   We had several hands-on projects for participants during the co-design workshop, such as exploring and playing the AI games on Google Labs, using Smart Motors to build an interactive garden project, and using Smart Motors to build a project based on the given context (Figure 1). We observed that participants got familiar with the emerging technology tools - Smart Motors during those hands-on activities. Compared to the first activity where the participants explored the Smart Motors, they could use the Smart Motors as a tool to support their projects efficiently and more comfortably during the hands-on processes after several hands-on projects.

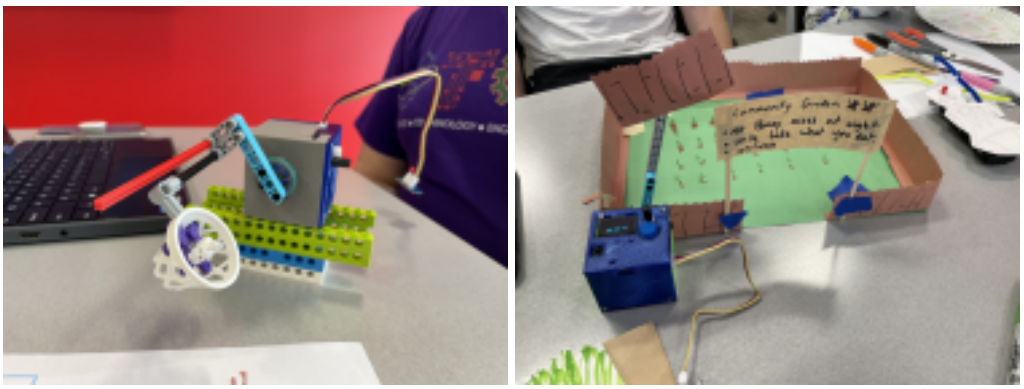

Figure 1: Examples of teachers' hands-on projects.

Maria (pseudonym) said *"I feel this sounds interesting and useful, but I'm so bad at technology. All kinds of technologies."* when she first heard that the workshop was related to AI/ML and emerging technologies. And in the very beginning of the first hands-on activity exploring and playing the AI games on Google Labs, Maria said *"Technologies will kill me, I told you guys I'm bad at it."* When we asked about her attitude toward teaching AI and ML, she said: "*I feel it's very good for students and they should learn those stuff, but I have no idea how to teach those*." Maria expressed she came with low confidence in using technologies and teaching technologies. However, after several rounds of hands-on projects with the researchers' help and encouragement, her confidence grew. There was a hands-on project using Smart Motors as a tool to build a project based on the given context, and the time limitation was 25 minutes. Maria said, *"It's impossible, I can't do it, definitely."* However, she

completed it on time successfully with a little bit of help and a lot of encouragement from researchers and other participants. She said *"I can't believe I did it, I feel so good. I'm proud of myself and it's not that hard after I really did it. I thought it was impossible in the very beginning, but I really did it."* In the post-interview, she mentioned this moment made her confidence grow. Emily(pseudonym), another participant mentioned in the post-interview: "*The interactive garden helped me understand how Smart Motors work, I'm excited to see how kids will use those in summer camp.*" Another participant, Alex(pseudonym), mentioned he had confidence when he came into the workshop, but hands-on projects helped him understand how Smart Motors works deeply and boosted his confidence.

All participants expressed their confidence in the post-interview, whatever their confidence level when they joined the workshop. Several participants also mentioned in the post-interviews that their confidence grew because they had a chance to keep in touch with emerging technologies and had an opportunity to build hands-on projects with them, so they have more sense of emergent technologies and have more confidence to teach those stuff.

2. When teachers get positive feedback on their ideas and perspectives and feel their ideas are heard and recognized, their confidence in implementing emerging ML tools seems to grow.

   Not every participant came with low confidence in emerging technologies, but all participants reported an increase in confidence in teaching emerging technologies. In the post-interview, Alex, the one who came in with confidence, said *"My confidence did grow, because I enjoyed sharing my ideas and talking to other participants. I felt good when other people loved or used my ideas. I also liked other people took my suggestions to improve their ideas and projects. Those made my confidence grow."* We noticed that he only answered researchers' questions at the very beginning of the workshop, and didn't share too many extra thoughts. However after he got positive feedback from other participants, he shared more of his ideas and perspectives, gave feedback and comments on other people's ideas, and always interacted in the discussions in the workshop. He expressed his opinion confidently and explained all his thoughts when someone gave him positive feedback, even when people had different ideas. He showed a high willingness to help other participants when they faced challenges, and he took more leadership and supportive roles and led the discussion after he had positive feedback from other participants. Combining all the evidence with his description in the post-interview, his perspective of getting positive feedback is the main reason that helped his confidence grow.

3. When teachers are involved in the collaborative design of curricula and activities related to emerging ML tools, they feel they are part of decision-making.

   The previous summer workshop was all designed by the research team, without involving any teachers in the design process. In the interview after last summer's workshop, teachers mentioned that they were confused because they got the curriculum 2 days before the workshop, so they felt unfamiliar with the tools we used and the curriculum we designed. As

one of the stakeholders, it's important to collaborate with teachers in the design process. They are more familiar with the current standards, the existing curriculum in the classroom, and student's interests, and they contribute their expertise in teaching and learning to the co-design workshop and get a chance to explore emerging technologies[23]. After teachers explored the emerging ML technology tools, they combined the technological knowledge with their pedagogical knowledge and designed suitable activities for the upcoming summer workshop. Figure 2 shows teachers contributed a lot of ideas to the curriculum design, every sticky note shows their ideas about the big topic, the materials, how to apply Smart Motors, what kind of sensors we could use, what kind of context we could provide for the activities, and how to lead students to involve in the projects, and so on. The blue, pink, and green sticky notes were contributed by the research team, and all yellow notes were contributed by teachers.

Figure 2: Teachers' ideas in the brainstorming session to collaborate on the curriculum.

In the post-interviews, several participants mentioned that they had more confidence in the upcoming summer workshop. This was because they were going to teach the activities they had prepared during the co-design workshop. The teachers were familiar with the contents and understood the reasons and thoughts behind designing those activities. Some participants said they felt heard during the co-design workshop, not only as the participants but also as the designers and decision-makers. Some participants expressed that applying their thoughts on curriculum design made them feel respected. They shared that it was different from being assigned the teaching duty and having the pressure to prepare for teaching. Since they were part of the designing and decision-making team, they had more confidence to teach the curriculum and were well prepared for the summer camp.

4. We claim that teachers' confidence shifts when they see a chance to integrate AI/ML into their classroom. When teachers have opportunities to learn, use, and combine emerging ML technologies with their existing curriculum, their confidence in teaching emerging technologies will grow, even if initially they don't see a space for AI/ML in their classroom. At the very beginning of the co-design workshop, when we asked participants how they felt about teaching AI/ML in their classrooms, Alex said, "*I have some smart devices in my class, like Sphero… and I always want to have a smart whiteboard… but I never think about the AI/ML stuff, and I don't know how that gonna work in the class*". Maria said, "*I even can't*

imagine what it looks like, I have no idea how to teach AI and ML" Emily said, "*I feel it's too hard to teach kids AI, I don't know AI very well.*" All participants expressed they didn't see a space in their classroom to teach and use those emerging ML technologies and concepts. Alex and Emily mentioned that they felt that providing students opportunities to learn those emerging technologies is important and useful, but they don't know how to teach AI/ML-related knowledge, and they have no idea how to teach those emerging and complex technologies to elementary kids. Maria expressed she never gets a chance to learn that content and she doesn't have the confidence to learn those "*fancy new technologies*". We saw the boundary between K-12 teachers and emerging technologies. As researchers we have resources and possibilities to apply those emerging technologies and tools in the classrooms, the teachers don't have access to those resources, which means they can't see a space in their classroom for those resources. Maria said, "*It sounds very hard and I don't think I can learn it.*"

However, after participants played around with the AI games on Google Labs, they got new perspectives and saw a possibility and space in their classroom to teach emerging AI/ML technologies. Alex said, *"I will use this in my art class. Oh, I have a good idea, I can ask students to try this AI drawing training game at the beginning of the semester and the end of the semester and see if there are any differences in their program. . . I mean there is a sketch gallery there to show how people train their program, I'd love to ask kids to compare how it changes!"* Emily said, *"Okay, so yeah, all those are really awesome...I just have to figure out where I'd be able to incorporate it into my classroom. . . "* and Maria said, "*Wow I like these games, I believe my girls will enjoy them.*" In the post-interview, participants expressed teaching AI/ML is not as hard as they thought, and they will try to add some AI games to their classes and curriculum. They said their confidence grew because they saw a chance to integrate AI/ML into their classroom, the game is a good way to start, and those emerging technologies don't seem that far away from them anymore which made their confidence grow.

Discussion

There were several instances in the co-design workshop where we noticed a boost in teachers' confidence. When the teachers got the opportunity to implement Smart Motors in hands-on projects that were relevant to their subject matter, it allowed them to notice and understand the underlying ML concept while making the connection to their expertise. Moreover, the nature of co-design workshops provided ample opportunity to provide feedback to the teachers' ideas. As evidenced by other research on technology and teacher confidence, these opportunities to engage in professional development training resulted in growth in confidence with the emerging ML tools. When the teachers collaboratively designed the curricula and activities for the students along with the experts they expressed ownership in the decision-making process. They were integrating their expertise in classroom management, content generation, activity design, child psychology, and the plethora of other teacher skills with an emerging ML toolkit to teach a new idea. And this opportunity to learn, use, and combine these technologies with their existing curriculum, shifted their confidence in teaching with the emerging technologies.

Conclusion

In this paper, we present four ways of supporting teachers through a co-design workshop to help them become familiar with emerging ML technologies, have the confidence to teach AI/ML-related concepts, and finally get them interested in teaching those to their students. To support more potential AI/ML classes in upper elementary schools, it's important to improve teachers' confidence to change their attitudes about ML technologies. Providing hands-on opportunities for teachers unfamiliar with ML/AI-related concepts, and who have never used emerging technologies before, can help teachers surmount the barriers to the emerging technology tools, become familiar with the technology, and see the potential of applying those emerging technologies tools in their classroom. In the co-design workshop, teachers felt their perspectives were respected, and they were part of the decision-making on the curriculum design. This appeared to make teachers' confidence grow and get more upper elementary educators to get involved in AI/ML education.

However, there was something we wanted to improve in the future research. There were only 5 participants in this co-design workshop. We hope to have more participants in future research to have a larger sample size and a larger diversity of skill sets. All participants were from the same city in this co-design workshop. We want to expand the scope of the participants, have more people from different areas join the workshop, and see how that impacts the results.

As a result, similar co-design workshops were done in Nepal and Brazil with around 20 in-service science and robotics teachers. They interacted with Smart Motors and worked with local experts to develop a curriculum to teach in their classrooms. Since they were mostly done as outreach efforts, we do not have generalizable data from these workshops. However, the facilitators noticed a positive shift in teachers' confidence, many of whom were introducing technology in their classrooms for the first time.

In the future, we plan to get more student data from these participants' classrooms to find how the growth in teachers' confidence influences their teaching and benefits their students and how we, as researchers, can support the emerging ML tools related to the teaching and learning process.

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