Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #45791

Bringing Artificial Intelligence (AI) and Machine Learning (ML) into Elementary Classrooms

Faiza Zafar, Rice University

Dr. Zafar is the Assistant Director for Equitable Research, Evaluation, and Grant Development at the Rice Office of STEM Engagement. She has her Ph.D. in Educational Leadership with an emphasis on Math Education. She earned her B.S. in Chemistry and M.Ed. from the University of St. Thomas, Houston, TX.

Carolyn Nichol, Rice University

Dr. Carolyn Nichol is a Faculty Fellow in Chemistry and the Director of the Rice Office of STEM Engagement (R-STEM). R-STEM provides teacher professional development to elementary and secondary teachers in science and math content and pedagogy, while also

Mr. Matthew Cushing, Rice University

As Executive Director of the Rice Office of STEM Engagement (R-STEM), Matthew oversees all programs and operations for the department. He has been presenting on AI in Education for the last few years at local, regional, and national conferences.

Bringing Artificial Intelligence (AI) and Machine Learning (ML) into Elementary Classrooms

Introduction

The integration of Artificial Intelligence (AI) and Machine Learning (ML) into educational environments is revolutionizing the way we engage students and enhance their learning experiences. However, for AI and ML to truly transform teaching and learning, educators must receive comprehensive, hands-on training that empowers them to teach these advanced concepts effectively. In response to this need, we have developed a virtual professional development program for STEM educators across elementary and secondary school levels to immerse teachers in cutting-edge research and applications in these rapidly changing fields. Through a 6-week virtual summer research experience, teachers gain deep computer science knowledge about how machine learning is being used to develop cost-effective health devices, with particular attention to diabetes and breast cancer research. Teacher participants collaborate with graduate student mentors, engage in discussions with faculty members engaged in digital health research, explore real datasets, and create grade-appropriate lesson plans. This paper focuses on the overall program design and the experiences of an elementary STEM teacher who participated in the program and implemented the lesson with her students.

Literature Review

Artificial Intelligence (AI) and Machine Learning (ML) in Elementary Curriculum

The integration of AI and ML into elementary education is an emerging area of interest that has the potential to equip young learners with foundational skills critical for the future [1]. As technology continues to evolve, it is becoming increasingly important to expose students to these concepts early on. While AI and ML are traditionally seen as complex and advanced topics, various studies suggest that they can be taught at an elementary level through age-appropriate methods and interactive tools [2-8]. Early exposure to age-appropriate concepts and simplification of the foundational principles of AI—such as pattern recognition, decision-making, and predictions—students can begin to understand how machines "learn" and interact with data. As Lin et al. [9] suggest, understanding this process is key for children to develop effective mental models for engaging with AI and the smart devices they interact with daily. Additionally, research indicates that hands-on AI learning experiences that are relatable to the students and are not abstract can provide a tangible understanding of ML for elementary students [10,11]. Examples include: utilizing data related to Disney Princesses, the concept of selfies, toys, current events, fake news, etc. [11]. As such, these simple interactive activities not only allow children to engage with and train machine learning models without requiring deep technical knowledge but also introduce the fundamentals of machine learning, potentially inspiring the next generation of AI researchers and software developers [10-11]. Although there are risks and challenges associated with AI and ML, embedding these activities within subjects

like math, science, and even art, allows educators to show students how these technologies connect to real-world problems, while also enhancing their knowledge and skills, learning attitudes, and interests in technology [12].

Teacher Professional Development (PD) for ML

The success of integrating Machine Learning (ML) into the elementary curriculum is heavily dependent on the preparedness of educators. Traditional teacher professional development (PD) programs often focus on subject-specific content or pedagogical strategies, but with the growing importance of AI and ML, there is a clear need for professional development that specifically targets these areas. Research highlights that teachers require foundational training in both the technical and ethical aspects of AI and ML to feel confident in teaching these topics [1, 13]. Thus, effective PD for teaching ML should emphasize curriculum integration, providing teachers with concrete examples of how to incorporate AI and ML into existing lesson plans [13,14]. Teachers often express concerns about the time and resources needed to redesign their curriculum to accommodate new topics [13], so PD should offer clear guidelines and ready-made materials that align with educational standards. Additionally, teacher PD must focus not only on the technical aspects of ML but also on the ethical and societal impacts of AI [1, 10, 13]. This is important because understanding the real-world implications of these technologies is critical for fostering critical thinking in students. As AI and ML continue to evolve, continuous PD is essential to keep educators up to date with the latest developments and pedagogical practices, ensuring that they are equipped to teach these subjects effectively [13].

Research by Lindner et al. [15] and Sanusi et al. [16] underscores that many teachers lack the necessary knowledge and experience to effectively introduce AI and ML concepts to students. Given this gap in teacher preparation, addressing it has become a significant challenge [17-20], and thus we have developed a 6-week virtual program, entitled "Summer Web-based Institute for Technologies in CompSci and Healthcare" (SWITCH) for teachers to enhance their teaching self-efficacy in machine learning.

Summer Web-Based Institute for Technologies in CompSci and Healthcare (SWITCH)

The **SWITCH RET** (Research Experience for Teachers) program is a 6-week, paid virtual summer internship designed to immerse computer science, technology, and programming teachers in discovery-based STEM research. Funded by the NSF Engineering Research Center entitled Precise Advanced Technologies and Health Systems for Underserved Populations (PATHS-UP; EEC-1648451) and NSF Expeditions in Computing grant entitled Seeing Under the Skin (NSF #: CCF-1730574), the SWITCH RET program offers teachers the opportunity to gain hands-on experience in computer science, engineering, and health technologies. The program aims to enhance teachers' understanding of STEM fields, provide them with research experience, and help them develop classroom-ready lessons to inspire students to pursue STEM careers. Participants engage in virtual research through Rice University, develop lesson plans based on their research projects, and create a research poster. Teachers also receive mentorship

from graduate students, attend weekly meetings with faculty, and collaborate on lesson development with the program's curriculum staff. Teachers are required to submit weekly blog posts, create lesson plans for publication, and implement the lessons in their classrooms during the following academic year. The program offers a stipend, networking opportunities, and access to a community of educators and researchers, making it a valuable professional development experience for STEM teachers wanting to learn more about machine learning. It is designed to cater to individuals at any level and ensures participants learn something new regardless of their background.

Methodology

Retrospective analysis of weekly reflective blog posts and a thirty-minute interview with the elementary teacher after the program served as our primary data sources to help us understand the teacher's experience in the program and how the teacher integrated machine-learning concepts into 3rd to 5th-grade classrooms. The weekly blog posts provided valuable insights into the teacher's thoughts, challenges, and growth throughout the program, and offered a detailed, ongoing account of how she engaged with the material and the ways in which she processed her learning.

For data analysis, the researcher read through the transcripts of the interview and the teacher's weekly reflective blog posts, taking an inductive approach to summarizing the findings. Given that this was a single case study, the analysis did not involve formal coding or the creation of specific themes. Instead, the researcher focused on providing an overall summary of what was learned from the data. The inductive approach allowed for a more holistic understanding of the teacher's experience, with the researcher drawing insights directly from the content of the blog posts and interview transcripts without pre-existing categories or frameworks. By closely reviewing the data, the researcher was able to identify key observations and takeaways related to the teacher's integration of machine-learning concepts into her 3rd to 5th-grade classroom. This approach emphasized a narrative-driven synthesis and highlighted the teacher's reflections, challenges, and successes in implementing new content, rather than focusing on granular coding or theme development. The resulting summary provided a clear, accessible overview of the teacher's learning journey in the program.

In terms of the teacher's background, she was a computer science major but did not have prior knowledge of machine learning. Her decision to pursue this program was driven by a personal interest in learning about ML, and she saw it as an opportunity to expand her understanding of new features and techniques in the field. She implemented her lesson at a charter school in a suburban area, where she served as the STEM teacher for 3rd-5th graders. The school enrolls a predominantly economically disadvantaged student body, with 85% of students coming from economically disadvantaged households. Additionally, 98.4% of the

student population is from minority backgrounds, including 45% Hispanic and 42% Black or African American.

Findings and Discussion

The teacher's blog posts provided valuable insights into how she was learning and processing the material during the program. She frequently made connections between the faculty lectures and the hands-on work she was doing with various datasets, reflecting on how these experiences complemented each other.

> "*These results made me think about something that Dr. Sabharwal said about the limitations of machine learning…[*and how*] computers cannot reason and that their conclusions can be hard to understand or explain*."

Throughout the program, she consistently thought about her upcoming project and how she could design lesson plans that offered students both choice and creative freedom.

> "*After experimenting with the process, [we] discussed ideas for our own project. We want to create a project where students can have some creativity and choice and help their community with machine learning*."

The blog posts revealed that she was excited by the new concepts she was learning related to machine learning and data, often expressing a desire to explore certain topics in greater depth. She posed numerous questions in her posts, linking her background knowledge to the faculty presentations and the datasets she was working with.

> *"I think this is really interesting and something I definitely want to learn more about* [referring to mitigating biases]. *I know the fetal health dataset I used this week relied on manual data labeling, and I wonder if there is any bias in the dataset."*

Additionally, she discussed the challenges she faced when working with datasets, highlighting the need to relearn or redo portions of her work to ensure accuracy.

> "*Looking at the confusion matrices taught me that just looking at the accuracy is not enough! There can be cases where your machine learning model performs really badly, but it does not show up in your final accuracy score…after realizing SMOTE would not work for my text dataset, I read some more articles and saw that there were a few strategies…but most were still in the research or theoretical phase. There was no function in scikit learn that could help me*!" She then attempted some strategies she read about.

These reflections provided a detailed view of what the learning process looked like during the six-week research experience and some of the struggles and questions she had. This

research experience was followed by applying the knowledge gained through the experience in their classroom by engaging students in a hands-on machine learning project. This particular teacher presented her lesson to over 300 3rd to 5th-grade students that spanned four class periods. She explained that the lesson planning tools provided by the SWITCH program made it easier to integrate machine learning and its concepts into the classroom.

She began her lesson planning by considering how to make complex concepts like AI and machine learning accessible to her students. She reflected on how she could relate these topics to the way students themselves learn.

> *"How can I relate it [*ML and AI*] to how they [*students*] learn and how computers learn? How is it similar?"*

This approach helped her frame the lesson in a way that was both understandable and engaging for young learners. The lesson itself started by explaining the fundamental difference between coding and AI. The teacher emphasized that coding involves giving the computer explicit instructions on what to do, whereas AI allows the computer to learn independently. She clarified this distinction by stating,

> "*When you do coding, you give computer directions of exactly what you want it to do, AI is different because the computer is like learning on its own*."

This explanation set the stage for students to understand the concept of machine learning in a more intuitive way and understand how computer learns.

For this particular lesson, students were tasked to train their AI model to distinguish between trash and fish and then use the trained model to clean up the ocean using the Machine Learning for Kids platform [20]. The teacher guided the students through the process of training the program with various examples. As students fed more training data into the model, they observed how the AI's ability to correctly identify objects improved, and thus offered a hands-on demonstration of machine learning in action.

This process also served as a natural entry point for discussing bias in AI. The teacher introduced the concept by showing a series of fish images, followed by a crab that was incorrectly labeled as trash. This misclassification sparked a discussion among the students about why the AI might have made that error. The conversation was then expanded to include other everyday examples of bias, encouraging students to think critically about the fairness and accuracy of AI systems.

The teacher observed that her fifth-grade students were particularly adept at discussing the impact and bias of AI. They were able to think more critically about the material compared to the younger students. The class was also highly engaged when discussing how technologies like

Alexa and Netflix use AI to make recommendations. Students expressed a strong interest in learning about things that they use regularly and learning how these systems work.

In sum, our findings indicate that introducing machine learning at younger educational levels is both feasible and engaging for the students. The virtual research experience provided educators with the essential knowledge and skills to incorporate these concepts into their classroom lessons. The program's collaborative environment, usage of real-time data, and the opportunity for teachers to create lessons based on their individual interests proved effective in making AI and ML concepts accessible and relevant for students.

Limitations

We acknowledge that this study is based on the case of a single teacher, which limits the generalizability of the findings. Future research should include a broader sample of teachers to explore how different educators implement lessons in their classrooms. Additionally, observational studies focusing on classroom engagement could provide valuable insights that teachers may not be able to fully observe themselves.

Conclusion

Professional development programs like the one explored in this study are crucial for equipping teachers with the knowledge and skills to bring emerging technologies like AI into the classroom. As we live in an increasingly tech-rich era where AI is shaping nearly every aspect of our lives, it is essential that students are introduced to these concepts early on. As such, teachers play a pivotal role in breaking down complex topics like machine learning and helping students understand how these technologies work and how they impact our world. While it is entirely possible to bring AI and ML into elementary classrooms, the real challenge lies in preparing teachers to effectively teach these concepts. Programs like SWITCH are key in this process, as they provide teachers with real-world connections, research-backed strategies, and a network of like-minded teachers. With this support, teachers can collaborate with curriculum staff to adapt cutting-edge ideas to a level that is engaging and accessible for young students. By participating in such professional development programs, educators can build their own understanding and, in turn, pass on this valuable knowledge to their students, and prepare them to navigate and engage with the AI-driven world of tomorrow

References

[1] Arriola-Mendoza, J., & Valerio-Ureña, G. (2024). Essential Elements for Implementing AI Tools in Elementary School: A Systematic Literature Review. *Education Sciences*, *14*(12), 1292. https://doi.org/10.3390/educsci14121292

[2] Kim, K., & Kwon, K. (2023). Exploring the AI competencies of elementary school teachers in South Korea. *Computers and Education: Artificial Intelligence*, *4*, 100137. https://doi.org/10.1016/j.caeai.2023.100137

[3] Rodríguez-García, J. D., Moreno-León, J., Román-González, M., & Robles, G. (2020a). Introducing Artificial Intelligence Fundamentals with LearningML: Artificial Intelligence made easy; Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality;(pp. 18–20).

[4] Rodríguez-García, J. D. R., Moreno-León, J., Román-González, M., & Robles, G. (2020b). LearningML: A Tool to Foster Computational Thinking Skills through Practical Artificial Intelligence Projects; *Revista de Educación a Distancia*; *20*(63).

[5] Rodríguez-García, J. D., Moreno-León, J., Román-González, M., & Robles, G. (2021). Evaluation of an online intervention to teach artificial intelligence with learningML to 10-16-year-old students. In *Proceedings of the 52nd ACM technical symposium on computer science education* (pp. 177–183).

[6] Sakulkueakulsuk, B. S.;Witoon, P. Ngarmkajornwiwat, P. Pataranutaporn, W. Surareungchai, P. Pataranutaporn, P. Subsoontorn (2018). "*Kids making AI: Integrating Machine Learning, Gamification, and Social Context in STEM Education"*. 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), 4–7 December 2018, Wollongong, NSW, Australia Page 1005 – 1010.

[7] Lin, P.-Y., Chai, C.-S., Jong, M. S.-Y., Dai, Y., Guo, Y., & Qin, J. (2021). Modeling the structural relationship among primary students' motivation to learn artificial intelligence. *Computers and Education: Artificial Intelligence*, *2*, 100006. https://doi.org/10.1016/j.caeai.2020.100006

[8] Relmasira, S. C., Lai, Y. C., & Donaldson, J. P. (2023). Fostering AI Literacy in Elementary Science, Technology, Engineering, Art, and Mathematics (STEAM) Education in the Age of Generative AI. *Sustainability*, *15*(18), NA-NA. https://doi.org/10.3390/su151813595

[9] Touretzky, D., Gardner-McCune, C., & Seehorn, D. (2023). Machine Learning and the Five Big Ideas in AI. *International Journal of Artificial Intelligence in Education*, *33*(2), 233–266. https://doi.org/10.1007/s40593-022-00314-1

[10] Zhou, X., Brummelen, J. V., & Lin, P. (2020). *Designing AI Learning Experiences for K-12: Emerging Works, Future Opportunities and a Design Framework* (No. arXiv:2009.10228). arXiv. https://doi.org/10.48550/arXiv.2009.10228

[11] 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*, *3*, 100065. https://doi.org/10.1016/j.caeai.2022.100065

[12] Ottenbreit-Leftwich, A., Glazewski, K., Jeon, M., Jantaraweragul, K., Hmelo-Silver, C. E., Scribner, A., Lee, S., Mott, B., & Lester, J. (2023). Lessons Learned for AI Education with Elementary Students and Teachers. *International Journal of Artificial Intelligence in Education*, *33*(2), 267–289. https://doi.org/10.1007/s40593-022-00304-3

[13] Tang, J., Zhou, X., Wan, X., Daley, M., & Bai, Z. (2023). ML4STEM Professional Development Program: Enriching K-12 STEM Teaching with Machine Learning. *International Journal of Artificial Intelligence in Education*, *33*(1), 185–224. https://doi.org/10.1007/s40593-022-00292-4

[14] Karalekas, G., Vologiannidis, S., & Kalomiros, J. (2023). Teaching Machine Learning in K-12 Using Robotics. *Education Sciences*, *13*(1), NA-NA. https://doi.org/10.3390/educsci13010067

[15] Lindner, A., Romeike, R., Jasute, E., & Pozdniakov, S. (2019). Teachers' perspectives on artificial intelligence. In *12th International conference on informatics in schools,"Situation, evaluation and perspectives", ISSEP*.

[16] Sanusi, I. T., Oyelere, S. S., Vartiainen, H., Suhonen, J., & Tukiainen, M. (2022). *A systematic review of teaching and learning machine learning in K-12 education. 28*(5), 5967-5997. https://doi.org/https://doi.org/10.1007/s10639-022-11416-7

[17] Rauber, M. F., & Gresse Von Wangenheim, C. (2023). Assessing the Learning of Machine Learning in K-12: A Ten-Year Systematic Mapping. *Informatics in Education*, *22*(2), 295–328. https://doi.org/10.15388/infedu.2023.11

[18] Chai, C. S., Lin, P.-Y., Jong, M. S.-Y., Dai, Y., Chiu, T. K. F., & Qin, J. (2021). Perceptions of and Behavioral Intentions towards Learning Artificial Intelligence in Primary School

Students. *Educational Technology & Society*, *24*(3), 89–101. https://www.jstor.org/stable/27032858

[19] Marques, L. S., Gress von Wangenheim, C., & Hauck, J. C. R. (2020). *Teaching Machine Learning in School: A Systematic Mapping of the State of the Art. 19*(2), 283–321. https://doi.org/https://doi.org/10.15388/infedu.2020.14

[20] Machine Learning for Kids. https://machinelearningforkids.co.uk/