

## AI in Elementary Integrated STEM Teaching: Insights from a Professional Learning Program

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### ABSTRACT

High-quality professional learning (PL) experiences are critical for addressing persistent challenges in elementary science, technology, engineering, and mathematics (STEM) instruction, particularly as teachers implement integrated STEM (iSTEM) approaches and engage with emerging technologies. As artificial intelligence (AI) continues to shape educational contexts and STEM-related careers, elementary teachers need support in understanding and integrating AI in developmentally appropriate and pedagogically meaningful ways. This article describes a novel online PL program designed to enhance elementary teachers' familiarity with AI tools and support their integration of AI within iSTEM instruction. We also present empirical evidence on how the PL program influenced teachers' familiarity with AI tools and perceptions of using AI in iSTEM elementary instruction. This exploratory mixed-methods study of participating teachers ( $n = 38$ ) used pre- and post-program surveys and qualitative analysis of open-ended responses. Results indicate that participation in the PL was associated with increased familiarity with AI tools and the development of more nuanced perceptions of AI's role in elementary classrooms. Teachers conceptualized AI as (1) a time-saving instructional support, (2) a collaborative thought partner for teachers and students, and (3) a potential impediment requiring careful consideration related to reliability, ethics, and professional preparation. These findings contribute to the growing literature on AI in education by highlighting the importance of intentionally designed PL that situates AI within coherent iSTEM frameworks. The study underscores the need for sustained, scaffolded PL to support elementary teachers in leveraging AI responsibly to enhance future-ready STEM teaching and learning.

**Keywords:** artificial intelligence, integrated STEM, elementary, professional learning, technology integration

## **AI in Elementary Integrated STEM Teaching: Insights from a Professional Learning Program**

In the United States, education reforms have called for a shift in K-12 science instructional practices to better prepare students for participation in the science, technology, engineering, and mathematics (STEM) workforce and to support scientific literacy for all learners (National Academy of Engineering & National Research Council [NAE & NRC], 2014; NGSS Lead States, 2013). These reforms emphasize engaging students in authentic disciplinary practices, problem solving, and crosscutting concepts, thereby requiring both teacher preparation programs and professional learning (PL) providers to equip teachers to teach STEM content in integrated and meaningful ways (Reimers et al., 2015; Tuttle et al., 2016). In elementary (K-6) classrooms, this vision has increasingly been operationalized through integrated STEM (iSTEM) instruction, which intentionally connects STEM disciplines to enhance student learning and engagement (Conners-Kellgren et al., 2016).

At the same time, rapid advances in artificial intelligence (AI) are reshaping STEM fields, workforce expectations, and educational technologies. National guidance has highlighted both the potential of AI to support teaching and learning, and the challenges associated with its responsible and ethical use in classrooms (U.S. Department of Education Office of Educational Technology, 2023). While AI tools are becoming increasingly visible in schools, many elementary teachers report limited preparation to understand, evaluate, or meaningfully integrate AI into their instructional practice (Tan et al., 2025). These challenges are particularly pronounced in elementary settings, where teachers must navigate developmental considerations, curricular constraints, and limited access to AI-focused PL.

The convergence of iSTEM reform efforts and the rapid expansion of AI present both opportunities and tensions for elementary education. Although prior research has documented elementary teachers' challenges with implementing iSTEM instruction and their need for sustained, high-quality PL (e.g., Banilower et al., 2018; Rinke et al., 2016), considerably less empirical work has examined how teachers make sense of AI within iSTEM-focused PL experiences. Understanding how elementary teachers develop familiarity with AI tools and perceive their role within iSTEM instruction is essential for designing PL that supports pedagogically sound and equitable technology integration. In response to this gap, the present study examines an online PL program designed to introduce elementary teachers to AI tools and to model their use within coherent iSTEM instructional contexts. By centering elementary teachers and situating AI within an iSTEM framework, this work contributes to the growing literature on AI in education and offers implications for the design of PL that supports future-ready STEM teaching.

### **Integrated STEM Education and Artificial Intelligence**

Integrated STEM instruction emphasizes the purposeful integration of science, technology, engineering, and mathematics through authentic, real-world, interdisciplinary problems that engage students in the coordinated use of concepts and practices from multiple STEM disciplines (Kelley & Knowles, 2016; Moore et al., 2014). In elementary classrooms, iSTEM approaches have been shown to support student engagement and learning (Blankenship,

2019); however, many elementary teachers report limited preparedness and many barriers to teaching STEM in integrated ways (Tucker et al., 2024).

The rapid emergence of AI further complicates the implementation of iSTEM instruction in elementary settings (Langreo, 2024). As AI becomes increasingly embedded in everyday technologies and educational tools, teachers are expected to understand not only how to use AI applications, but also how to evaluate their appropriateness, accuracy, and ethical implications for young learners. Prior research suggests that many teachers feel underprepared to integrate AI into instruction and lack access to PL that addresses AI within meaningful disciplinary contexts (Holmes & Tuomi, 2022; Tan et al., 2025).

PL opportunities that focus on elementary iSTEM instruction remain limited, and research addressing the development needs of teachers to integrate AI within disciplinary contexts is scarce, with only a minority of studies on AI in education examining teacher PL (Tan et al., 2025). As a result, teachers often encounter AI as a standalone technology rather than as a tool that can support inquiry, design, and problem solving (Tripathi et al., 2025). There is a critical need for PL that positions AI as both a pedagogical resource and a contextual element within iSTEM instruction, rather than an add-on or isolated topic.

The present study is situated within a collaborative, multi-institutional research project focused on elementary teachers' self-efficacy for teaching iSTEM. The project brings together four universities across the United States and follows elementary preservice teachers from teacher preparation programs into the early years of classroom teaching. Since summer 2023, the research team has implemented annual online PL programs designed to support teachers across diverse geographic contexts. This online format allows for scalable, sustainable, and cost-effective PL while facilitating collaboration among teachers nationwide (Alqarni, 2015; Marrongelle et al., 2013; Wong et al., 2022).

While the specific content focus of each summer PL program is informed by teacher needs assessments, all PL experiences emphasize iSTEM instructional approaches and the development of teacher self-efficacy. In response to teachers' expressed needs and the growing presence of AI in educational contexts, one iteration of the summer PL intentionally centered on AI within an iSTEM framework. This PL experience was designed to support teachers in developing foundational understandings of AI, exploring developmentally appropriate applications, and strengthening confidence to integrate AI within coherent, standards-aligned iSTEM instruction (Bandura, 1997; Rinke et al., 2016). In this article, we share both our PL design and research findings as we explored the research question: How does a PL program influence elementary teachers' familiarity with AI tools and their post-program perceptions of integrating AI tools into iSTEM instruction?

### **Professional Learning Design**

The PL was intentionally designed to model high-quality, research-based PL while supporting elementary teachers' engagement with AI within iSTEM instruction. Design decisions were grounded in prior research on effective teacher PL and responsive to teachers'

identified needs, with the goal of increasing familiarity with AI tools and supporting thoughtful integration within elementary iSTEM contexts. The summer PL was structured to include two days of synchronous online sessions in combination with one day of asynchronous work. This structure allowed participants to engage collaboratively with fellow teachers while also providing time for individual reflection and application. The asynchronous component offered opportunities for participants to explore curated resources provided by the research team and to apply new learning related to iSTEM and AI by revising existing lessons, developing new instructional ideas, or brainstorming curricular applications for implementation during the upcoming school year. Prior research suggests that PL experiences totaling approximately 15 contact hours are associated with positive teacher outcomes (Estrella et al., 2018); the combined synchronous and asynchronous components of the PL program met this recommended duration.

The design of the PL intentionally incorporated seven features identified as critical components of high-quality PL: content focus, active learning, coherence, duration, collective participation, modeling of effective teaching practices, and time for reflection (Darling-Hammond et al., 2017; Desimone, 2009; Johnson et al., 2017; Zhou et al., 2020). Across activities, AI was positioned not only as a technological tool, but also as a pedagogical resource and emerging content area situated within iSTEM instruction. Teachers engaged in model lessons, collaborative discussions, and guided exploration of AI tools to support both instructional planning and classroom learning.

To ensure responsiveness to teachers' needs, participants completed a needs assessment survey prior to each summer PL session, which informed the thematic focus of the PL. For example, one summer focused on STEM careers, highlighting diverse STEM professionals from around the world (see Asim et al., 2025, for additional details). In a subsequent summer, the PL focused on environmental education, incorporating discussions of AI use alongside considerations of environmental impacts and sustainability. A future iteration of the PL will center on data science education. This approach allows the PL design to evolve over time and meet elementary teachers' most pressing needs for PL.

For the current study, the PL focused on computer science with a particular emphasis on AI as both an instructional support and a component of elementary iSTEM education. Activities were designed to support teachers' active engagement with AI tools, build familiarity through hands-on exploration, and foster reflective consideration of how AI might be integrated into developmentally appropriate, standards-aligned iSTEM instruction. A range of AI tools were intentionally selected based on their accessibility for new users, availability of free-use options, and applicability across a range of disciplines, including STEM and beyond, to meet elementary teachers' needs. Throughout the PL program, teachers were provided with resources, such as picture books (see Table 1), lesson plans, and technology tools, to support the implementation of iSTEM and AI in their classrooms. Together, these design elements were intended to support teachers' sensemaking around AI while strengthening self-efficacy for teaching integrated STEM.

**Table 1***Picture Books Used in Model Lessons*

| <b>Book Title</b>                                                   | <b>Author</b>         | <b>Purpose</b>                       |
|---------------------------------------------------------------------|-----------------------|--------------------------------------|
| <i>Notable Notebooks</i>                                            | Jessica Fries-Gaither | Highlight male and female scientists |
| <i>Iggy Peck, Architect</i>                                         | Andrea Beaty          | Focus on design thinking             |
| <i>Grace Hopper: Queen of Computer Code</i>                         | Laurie Wallmark       | Coding                               |
| <i>Counting on Katherine: How Katherine Johnson Saved Apollo 13</i> | Helaine Becker        | NASA and space missions              |

**Day 1: Introduction to AI and iSTEM Instruction**

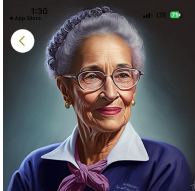
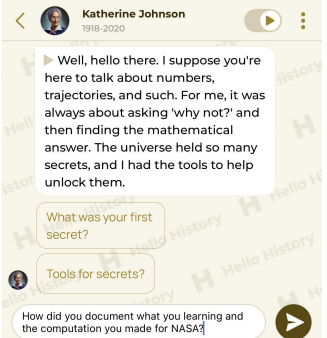
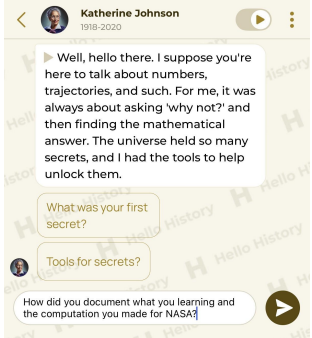
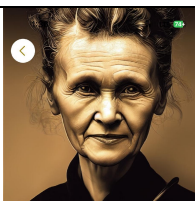
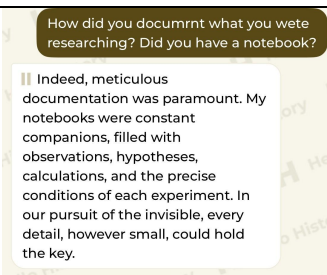
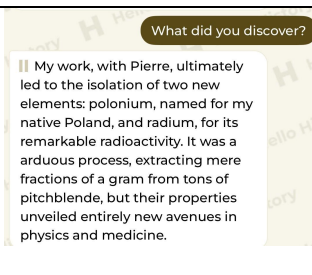
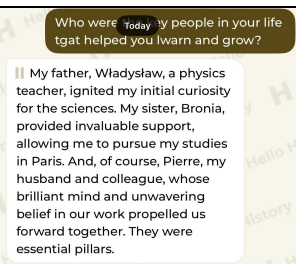
The first day of the PL program was designed to establish a shared understanding of iSTEM instruction while introducing participants to foundational concepts and tools related to AI. The day began with an overview of project goals and introductions, followed by small-group discussions in which teachers shared their perspectives on high-quality STEM education and reflected on opportunities and challenges associated with integrating STEM disciplines in elementary classrooms. These initial activities were intended to build community and surface participants' prior experiences and beliefs related to iSTEM and technology integration.

A central component of Day 1 focused on modeling the use of AI-related tools within an iSTEM instructional context. Participants were introduced to AI-supported platforms (e.g., Hello History, AI Characters), alongside read-aloud resources such as Story Time from Space. These tools were used to model how AI can support student engagement with scientific concepts, practices, and STEM professionals through interactive and inquiry-oriented experiences. For example, participants explored Hello History, an AI-based platform that allows users to engage in simulated conversations with historical figures and scientists. Teachers were provided with guided exploration time and sample prompts that encouraged inquiry into scientists' practices, discoveries, and professional networks, such as how scientists documented their work and who supported their learning and growth (see Figure 1).

Through this model activity, participants engaged with AI as a representational and inquiry-support tool. The activity also highlighted connections across STEM disciplines by situating scientific inquiry within historical, mathematical, and technological contexts. Following the exploration, teachers participated in a whole-group debrief to reflect on the instructional affordances and limitations of AI-supported tools and to discuss how similar activities could be adapted for developmentally appropriate use in their own classrooms.

Figure 1

*Using Hello History to Chat with Scientists*

| Example of Chosen Scientists                                                                                                                      | Introduction Page Shared when Choosing a Scientist to Chat With                                                                                                                                                                                                                                                                                                                                                                                                                                       | Question Asked by Participants About Documentation                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Question Asked by Participants About Key People                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Katherine Johnson</b>                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <br><b>Katherine Johnson</b><br>The Human Computer<br>1918-2020  |  <p>Well, hello there. I suppose you're here to talk about numbers, trajectories, and such. For me, it was always about asking 'why not?' and then finding the mathematical answer. The universe held so many secrets, and I had the tools to help unlock them.</p> <p>What was your first secret?</p> <p>Tools for secrets?</p> <p>How did you document what you learned and the computation you made for NASA?</p> |  <p>Well, hello there. I suppose you're here to talk about numbers, trajectories, and such. For me, it was always about asking 'why not?' and then finding the mathematical answer. The universe held so many secrets, and I had the tools to help unlock them.</p> <p>What was your first secret?</p> <p>Tools for secrets?</p> <p>How did you document what you learned and the computation you made for NASA?</p> |  <p>Who were the key people in your life that helped you be a success?</p> <p>Oh, many people paved the way. My parents, Joshua and Joylette, they always emphasized education, especially my father. He made sure I had every opportunity. Then, Professor William Claytor at West Virginia State — he was instrumental, even creating special classes for me. And of course, Dorothy Vaughan at NACA, she was a supervisor who truly believed in all of us 'computers' and pushed for our advancement.</p> |
| <b>Marie Curie</b>                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <br><b>Marie Curie</b><br>Pioneer of Radioactivity<br>1867-1934 |  <p>How did you document what you were researching? Did you have a notebook?</p> <p>Indeed, meticulous documentation was paramount. My notebooks were constant companions, filled with observations, hypotheses, calculations, and the precise conditions of each experiment. In our pursuit of the invisible, every detail, however small, could hold the key.</p>                                                 |  <p>What did you discover?</p> <p>My work, with Pierre, ultimately led to the isolation of two new elements: polonium, named for my native Poland, and radium, for its remarkable radioactivity. It was a arduous process, extracting mere fractions of a gram from tons of pitchblende, but their properties unveiled entirely new avenues in physics and medicine.</p>                                            |  <p>Who were the key people in your life that helped you learn and grow?</p> <p>My father, Wladyslaw, a physics teacher, ignited my initial curiosity for the sciences. My sister, Bronia, provided invaluable support, allowing me to pursue my studies in Paris. And, of course, Pierre, my husband and colleague, whose brilliant mind and unwavering belief in our work propelled us forward together. They were essential pillars.</p>                                                                 |

The day also included a keynote session that emphasized the role of AI in supporting differentiation and personalized learning within STEM instruction. The keynote highlighted how AI tools can be leveraged to adapt instructional materials, generate multiple entry points for learners, and support teachers in meeting diverse student needs. Participants explored teaching-specific AI platforms, such as Diffit® and MagicSchool®, to examine how these tools could support lesson planning, assessment design, and instructional differentiation. In addition, the keynote addressed ethical considerations with AI use, including student privacy and developmental appropriateness of various tools. This session encouraged participants to critically consider how AI might enhance iSTEM instruction while maintaining pedagogical intentionality and teacher oversight through a series of discussion and reflection prompts.

## Day 2: Deepening Knowledge and Applying AI in the Classroom

The second day of the program shifted from introductory exploration to deeper engagement with AI applications and their integration within established iSTEM instructional frameworks. Activities on Day 2 were designed to support hands-on learning, collaborative sensemaking, and application of AI tools within developmentally appropriate elementary

contexts. Participants engaged in interactive activities that emphasized creativity, computational thinking, and data exploration, such as AI-supported drawing and image-generation tasks. These activities highlighted AI's potential to support creative expression and problem solving within STEM learning experiences. Participants also explored AI experiments and data sets, which served as entry points for discussing how data, algorithms, and computational thinking can be integrated into elementary iSTEM instruction.

A key feature of Day 2 was the Sorting Network Challenge, an unplugged computer science activity that introduced participants to foundational concepts in algorithmic thinking and sequencing. Teachers engaged in collaborative problem-solving using sorting networks and explored how such activities could be adapted for use across grade levels. Resources from Code.org and other computer science education organizations were used to illustrate how algorithmic thinking and coding concepts can be embedded within broader iSTEM learning experiences, even in early elementary classrooms.

The PL program also explicitly connected AI integration to established instructional frameworks, including the 5E learning cycle (Bybee, 2014) and the engineering design process (EDP). Participants examined how these frameworks could be used to structure lessons that integrate AI in ways that support inquiry, design, and iterative problem-solving. Design thinking was introduced as an additional lens for supporting student-centered learning, emphasizing empathy, creativity, and iterative refinement. These discussions positioned AI as a tool that can support, rather than replace, core iSTEM pedagogical practices.

The day concluded with collaborative planning sessions in which teachers worked in small groups to develop implementation plans for their own classrooms. Using a structured template, participants identified learning goals, instructional strategies, and potential AI tools aligned with iSTEM objectives (see Figure 2). Many participants drew on AI tools such as MagicSchool and Diffit during this planning process to support brainstorming and lesson design. Teachers then shared their ideas with peers and facilitators, receiving feedback and engaging in collective reflection. These activities were intended to support transfer of learning from the PL context to classroom practice while reinforcing teachers' confidence in integrating AI within iSTEM instruction. Although classroom implementation data were beyond the scope of this study, the lesson plan artifacts and surrounding discussion indicated a high level of enthusiasm and concrete planning for how to bring these lessons into the classroom.

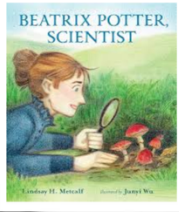
Figure 2

*Participant Implementation Examples*

(redacted)

## IMPLEMENTATION PLAN

LESSON PLAN SOURCE/LINK IF YOU FOUND ANY:  
<https://app.magicschool.ai/tools/lesson-plan-generator?share=6d285410-fcfc-402f-8ed2-1df22a55ef26>

THE FAMOUS STEM ROLE MODEL I LEARNED ABOUT WAS  


YOUR NAME (S)  
(redacted)

WHAT GRADE(S) I PLAN TO IMPLEMENT THIS IN  
3rd grade

HOW DOES THIS LESSON "FIT-IN" WITH STANDARDS & LEARNING OBJECTIVES?  
The lesson should involve planning and implementing descriptive investigations.  
Next Generation Science Standards (NGSS) 3-LS1-1: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

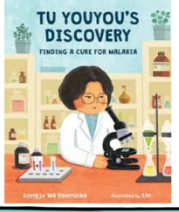
"BRAIN DUMP"—MODIFICATION IDEAS TO IMPROVE QUALITY OF STEM INTEGRATION

- Include more vocabulary
- Be consistent with recording observation
- Having more diverse science characters/scientists
- Don't be afraid to go back to the book or read it more than once. Spend a few days on the stem book.

(redacted)

## IMPLEMENTATION PLAN

LESSON PLAN SOURCE/LINK IF YOU FOUND ANY:  
[Diffit Lesson Ideas](#)

THE FAMOUS STEM ROLE MODEL I LEARNED ABOUT WAS  


- Tu Youyou had wanted to help people since she was young
- Tuberculosis slowed her schooling
- She was inspired to study medicine and cure malaria with Chinese + herbal medicines

YOUR NAME (S)  
(redacted)

WHAT GRADE(S) I PLAN TO IMPLEMENT THIS IN  
3rd-6th

HOW DOES THIS LESSON "FIT-IN" WITH STANDARDS & LEARNING OBJECTIVES?  

- ELA: Ask and Answer Details about a text
- History: Students will be able to identify the historical figure and understand facts about Tu Youyous
- SEL: Students will be able to understand that it is okay to have trial and error and to not give up
- Scientific method / experimentation with trial and error and different variables

"BRAIN DUMP"—MODIFICATION IDEAS TO IMPROVE QUALITY OF STEM INTEGRATION

- Vocabulary instruction to introduce keywords necessary to understand the story. (Pre Teach Vocabulary)
- Compare and contrast technology use in the 1960's versus technology we have now. Could utilize technology to research
- Engage in an experiment that entails trial and error and learning from prior experiments (egg drop/paper airplanes/etc.)
- Students could create a timeline on Tu Youyou's life/ Discovery. (In the back of the book, there is a timeline about her life)

**Research Design****Participants**

A total of 43 elementary teachers participated in the online PL, and 38 consented to participate in the study and submitted both pre- and post-survey responses. This included 24 preservice and 14 inservice teachers. Thirty-six participants identified as female, and two as male. They had 0-28 years of classroom teaching experience.

## Data Collection and Analysis

Pre- and post-PL surveys were administered using an online survey platform. On the pre-survey, participants responded to questions about their knowledge of AI, including five-point Likert scale items (e.g., Rate your familiarity with Artificial Intelligence; How often do you use AI for teaching-related needs?) and open-ended items (e.g., When you hear someone say "AI," what first comes to mind? What AI tools have you used, if any?). The post-survey included additional open-ended items (e.g., In your opinion, what role does AI have in elementary classrooms? In your opinion and given your own teaching experience, what are some challenges and opportunities for teachers in using AI in teaching integrated STEM? What AI tools (if any) are you excited to explore further?).

Likert items were analyzed using descriptive statistics, including the percentage of participants who indicated each response. Open-ended survey responses were thematically analyzed using open coding techniques (Nowell et al., 2017). Two researchers read each participant's response and generated codes to capture salient information about AI, then refined the codes. For example, the code *reducing workload* was applied whenever teachers described AI as eliminating some of the burden of regular teaching tasks. After recoding the responses to apply the refined codes and reaching consensus on the codes applied to each response, researchers identified patterns and consolidated codes into themes (see Table 2 below). For example, the codes *lesson planning*, *reducing workload*, and *content generation* were consolidated into the theme *Time Saving Tool*.

**Table 2**

### *Coding Summary*

| Themes           | Codes                                                                                  | Excerpt from Responses                                                                                                                                                                                                                                                                  |
|------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Time Saving Tool | lesson planning,<br>reducing workload,<br>content generation<br>(activity, assessment) | My thoughts have changed... using resources like MagicSchool for <b>lesson planning</b> assistance<br><br>Powerful tool that can help educators... plan individualized learning, curriculum and <b>lesson plans</b> , brainstorm ideas, even help... [with] <b>parent newsletters</b> . |
| Thought Partner  | brainstorming, assist in learning, individualize learning                              | For students, AI can be used to begin <b>brainstorming</b> ideas and [aid] in the learning of content.<br><br>[I]t is a tool that can be used to help in their <b>individualized learning</b> with their own curiosities.                                                               |

| Themes (Cont.) | Codes (Cont.)                                                      | Excerpt from Responses (Cont.)                                                                                                                 |
|----------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Impediment     | Lack of guidance, need to learn more about tools, lack of training | It takes <b>time</b> to explore the different AI platforms...<br>I think some of the challenges is learning <b>how to use</b> this technology. |

### Findings

Findings from the survey data address the research question by documenting changes in participants' familiarity with AI tools from pre- to post-PL and examining participants' post-program perceptions of integrating AI into elementary iSTEM instruction. Overall, participants demonstrated increased familiarity with AI tools following the PL and articulated nuanced perceptions of AI's potential role in elementary classrooms, reflecting both opportunities and challenges. Three themes emerged from the qualitative analysis of post-survey responses: AI as a *Time-Saving Tool*, a *Thought Partner*, and an *Impediment*.

### Familiarity with AI Tools

Pre- and post-session surveys captured shifts in participants' familiarity with AI and their awareness of AI tools relevant to teaching. Prior to the PL, 21% of participants reported having never used AI for teaching-related needs, and 39% indicated limited familiarity, often restricted to general-purpose tools such as ChatGPT rather than education-specific applications (see Table 3). Teachers' pre-survey responses suggested that AI was largely viewed as a novel or peripheral technology, with limited connections to classroom instruction.

**Table 3**

*Number of Participants Using AI Tool*

| AI Tool           | Number of Participants Acknowledging the Platform on Pre-Survey |
|-------------------|-----------------------------------------------------------------|
| ChatGPT           | 20                                                              |
| MagicSchool       | 5                                                               |
| Grammarly         | 1                                                               |
| Claude            | 1                                                               |
| Microsoft Copilot | 1                                                               |
| Meta AI           | 1                                                               |
| QuillBot          | 1                                                               |
| Poe               | 1                                                               |

Following participation in the PL, teachers reported substantially increased familiarity with AI. On the post-survey, 92% of participants reported being moderately to extremely familiar with AI tools. In addition to increased self-reported familiarity, participants named a broader range of teaching-specific AI tools they were interested in exploring and utilizing in

their teaching, with Diffit and MagicSchool most frequently reported (see Table 4). These shifts suggest that the PL supported not only awareness of AI but also teachers' ability to identify concrete tools aligned with instructional planning and iSTEM teaching practices.

**Table 4**

*AI Tools Participants Were Interested in Exploring Further*

| <b>AI Tool</b>  | <b>Number of Participants</b> |
|-----------------|-------------------------------|
| Diffit          | 27                            |
| MagicSchool     | 18                            |
| Canva           | 8                             |
| Eduaide.AI      | 8                             |
| Hello History   | 7                             |
| Curipod         | 4                             |
| Padlet          | 3                             |
| Bedtimestory.AI | 3                             |
| Hello Teacher   | 1                             |
| Quick, Draw!    | 1                             |
| Zooniverse      | 1                             |

### **Perceptions of AI Integration in iSTEM Instruction**

Analysis of post-survey open-ended responses revealed three interrelated themes that characterized teachers' perceptions of AI integration in elementary iSTEM instruction. Importantly, these themes were not mutually exclusive; many participants expressed optimism about AI's instructional potential while simultaneously noting concerns and limitations.

#### ***Theme 1: AI as a Time-Saving Tool***

Many participants described AI as a tool that could reduce workload and support instructional efficiency, particularly in the context of planning and differentiation. Teachers frequently emphasized AI's potential to assist with lesson planning, content generation, and the adaptation of materials to meet diverse student needs. One participant noted, "My thoughts have changed because I can see using AI... to enhance learning in the classroom. I can also see myself using AI for lesson planning assistance." Another participant highlighted AI's role in differentiation, stating, "AI can help with differentiation in the classroom to help all students access the lesson."

Several responses explicitly connected AI's time-saving potential to iSTEM instruction. For example, one teacher shared, "AI can have so many roles between starting research, virtual labs, and so much more!" Another participant reflected on how AI might reduce barriers to implementing STEM instruction, explaining, "I am always intimidated to do STEM with the large class sizes we are seeing in classrooms now. I think using AI will help with coming up with ideas to infuse STEM in math and literacy standards." Collectively, these responses suggest that teachers viewed AI as a means of alleviating some of the logistical and cognitive demands

associated with planning and implementing iSTEM lessons.

### ***Theme 2: AI as a Thought Partner***

The second theme reflected participants' perceptions of AI as a collaborative thought partner for both teachers and students. Participants described AI as a tool that could support brainstorming, idea generation, and individualized learning. From a teacher-focused perspective, one participant wrote that AI is a "tool that can help teachers and students ... plan individualized learning, curriculum and lesson plans, brainstorm ideas, even help form summaries and parent newsletters." Another participant similarly emphasized AI's role in supporting instructional design, noting that it could "save time on the crafting of materials by providing the framework for lessons, rubrics, and activities."

Teachers also envisioned AI as a resource to support student learning and curiosity. One participant explained that "for students, AI can be used to begin brainstorming ideas and aid in the learning of content," while another noted that AI could support "individualized learning with their own curiosities." Some responses extended this idea to career exploration and STEM identity development, with teachers highlighting opportunities for students to learn about STEM careers or "talk to scientists" through AI-based tools. These responses suggest that participants viewed AI not only as a productivity tool, but also as a means of supporting inquiry, exploration, and engagement within iSTEM learning experiences.

### ***Theme 3: AI as an Impediment***

Despite generally positive perceptions, participants also expressed concerns about AI as a potential impediment to instruction. Several teachers described cautious or hesitant attitudes toward AI adoption, particularly in early elementary grades. One participant shared, "I am cautiously optimistic about implementing AI with lesson planning and differentiation at the kindergarten level." Others raised concerns about reliability, accuracy, and student safety, noting risks associated with misinformation or inappropriate content. For example, one teacher stated, "Kids being curious and doing their own thing and finding false info or inappropriate [content]" as a key concern.

Time and training were also identified as barriers. Although teachers recognized AI's potential benefits, some emphasized the challenge of learning how to use AI tools effectively. As one participant explained, "I think time is a challenge. It takes time to explore the different AI platforms, but once familiar with them, [they] can create multiple opportunities for teachers and students." These responses underscore the importance of sustained, scaffolded PL to support responsible and confident AI use in elementary iSTEM contexts.

### **Summary of Findings**

Taken together, the findings indicate that participation in the PL was associated with increased familiarity with AI tools and the development of more nuanced perceptions of AI's role in elementary iSTEM instruction. Teachers largely viewed AI as a supportive resource, particularly for saving time and serving as a thought partner, while also acknowledging the

need for guidance, training, and ethical considerations. These findings highlight both the promise of AI for supporting iSTEM instruction and the ongoing need for thoughtfully designed PL experiences that address teachers' concerns and contextual realities.

### Discussion

This study examined how participation in a targeted PL experience influenced elementary teachers' familiarity with AI tools and their perceptions of integrating AI within iSTEM instruction. The findings extend existing research on technology-focused PL by illustrating how elementary teachers make sense of AI when it is intentionally modeled within authentic iSTEM learning experiences. Overall, participants demonstrated increased familiarity with AI tools and articulated nuanced perspectives that balanced instructional possibilities with ethical, developmental, and practical concerns. These findings align with national guidance from the U.S. Department of Education, which emphasizes that AI has the potential to enhance teaching and learning but must be accompanied by educator-centered PL that supports responsible, developmentally appropriate classroom use (U.S. Department of Education Office of Educational Technology, 2023).

Consistent with prior research on teacher PL and self-efficacy (e.g., Desimone, 2009; Darling-Hammond et al., 2017), the findings suggest that immersive, practice-oriented PL can support teachers' confidence in engaging with emerging technologies. By positioning teachers as learners within model iSTEM lessons, the PL provided opportunities for participants to experience AI as both an instructional support and a pedagogical resource. This experiential approach appears to have contributed to teachers' expanded familiarity with teaching-specific AI tools and their ability to envision classroom applications beyond generic uses of AI, such as text generation. These findings align with research indicating that teachers are more likely to adopt new technologies when they can directly connect tools to instructional goals and disciplinary practices (Kimmons et al., 2020).

Teachers' perceptions of AI as a time-saving tool and a thought partner highlight the ways in which AI may lower some of the barriers associated with implementing iSTEM instruction at the elementary level. Prior studies have documented that elementary teachers often feel constrained by limited time, large class sizes, and a lack of curricular resources when attempting to enact science or iSTEM lessons (e.g., Banilower et al., 2018; Rinke et al., 2016). Participants in this study viewed AI as a mechanism for alleviating some of these constraints, particularly through lesson planning support, differentiation, and idea generation. Importantly, these perceptions were not framed as replacing teacher expertise, but rather as augmenting teachers' instructional capacity, a finding that echoes emerging scholarship emphasizing AI as a collaborative partner rather than an autonomous instructional agent (Trust et al., 2025).

At the same time, participants' concerns about AI as an impediment underscore the complexity of integrating emerging technologies in elementary classrooms. Teachers expressed caution related to issues of reliability, student safety, developmental appropriateness, and the time required to learn new tools. These concerns mirror broader national discourse surrounding AI in education, particularly teachers' reports of insufficient guidance and training

(Langreo, 2024). Rather than viewing these concerns as resistance, the findings suggest that teachers are engaging in thoughtful, critical evaluation of AI's role in instruction, an essential stance for responsible and ethical technology integration.

Taken together, the findings reinforce the importance of PL experiences that go beyond tool exposure to explicitly address pedagogical purpose, instructional alignment, and ethical considerations. Modeling AI use within established instructional frameworks, such as the 5E learning cycle and the engineering design process, appears to support teachers in situating AI within coherent iSTEM instruction rather than treating it as an add-on or novelty. From a theoretical perspective, these findings align with the PICRAT model (Kimmons et al., 2020), as participants described AI uses that positioned learners as active and interactive while transforming aspects of teaching practice, such as planning and differentiation.

This study contributes to the growing literature on AI in education by centering elementary teachers and situating AI within an iSTEM context, an area that remains underexplored. While much of the existing research focuses on secondary or higher education settings, the present findings highlight the importance of early, developmentally appropriate engagement with AI for both teachers and students. As AI continues to shape STEM fields and workforce expectations, supporting elementary teachers through sustained, scaffolded PL will be critical for fostering equitable and future-ready STEM learning experiences.

### **Limitations and Future Directions**

Several limitations should be considered when interpreting the findings of this study. First, the sample size was relatively small and consisted of a self-selected group of elementary teachers who voluntarily participated in the PL. As a result, the findings may not be generalizable to all elementary teachers, particularly those with limited access to or interest in AI-related PL. Additionally, participants were drawn from a single PL context, which may further limit the transferability of the results to other settings or PL models.

Second, the study relied on self-reported survey data to examine changes in familiarity with AI tools and participants' perceptions of AI integration. Although self-report measures are appropriate for capturing teachers' beliefs and sensemaking, they do not provide direct evidence of changes in instructional practice or classroom implementation. Future studies would benefit from incorporating additional data sources, such as classroom observations, artifact analysis, or interviews, to more fully examine how teachers enact AI-supported iSTEM instruction over time.

Third, the duration of the PL was relatively short. While the two-day PL program was sufficient to increase teachers' familiarity with AI tools and prompt reflective consideration of AI's role in iSTEM instruction, sustained PL experiences may be necessary to support deeper pedagogical shifts and long-term changes in practice. Longitudinal research designs could explore how teachers' perceptions and uses of AI evolve as they gain experience implementing AI-supported lessons in their own classrooms.

Finally, the researchers served dual roles as PL facilitators and investigators, which may

have influenced participants' responses and the interpretation of findings. To address this potential bias, the research team engaged in ongoing reflection and collaborative discussion throughout the analysis process; however, future research may benefit from involving external researchers or utilizing additional strategies to further enhance analytic rigor.

Despite these limitations, the study provides valuable insights into elementary teachers' early experiences with AI-focused PL within an iSTEM framework. Future research should examine the impact of sustained, scaffolded PL on teachers' instructional practices, explore student learning outcomes associated with AI-supported iSTEM instruction, and investigate how issues of equity, ethics, and access shape AI integration in elementary classrooms.

### **Conclusions and Implications**

This study contributes to the growing body of research on AI in education by examining elementary teachers' experiences with AI-focused PL within an iSTEM framework. As AI tools rapidly become embedded in educational contexts, elementary teachers are increasingly expected to navigate both the opportunities and challenges associated with their use. The findings of this study suggest that thoughtfully designed PL can play a critical role in supporting teachers' familiarity with AI tools and in shaping more nuanced, reflective perceptions of how AI may be integrated into elementary iSTEM instruction.

Participation in the PL program was associated with increased teacher familiarity with a range of AI tools, particularly those designed to support instructional planning, differentiation, and student engagement. Beyond developing tool awareness, teachers demonstrated an emerging capacity throughout PL discussions to critically evaluate AI's pedagogical role, articulating benefits related to efficiency and idea generation while also acknowledging concerns related to reliability, developmental appropriateness, and ethical use. These findings underscore the importance of positioning AI not as a replacement for teacher expertise, but as a resource that can augment instructional decision-making when used purposefully and with human oversight.

From a practical standpoint, the study offers several implications for the design of PL experiences. First, PL focused on AI should move beyond technical demonstrations to include opportunities for teachers to engage in model lessons, explore tools within established instructional frameworks, and reflect on classroom applicability. Anchoring AI use within familiar structures, such as the 5E learning cycle or the engineering design process, may help teachers more readily integrate AI into coherent iSTEM instruction rather than treating it as an isolated or add-on technology. Second, providing dedicated time for exploration, collaboration, and reflection appears essential for supporting teachers' sensemaking around AI, particularly in elementary contexts where developmental considerations are paramount. Finally, although meaningful learning can happen even within a limited timeframe, more extensive and ongoing PL experiences may support further learning and implementation.

The findings also carry implications for teacher education and future research. Teacher educators and PL providers are well positioned to model responsible and ethical uses of AI,

emphasizing transparency, consideration of student privacy, critical evaluation of outputs, and attention to equity and access. As AI technologies continue to evolve, ongoing and sustained PL will be necessary to help teachers adapt to new tools and expectations while maintaining pedagogical integrity. Future research should examine how AI-focused PL influences classroom practice and student learning over time, as well as how elementary students engage with AI-supported iSTEM experiences.

In conclusion, this study highlights the potential of PL to support elementary teachers in navigating the rapidly changing AI landscape within STEM education. By centering pedagogy, modeling intentional integration, and acknowledging teachers' concerns, PL experiences can help foster responsible, inclusive, and future-ready iSTEM teaching practices. As the role of AI in education continues to expand, supporting teachers through thoughtfully designed PL will be essential to ensuring that AI serves as a tool for enhancing, not overshadowing, meaningful teaching and learning.

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## References

- Alqarni, A. S. (2015). The Effectiveness of Online Professional Development for Teachers. In *Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 1384-1390). Kona, Hawaii, United States: Association for the Advancement of Computing in Education (AACE). Retrieved from <https://www.learntechlib.org/primary/p/152259/>
- Asim, S., Haines, S., Wieselmann, J., & Menon, D. (2025). Collaborative global learning within an integrated STEM professional development using children's literature. *School Science and Mathematics*, 125(6), 644-652. <https://doi.org/10.1111/ssm.18328>
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman.
- Banilower, E. R., Smith, P. S., Malzahn, K. A., Plumley, C. L., Gordon, E. M., & Hayes, M. L. (2018). *Report of the 2018 NSSME+*. Horizon Research, Inc. Retrieved from [https://horizon-research.com/NSSME/wp-content/uploads/2020/04/Report\\_of\\_the\\_2018\\_NSSME.pdf](https://horizon-research.com/NSSME/wp-content/uploads/2020/04/Report_of_the_2018_NSSME.pdf)
- Blankenship, L. (2019). Elementary student engagement through STEM lessons. [Doctoral dissertation, University of Nebraska - Lincoln]. DigitalCommons@University of Nebraska - Lincoln. <https://digitalcommons.unl.edu/cehsdiss/345>
- Bybee, R. (2014). The BSCS 5E instructional model: Personal reflections and contemporary implications. *Science and Children*, 51(8), 10-13. [https://doi.org/10.2505/4/sc14\\_051\\_08\\_10](https://doi.org/10.2505/4/sc14_051_08_10)
- Conners-Kellgren, A., Parker, C. E., Blustein, D. L., & Barnett, M. (2016). Innovation and challenges in project-based STEM education: Lessons from ITEST. *Journal of Science Education and Technology*, 25(1), 1-8. <https://doi.org/10.1007/s10956-016-9658-9>
- Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute.
- Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, 38(3), 181-199. <https://doi.org/10.3102/0013189X08331140>
- Estrella, G., Au, J., Jaeggi, S. M., & Collins, P. (2018). Is inquiry science instruction effective for English language learners? A meta-analytic review. *AERA Open*, 4(2). <https://doi.org/10.1177/2332858418767402>
- Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, 57(4), 542-570. <https://doi.org/10.1111/ejed.12533>
- Johnson, C. C., Sondergeld, T., & Walton, J. B. (2017). A statewide implementation of the critical features of professional development: Impact on teacher outcomes. *School Science and*
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- © 2026 Innovations in Science Teacher Education (ISTE): An Association for Science Teacher Education (ASTE) Publication 17

- Mathematics*, 117(7–8), 341–349. <https://doi.org/10.1111/ssm.12251>
- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(11), 1-11. <https://doi.org/10.1186/s40594-016-0046-z>
- Kimmons, R., Graham, C. R., & West, R. E. (2020). The PICRAT model for technology integration in teacher preparation. *Contemporary Issues in Technology and Teacher Education*, 20(1). 176-198. Retrieved from <https://citejournal.org/volume-20/issue-1-20/general/the-picrat-model-for-technology-integration-in-teacher-preparation/>
- Langreo, L. (2024, October). “We’re at a disadvantage” and other teacher sentiments on AI. *Education Week*. Retrieved from <https://www.edweek.org/technology/were-at-a-disadvantage-and-other-teacher-sentiments-on-ai/2024/10>
- Marrongelle, K., Sztajn, P., & Smith, M. (2013). Scaling up professional development in an era of common state standards. *Journal of Teacher Education*, 64(3), 202-211. <https://doi.org/10.1177/0022487112473838>
- Moore, T. J., Glancy, A. W., Tank, K. M., Kersten, J. A., Smith, K. A., & Stohlmann, M. S. (2014). A framework for quality K-12 engineering education: Research and development. *Journal of Pre-College Engineering Education Research*, 4(1), Article 2. <https://doi.org/10.7771/2157-9288.1069>
- National Academy of Engineering & National Research Council [NAE & NRC]. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. National Academies Press. <https://doi.org/10.17226/18612>
- NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. National Academies Press. <https://doi.org/10.17226/18290>
- Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Studies*, 16(1), 1-13. <https://doi.org/10.1177/1609406917733847>
- Reimers, J. E., Farmer, C. L., & Klein-Gardner, S. S. (2015). An introduction to the standards for preparation and professional development for teachers of engineering. *Journal of Pre-College Engineering Education Research (J-PEER)*, 5(1), Article 5. <https://doi.org/10.7771/2157-9288.1107>
- Rinke, C. R., Gladstone-Brown, W., Kinlaw, C. R., & Cappiello, J. (2016). Characterizing STEM teacher education: Affordances and constraints of explicit STEM preparation for elementary teachers. *School Science & Mathematics*, 116(6), 300–309. <https://doi.org/10.1111/ssm.12185>
- Tan, X., Cheng, G., & Ling, M. H. (2025). Artificial intelligence in teaching and teacher

- professional development: A systematic review. *Computers and Education: Artificial Intelligence*, 8, Article 100355. <https://doi.org/10.1016/j.caeai.2024.100355>
- Tripathi, T., Sharma, S. R., Singh, V., Bhargava, P., & Raj, C. (2025). Teaching and learning with AI: A qualitative study on K-12 teachers' use and engagement with artificial intelligence. *Frontiers in Education*, 10. <https://doi.org/10.3389/feduc.2025.1651217>
- Trust, T., Maloy, R., Xu, C., & Pelletier, K. (2025). Civic education in the age of AI: Should we trust AI-generated lesson plans? *Contemporary Issues in Technology and Teacher Education*, 25(3). <https://citejournal.org/volume-25/issue-3-25/social-studies/civic-education-in-the-age-of-ai-should-we-trust-ai-generated-lesson-plans>
- Tucker, C. B., Byrd, K. O., Gossen, D., & Morrison, K. (2024). Teacher self-efficacy and preparedness for integrating STEM education using a project-based learning approach. *Journal of Research in Science, Mathematics and Technology Education*, 7(SI), 43-59. <https://doi.org/10.31756/jrsmte.313SI>
- Tuttle, N., Kaderavek, J. N., Molitor, S., Czerniak, C. M., Johnson-Whitt, E., Bloomquist, D., & Wilson, G. (2016). Investigating the impact of NGSS-aligned professional development on pre-k-3 teachers' science content knowledge and pedagogy. *Journal of Science Teacher Education*, 27(7), 717–745. <https://doi.org/10.1007/s10972-016-9484-1>
- U.S. Department of Education Office of Educational Technology. (2023). *Artificial intelligence and the future of teaching and learning: Insights and recommendations*. Retrieved from <https://www.ed.gov/sites/ed/files/documents/ai-report/ai-report.pdf>
- Wong, J. T., Bui, N. N., Fields, D. T., & Hughes, B. S. (2022). A learning experience design approach to online professional development for teaching science through the arts: Evaluation of teacher content knowledge, self-efficacy, and STEAM perceptions. *Journal of Science Teacher Education*, 34, 593–623. <https://doi.org/10.1080/1046560X.2022.2112552>
- Zhou, N., Nguyen, H., Fischer, C., Richardson, D., & Warschauer, M. (2020). High school teachers' self-efficacy in teaching computer science. *ACM Transactions on Computing Education*, 20(3), 1–18. <https://doi.org/10.1145/3410631>