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Perceptions and Barriers to Adopting Artificial Intelligence in K-12 Education: A Survey of Educators in Fifty States

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Chapter

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Abstract

Artificial Intelligence (AI) is making significant strides in the field of education, offering new opportunities for personalized learning and access to education for a more diverse population. Despite this potential, the adoption of AI in K-12 education is limited, and educators' express hesitancy towards its integration due to perceived technological barriers and misconceptions. The purpose of this study is to examine the perceptions of K-12 educators in all 50 states of the USA towards AI, policies, training, and resources related to technology and AI, their comfort with technology, willingness to adopt new technologies for classroom instruction, and needs assessment for necessary infrastructure, such as reliable internet access, hardware, and software. Researchers analyzed regional differences in attitudes towards AI integration in the classroom. The findings suggest the overall positive perception of AI and openness towards its integration. However, disparities in access to technology and comfort levels with technology exist among different regions, genders, and age groups. These findings suggest that policymakers and educators need to develop targeted strategies to ensure equitable access to technology and AI integration in the classroom. The implications of this work are the need for an authentic STEM model for integrating AI into K-12 education and offer recommendations for policymakers and educators to support the successful adoption of AI in the classroom.

Keywords: artificial intelligence, education, emerging technologies, machine learning, innovative pedagogy, integrated STEM

1. Introduction

The rapid advancement of artificial intelligence (AI) and machine learning (ML) includes their integration into various aspects of our daily lives, from image recognition to language understanding [1]. Over the past few decades, AI systems have evolved from rudimentary, remote-controlled devices to sophisticated models capable of generating photorealistic images and interpreting complex language [2, 3]. As AI development accelerates, driven by increasing investments and faster computational

training, its potential impact on society grows [4, 5]. The broad range of AI applications can have both positive and negative consequences, emphasizing the importance for educators, researchers, and the public to understand and engage in discussions about the future of this technology. Continuous advancements in AI-related metrics and publicly available resources will facilitate these essential discussions and guide decisions on the responsible application of AI across various fields [6, 7], including K-12 education where AI integration is increasingly important as educators teach and utilize AI in their classrooms [8].

The rapid proliferation of generative AI technologies, such as OpenAI's ChatGPT-3 and ChatGPT-4, underscores the importance of enhancing STEM education before college enrollment [9]. In the United States, less than half of students who enter science, technology, engineering, and mathematics (STEM) undergraduate curricula as freshmen will graduate with a STEM degree [10], with even greater disparities in the national STEM graduation rates of underrepresented minority students, with around three-quarters leaving STEM disciplines at the undergraduate level [11]. As these technologies become increasingly central to our lives and work in the future, it is critical that educational institutions take a comprehensive approach that begins in early childhood education and scaffolds an authentic STEM model through high school graduation, equipping the next generation with the skills and knowledge they need to thrive [12]. Additionally, the current AI community's lack of diversity can lead to unintended algorithmic bias, highlighting the need for concerted efforts to support underrepresented populations and ensure responsible and ethical AI development, deployment, and evaluation in the future [13].

The importance of integrating artificial intelligence (AI) in K-12 education is underscored by research that demonstrates the achievement of successful learning outcomes for students through a unified set of requirements involving all stakeholders in planning, development, and implementation processes [14–16]. However, before any curriculum revisions are considered, it is crucial to examine the barriers to entry and adoption from educators' perspectives. This issue is further exacerbated by the current crisis of teacher attrition in educational fields, which has been compounded by the pandemic and characterized by a significant number of educators leaving the profession [9, 17]. Adding an extra layer of perceived bureaucracy and workload as a result of AI to their existing job requirements might exacerbate the situation, as identified by Li and Yao [18]. Therefore, it is essential to understand K-12 educators' perceptions and needs concerning AI integration in the classroom to ensure that the technology's introduction is seamless and beneficial to all stakeholders.

Investigating K-12 educators' perceptions of AI and identifying potential barriers to adoption can significantly benefit the education domain and scholarly research and avoid further losses to the profession. By discerning educators' attitudes and perceptions towards AI, researchers can identify potential barriers to adoption and develop interventions to address them, as similar studies have confirmed. This understanding and insight may enhance AI adoption across K-12 education, potentially leading to improved student outcomes and increased efficiency in the classroom. Additionally, analyzing educators' perceptions can inform the development of AI tools and systems that better cater to their needs and preferences, improving the effectiveness and usability of AI tools and facilitating more substantial adoption, and providing outcomes for students. Lastly, exploring educators' perceptions can contribute to the broader educational sphere by offering insights into educators' reception and adoption of new technologies. Such insights can inform strategies for supporting the adoption of other innovative technologies in education and contribute to a more

comprehensive understanding of how technology can be employed to strengthen teaching and learning.

To obtain a comprehensive understanding of the perception, current utilization, and future potential deployment of Artificial Intelligence (AI) in K-12 education, we conducted a survey of educators from all 50 states in the United States. Acknowledging variations in certifications and rank designations across different states, K-12 education is defined as follows: early elementary education ranging from birth to kindergarten, elementary education spanning first to fifth grades, middle school education covering sixth to eighth grades, and high school education encompassing ninth to twelfth grades.

The focus of this study was to investigate the perception, utilization, and potential deployment of Artificial Intelligence (AI) in K-12 education by surveying educators from all 50 states in the United States. We examined policies, training, and existing resources related to technology in general and AI in particular, as well as the comfort level and willingness of educators to adopt new technologies for classroom instruction. We performed a needs assessment to determine the necessary infrastructure, including reliable internet access, hardware, and software. Data includes responses from over 4500 educators from across PK-12 and representing all 50 states. The findings respond to the focal research questions: What are the perceptions and barriers to adopting artificial intelligence in K-12 education?

2. Integration of AI in education

Artificial intelligence (AI) has been in development for decades, and the latest generation of AI applications has been a long time coming [19]. However, the 2020 COVID-19 pandemic accelerated the adoption of technology globally, including in education at all levels, from kindergarten to graduate studies [20]. The pandemic brought about profound changes in the education industry, with AI being at the forefront of these changes. AI has transformed institutional practices and student learning experiences, providing educators and students with valuable tools to improve the quality of education. Educators already benefit from AI through support with administrative tasks, enhancements to personalized learning strategies, AI tutoring programs and access to information anytime, and changes to the way students interact with educational materials.

One way in which AI has improved education is by automating administrative tasks, such as attendance, record keeping, assignment checking, and assessment. These time intensive activities can take away from attention to students. AI tools can free up educators' time and enable them to focus on core teaching responsibilities and individualized learning [21]. Machine learning algorithms can be used to grade multiple-choice questions, while natural language processing can be used to grade essays and written responses. AI-powered assessment tools are increasingly being utilized to administer secure online exams, offering potential benefits such as saved time and increased efficiency [22]. When analyzing large amounts of data, such as student performance data or demographic data, to identify patterns and insights that can inform decision-making, AI tools can save time. For example, predictive analytics can be used to identify students who may be at risk of falling behind, so that educators can provide services [23]. AI can even be used as a scheduling assistant to help educators and administrators schedule student courses and services to meet their needs.

Personalized learning, a hallmark of twenty first century education, is expected of educators in today's student-centered classrooms. AI has the potential to revolutionize personalized learning by providing AI driven learning tools that cater to students' individual needs and learning styles. Educators can provide students with feedback on their progress in real-time, identify gaps in their understanding, and adapt the curriculum to their individual learning needs [24]. This approach enables students to take ownership of their learning and allows them to work at their own pace.

Recent advances in AI have also revolutionized the way students access and interact with educational materials. The use of smart content, such as digitized textbooks, video lectures, and interactive learning modules, has significantly enhanced the accessibility and efficiency of learning materials for students [25, 26]. Discipline specific examples of AI include virtual dissections in anatomy courses where students can interact with layers or specific structures of the body using methods that are very similar to real time dissection sessions [27]. Math tools can recognize mathematical equations from images and support students in developing a solution by showing a detailed process with explanations and interactive graphs to allow for deeper learning [28]. A variety of reading programs recognize students' reading level and provide materials that move them through the progression of learning to read. Augmented reality programs can bring ideas to three dimensions with life-like quality so that student can experience phenomenon [29]. Platforms such as Packback can analyze students' strengths and weaknesses to provide targeted feedback and customized learning experiences. The platforms' ability to facilitate translations into multiple languages promotes inclusivity and diversity, further extending the reach of educational materials [22].

Expanding on the potential benefits of integrating AI into K-12 classrooms, studies have looked at using AI as tutors or to assist in game-based learning. Schofield, Eurich-Fulcer, and Britt [30] reported on early findings of AI tutor services and found that while students may claim that a teacher offers better help than an AI-based computer tutor, they prefer using the tutor and seem to learn more effectively with it. The study included a comprehensive qualitative analysis of eight classrooms using the AI tutors, as well as control and comparison classrooms. The findings reveal three factors that explain this paradox. First, the AI tutor serves as an additional resource rather than replacing the teacher. Second, the use of AI tutors enables teachers to offer more personalized assistance. Third, students have greater control over the type and amount of help they receive from the teacher, making interactions more private and potentially less embarrassing. The results support the benefits of automating aspects of a teacher's role to allow time for more one-on-one attention.

AI can also help with game-based learning, an increasingly popular method of instruction, for which AI has the potential to improve. AI can be used to create games that adapt to students' skill levels and provide immediate feedback, promoting more effective learning [31]. Students can also learn computational thinking, an increasingly important skill set in the modern world through AI computational thinking programs that teach concepts in an engaging and interactive ways [29].

The integration of AI in education has the potential to enhance learning experiences through the provision of various tools and assistive technologies that cater to diverse learning needs. AI-powered predictive text and spell-check tools, for example, can assist students in refining their writing skills by offering real-time suggestions and corrections [32]. Similarly, advanced AI platforms like Grammarly can help students improve their writing style and grammar, thereby enhancing their language proficiency [33].

AI's influence in developing assistive technologies allows options for students needs to be met and increases motivation for students to remain engaged in learning [34]. AI-powered chatbots have also demonstrated the potential to assist students 24/7, enabling them to resolve doubts quickly and efficiently [35]. For example, a university professor utilized a chatbot as one of his teaching assistants and students found the tool to be very helpful [36]. Facial recognition systems implemented in some institutions can enhance security, streamline administrative processes, and monitor student behavior [24].

There are many benefits of integrating AI into classrooms. Each of these tools may have a positive impact on student learning. However, it is essential to recognize that involving teachers in the planning and integration of any new pedagogical tool is critical. As demonstrated by Lee et al. [37] teacher input on the use of AI is essential for success. Lee et al. [37] conducted a study in upper elementary school (ages 8 to 11) classrooms, and their results present insights from interviews with teachers to understand how to support AI integration and introduce PRIMARYAI, a game-based learning environment centered on AI for solving life-science problems. The study's findings concluded that teacher insight into the best methods to support AI integration into the classrooms was paramount for successful game-based learning adoption.

Overall, the integration of AI in education has brought about significant transformations in institutional practices and student learning experiences. The use of AI-powered tools and platforms has led to improved efficiency with administrative tasks, personalized learning, available assistive technology, and access to content and support. With the potential to cater to a range of learning needs, AI-based tools can streamline academic processes, moving away from a one-size fits all model, to foster a supportive personalized learning environment, and enhance students' academic achievements.

Looking ahead to the future, the human-AI collaborative model seems to still be dominant. As Timms [38] outlined, the field of Artificial Intelligence in Education (AIED) has matured enough to move beyond the reliance on computers and tablets, enabling more innovative engagement with students and enhanced teaching effectiveness. The future of AIED involves integrating advancements in robotics and sensor technology, leading to educational cobots assisting teachers and smart classrooms utilizing sensors for innovative learning experiences.

Assuming that schools will still exist in some form in 25 years, with teachers continuing to guide and facilitate student learning, educational cobots could assist teachers in future classrooms. Research in robotics has already shown the potential for robots to help teachers in several areas, such as providing educational materials, conducting assessments, and helping students with special needs [39]. These cobots could offer more personalized assistance, freeing up teachers' time to focus on more individualized learning experiences for their students. Overall, the integration of AI into K-12 education has the potential to revolutionize the way we teach and learn. However, as with any new technology, involving teachers in the planning and integration process is essential for successful adoption and achieving the best possible outcomes for students.

3. Organizational guidance for STEM integration

Numerous professional education organizations offer guidance for integrating AI in various subjects in traditional K-12 school settings. These organizations aim to

bridge the gap between researchers and practitioners, providing up-to-date information on best practices in their respective fields. For example, the National Science Teachers Association (NSTA) offers a plethora of resources, including workshops, webinars, and online courses, for educators to incorporate AI into their STEM curricula while promoting scientific inquiry and engineering design practices [40, 41]. Similarly, the International Society for Technology in Education (ISTE) provides a framework for technology integration, emphasizing the development of digital literacy skills and the responsible use of technology across all subject areas [42]. As integrated STEM education involves the authentic integration of all subjects, many of these organizations have dedicated considerable effort to promoting effective methods and approaches for teaching high-quality integrated STEM education while respecting each subject area's unique qualities and requirements [41, 42].

Incorporating new technologies such as AI into early childhood and elementary education is not yet a widespread practice. However, numerous subject area professional organizations are encouraging the adoption of innovative technologies to improve learning outcomes for students. These organizations often promote the integration of new technologies in the standards they set for their membership. Notably, the National Science Teachers Association (NSTA) and the International Society for Technology in Education (ISTE) are two prominent organizations that advocate for integrated STEM education and the incorporation of new technologies, including AI, into the classroom. While these organizations have been vocal about the benefits of integrating new technologies into education, they are not the only ones advocating for this approach.

The importance of 21st-century skills such as teamwork, collaboration, problem-solving, communication, and creative thinking for students is emphasized in the NSTA Position Statement on STEM Education [41]. This emphasis is also reflected in the Next Generation Science Standards (NGSS), a set of K-12 science standards recommended by the NSTA for adoption and implementation by all states. While not all states have implemented the NGSS, 20 states and the District of Columbia have embraced the standards, and 24 states have created their own versions based on the recommendations [41].

The International Society for Technology in Education (ISTE) also emphasizes the use of technology for learning, promoting its own set of standards that focus on empowering students in seven areas: as digital citizens, knowledge constructors, innovative designers, computational thinkers, creative communicators, and global collaborators [42]. These standards have been adopted by all fifty states in the US and numerous countries worldwide [42]. In addition, ISTE has integrated the Five Big Ideas in AI (**Figure 1**) developed by the AI4K12 Initiative into their standards, which form the foundation of what ISTE proposes all students should know and accomplish regarding AI, including Perception, Representation and Reasoning, Learning, Natural Interaction, and Societal Impact [43].

The National Council of Teachers of Mathematics has outlined the importance of technology in teaching and learning mathematics through its Position Statement on the Strategic Use of Technology in Teaching and Learning Mathematics [44, 45]. According to this statement, regular and strategic use of technologies is crucial for developing essential skills such as reasoning, problem-solving, oral communication, and mathematical sense-making. NCTM further emphasizes that greater access to mathematics education for all students is possible when teachers incorporate technology in their teaching strategies [44].

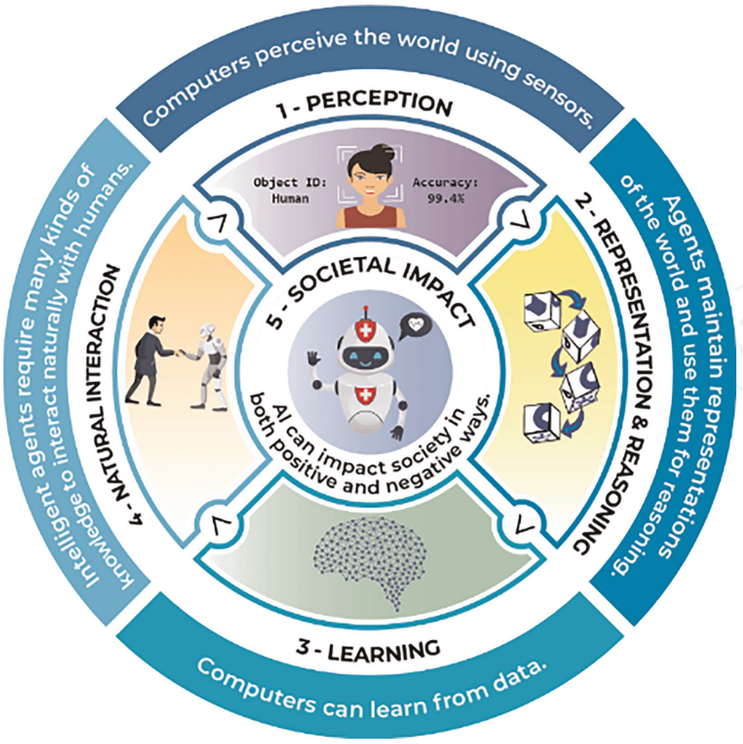

Figure 1.
Five big ideas in AI. Credit: AI4K12 initiative. Licensed under the Creative Commons attribution-noncommercial-ShareAlike 4.0 international license.

The NCTM also acknowledges the importance of digital tools in the Common Core State Standards, a set of federal standards for English Language Arts and Mathematics provided to states. In their Position Statement on Supporting the Common Core State Standards [45], NCTM highlights the significance of using mathematical tools, including digital technology tools, strategically to foster student learning. The organization has also taken steps to incorporate AI in mathematics education. The organization offers webinars as part of professional development for educators on their website, such as "The Future of Mathematics Education: Using Artificial Intelligence to Provide Efficient Feedback" [46], which focuses on using AI as an evaluation tool in the classroom.

Finally, the International Technology and Engineering Educators Association (ITEEA) is an organization that aims to advance engineering and technology education through promoting technology and engineering standards, professional development, publications, conferences, networking opportunities, and classroom resources, all of which promote integrated STEM education [47]. ITEEA has a particular focus on engineering and technology and works to promote technological literacy in both K-12 and higher education environments. The organization offers a range of professional development and classroom resources that center around bringing Artificial Intelligence into the classroom as a necessary inclusion in a quality integrated STEM education experience.

3.1 Other organizations

Non-profit organizations also play a vital role in supporting educators in integrating AI into the classroom. Common Sense Media, a prominent non-profit organization, provides guidance to educators, schools, and families on the appropriate use of

media for students. Common Sense Media recommends that teachers learn to use AI platforms to better understand how students write, the way they ask questions, and give writing prompts to students. Additionally, the organization suggests discussing the ethics of AI tools with students [48].

Both professional education organizations and non-profit organizations aim to facilitate the integration of technology in the classroom while maintaining high standards of education. With the swift evolution of technology, these organizations have been increasing their efforts to research and advise educators on utilizing technology in ways that not only engage students but also enhance their learning experience. The purpose of technology in the classroom must go beyond mere entertainment or a temporary distraction. AI is no exception to this rule, and organizations like Common Sense Media continue to provide new recommendations to educators to effectively utilize AI in the classroom, enabling students to acquire skills that align with the demands of the workforce.

3.2 Investigating teacher readiness

As the integration of AI in education continues to gain importance, it becomes essential to understand the factors that influence educators' adoption of AI and to identify ways to enhance their preparedness and readiness [49]. To explore teacher preparedness and readiness to adopt AI in classrooms, it is necessary to examine the underlying variables that contribute to teachers' ability and willingness to incorporate these innovative technologies effectively. Chiu and Chai [49] conducted a case study that explored the views of teachers on creating, implementing, and refining a formal AI curriculum for K-12 schools. The study addressed the lack of research guiding AI curriculum design, utilizing self-determination theory (SDT) and four basic curriculum planning approaches (content, product, process, and praxis) as theoretical frameworks. Semi-structured interviews were conducted with 24 teachers, half with AI teaching experience and half without. The authors employed thematic analysis to analyze the data. Results suggested that effective curriculum creation should incorporate all four curriculum design approaches, guided by teachers' self-determination to orchestrate student learning experiences. The study also proposed a curriculum development cycle which could help integrate AI into the curriculum more effectively.

Ayanwale et al. [50] investigated the factors influencing Nigerian in-service teachers' behavioral intention and readiness to integrate AI into K-12 education. The results of the study demonstrated that confidence in teaching AI was a predictor of the intention to teach AI, while AI relevance strongly predicted readiness to teach AI. The findings suggest that teachers' confidence and relevance are critical components in successfully integrating AI into education. Educators who are confident in their ability to teach AI are more likely to intend to teach it, while those who perceive the relevance of AI to their teaching are more likely to be prepared to teach it. These findings are consistent with previous studies that suggest teacher preparedness, confidence, and beliefs are crucial components for the successful integration of new technologies in education [49].

Both Chiu and Chai [49] and Ayanwale et al. [50] suggest the need for providing adequate training and support to educators, including addressing their lack of knowledge as a barrier to AI instructional facilitation, to ensure successful adoption of AI in classrooms. Evaluating and addressing educators' skills, confidence, and attitudes towards AI, along with the support they receive from administrators and teacher-preparation programs, is crucial for successful AI integration in education.

4. Methodology

We utilized a mixed-methods approach to explore the perceptions of AI among K-12 educators in all 50 states in the USA and the territory of Puerto Rico. Using Qualtrics, we distributed a survey, approved by the Lindenwood University Institutional Review Board, using social media tags which we identified as common threads for educators. We distributed the survey on two different dates, approximately 10 days apart, to attempt to include a wide range of participants. We sought to understand the policies, training, and available resources in districts concerning technology in general and AI in particular. We examined the level of comfort with technology and the willingness of educators to adopt new technologies for classroom instruction. A needs assessment provided insight on necessary infrastructure, such as reliable internet access, hardware, and software. The sample comprised 4528 educators from a range of districts, including rural, suburban, and urban.

4.1 Survey instrument

We employed a survey instrument that aimed to gather both qualitative and quantitative information (see Appendix A). The survey was constructed to cover various aspects, such as educator demographics, institutional classification, technology experience, and perceived obstacles to AI integration in their districts. We aimed to understand educators' views and encounters regarding AI and technology in their classrooms. The survey's validity was established by utilizing previous research on the challenges and barriers to integrating emerging technologies, specifically AI, into K-12 education, as identified in the literature review. This information was then incorporated into the survey design to address these obstacles comprehensively, such as the lack of resources, training, and infrastructure, allowing for a comprehensive understanding of the factors influencing the adoption and integration of AI technologies in K-12 education. By examining various topics such as district policies, personal experiences, access to resources, and familiarity with AI tools, we sought to gain a complete understanding of the factors that influence the integration and adoption of AI technologies in K-12 education.

5. Results

5.1 Demographics

While participants from all age groups, gender, and ethnicity were included in this study, the majority of participants were between 25 and 34 years of age and more identified as male than female or non-binary. Most participants identified as White/Caucasian as shown in **Table 1**.

The levels at which respondents taught are as follows: second grade had the highest representation with 11.10%, followed closely by the third grade with 10.49%. Kindergarten and first grade were represented with percentages of 9.46 and 9.25%, respectively. Fourth and fifth grade had slightly lower representation percentages of 8.89 and 8.09%, respectively. Sixth, seventh, and eighth grade had similar representation percentages of 7.39, 6.20, and 6.38%, respectively. PreK educators comprised 5.17%, while ninth and tenth grade had representation percentages of 5.41 and 4.96%,

Demographic Category	Percentage
Age Group	
18–24 years	8.77%
25–34 years	53.95%
34–44 years	28.00%
45–54 years	7.16%
55–64 years	2.09%
65 or older	0.02%
Gender Identity	
Female	46.83%
Male	51.16%
Non-Binary	1.16%
Preferred Not to Say	0.84%
Ethnicity/Race	
White/Caucasian	78.95%
Black or African American	6.83%
American Indian or Alaskan Native	5.82%
Asian	4.81%
Native Hawaiian/Pacific Islander	3.38%
Hispanic/LatinX	29.19%
Other	0.20%

Table 1.
Participant demographics.

respectively. The least represented grades were eleventh grade with 3.73% and twelfth grade with 3.48%. Across all levels, gender distribution was relatively even with only slight percentage differences in each grade.

When considering different variables, including region, grade level and demographics, the data suggests a correlation between the age of the educators and the grade levels they teach. Younger educators [18–34] tended to teach younger grade levels (Kindergarten, First Grade, Second Grade) more often, whereas older educators (55–64) tended to teach older grade levels (Seventh Grade, Eighth Grade, Ninth Grade). Interestingly, educators in the 35–44 and 45–54 age groups have a more even distribution of grade levels taught, with a higher percentage teaching middle school grades (Sixth Grade, Seventh Grade, Eighth Grade) and high school grades (Ninth Grade, Tenth Grade, Eleventh Grade, Twelfth Grade).

5.2 Institutional classification

Most of the institutions represented in the sample were public, almost 60%. Private institutions made up 40% of the respondents. Finally, other types of institutions were represented to a very small degree, with only 0.33% of the sample falling under this category, identifying as home schooling. The study included K-12 educators from

all 50 states in the USA, with the highest percentage of participants coming from California, representing 15.66% of the total sample. Other states with a high representation of participants were Florida (8.24%), Texas (1.80%), and Virginia (3.22%). Alaska (6.12%), Arkansas (5.46%), and Colorado (6.05%) were also well-represented in the study. In contrast, states with a lower percentage of representation included Indiana (0.94%), Kansas (0.94%), and Kentucky (0.94%). Additionally, several states had less than 1% representation in the study, including Oklahoma (0.34%), Utah (0.37%), and Wyoming (0.37%). For reporting purposes, the United States are divided in 10 regions by the U.S. Department of Education. These regions are represented in the results section as District I (CT, MA, ME NH, RI, VT) through District X (AK, ID, OR, WA).

Of the districts surveyed, 64.07% reported having policies on the use of AI in their educational practices. On the other hand, 20.39% responded that they did not have policies on the use of AI. The remaining 15.53% of respondents were not sure if their district had policies in place regarding the use of AI (**Figure 2**). When asked whether their district had a policy to teach technology in an ethical and responsible way, the majority of respondents (82.53%) answered yes. Only a small percentage (9.58%) answered no, while the remaining respondents (7.90%) were unsure (**Figure 3**). This indicates that a significant proportion of districts have recognized the importance of ethical and responsible technology use and have taken steps to implement policies to ensure that this is taught in schools. However, the results also suggest that some educators may not be aware of whether such policies exist in their district, highlighting the need for greater communication and transparency regarding district policies.

5.3 Technological proficiency

The next series of questions related to the perceived level of comfort with technology and reported preparation in their education (**Figure 4**). According to the survey, most educators reported being at least somewhat comfortable with technology. 40.77% of the respondents stated that they were somewhat comfortable with technology, and 16.13% reported being extremely comfortable. On the other hand,

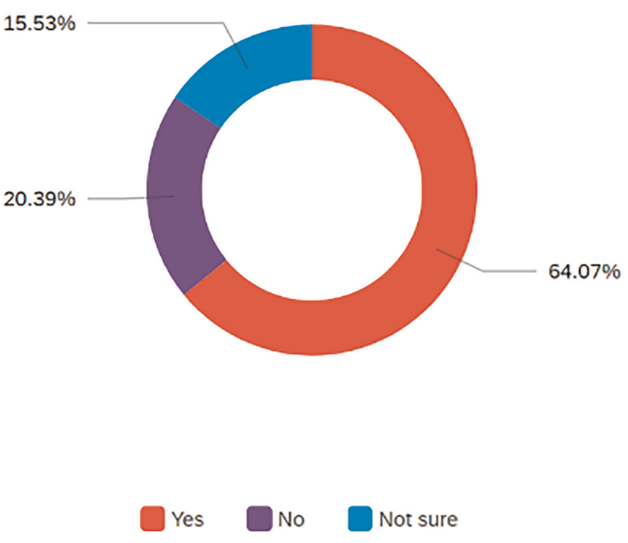

Figure 2.
Existing district policies on artificial intelligence (AI).

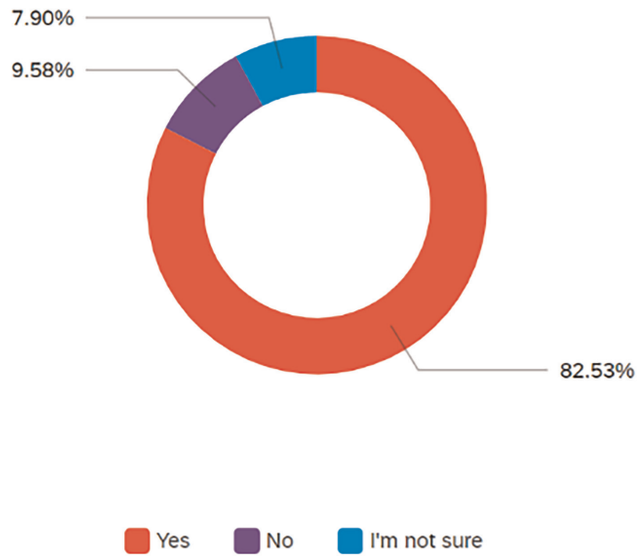

Figure 3.
Existing district policies on teaching technology in ethical and responsible way.

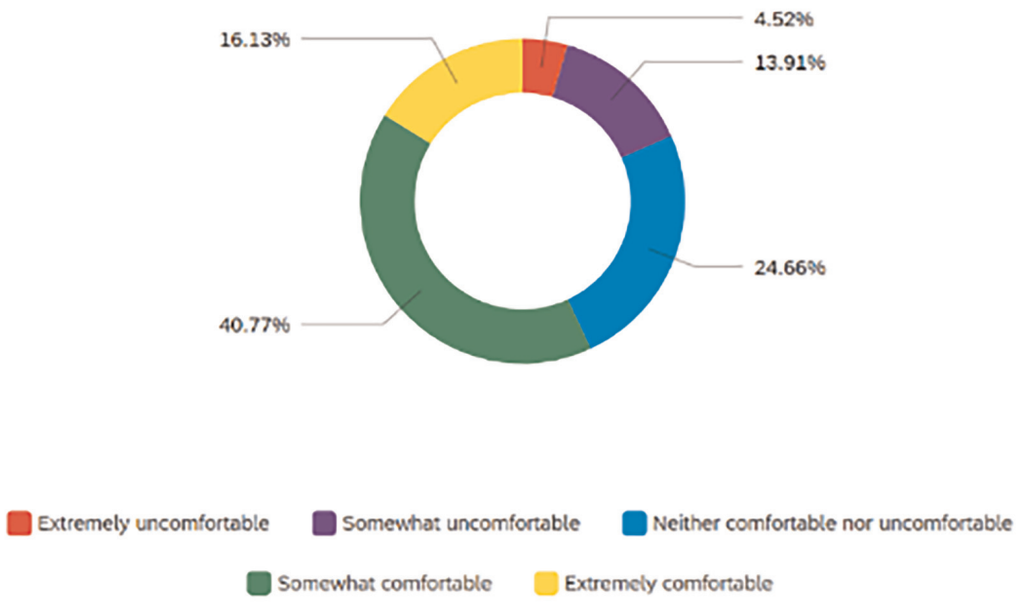

Figure 4.
Level of comfort with technology in general.

13.91% of the educators were somewhat uncomfortable, and only 4.52% of them were extremely uncomfortable. Almost one-fourth of the respondents reported being neither comfortable nor uncomfortable with technology.

At the same time, it appears that female educators are slightly more comfortable with technology than male educators, with a higher percentage of female educators reporting feeling "somewhat comfortable" or "extremely comfortable" with technology in comparison to male educators. However, the difference is not very significant, and both genders report a relatively high level of comfort with technology in general.

There is, however, a difference in grade level with an overall trend of increasing comfort with technology as the grade levels progress. The highest level of comfort

with technology is reported among the 6–8 grade level group, with 42.23% reporting being somewhat comfortable and 19.72% reporting being extremely comfortable. The Pre-K through Kindergarten group reports the lowest level of comfort, with only 15.56% reporting being extremely comfortable with technology. It is also notable that the percentage of respondents who report being extremely uncomfortable with technology decreases as grade level increases, with the highest percentage of extremely uncomfortable responses coming from the Pre-K through Kindergarten group at 8.89% and the lowest coming from the 6–8 grade level group at 2.67%.

Technological proficiency appears to generally increase with age. Educators who are 18–24 years old have the highest percentage of respondents who feel "neither comfortable nor uncomfortable" with technology, while those who are 55–64 years old have the highest percentage of respondents who feel "somewhat comfortable" or "extremely comfortable" with technology. It is also notable that the percentage of respondents who feel "extremely uncomfortable" with technology generally decreases as age increases, while the percentage of respondents who feel "somewhat comfortable" or "extremely comfortable" with technology generally increases as age increases. This suggests that younger educators may benefit from more training and support to increase their technological proficiency.

5.4 Preparation and use

Next, training and preparation prior to their role in the classroom was considered with regards to technology (**Figure 5**). When asked about the amount of training they received in technology as part of their teacher-prep program, the respondents had varying levels of experience. A moderate amount of training was the most common, reported by 35.07% of respondents. This was followed by a lot of training, which was reported by 33.01%. A great deal of training was reported by 10.96%, while 15.08% reported receiving only a little training. A small percentage of respondents, 5.87%, reported receiving no training at all on technology as part of their teacher-prep program. When considering the ages of respondents, the majority from each age category claimed to have received at least some training on technology in general during their teacher-prep program. The age category with the highest percentage of respondents who claimed to have received a lot or a great deal of training on technology in general was the18–24-year-old age category, with a combined percentage of

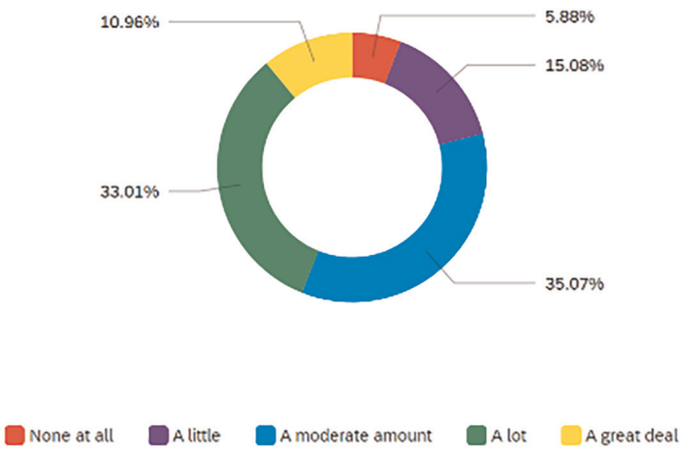

Figure 5.
Amount of training on technology received as part of teacher-prep programs.

35.91%. The age category with the lowest percentage of respondents who claimed to have received a lot or a great deal of training on technology in general was the 55–64-year-old age category, with a combined percentage of 36.8%. Therefore, while comfort with technology was reported to increase by age, training seems to have been present in more recent teacher-prep programs.

When asked how open they were to learn new technology, the majority of respondents (56.74%) answered "probably yes" or "definitely yes," while 19.01% answered "probably not" or "definitely not." The remaining 24.24% said they "might or might not" be open to learning new technology. Overall, the results suggest that a significant proportion of educators are open to learning new technology, but a non-negligible minority may be resistant to doing so.

Educators in the 18–24 age group tend to report feeling less comfortable with technology but are more likely to have received a lot of training in technology through their teacher-prep programs. They are also more likely to feel open to learning new technology. Educators in the 25–34 age group tend to feel more comfortable with technology than the 18–24 age group but are less likely to have received a lot of training in technology through their teacher-prep programs. However, they are the most open to learning new technology. Educators in the 35–44 age group tend to feel more comfortable with technology than the 18–24 age group and are more likely to have received a moderate or a lot of training in technology through their teacher-prep programs. They are also very open to learning new technology. Educators in the 45–54 age group tend to feel less comfortable with technology than the 35–44 age group but are more likely to have received a moderate or a lot of training in technology through their teacher-prep programs. They are also open to learning new technology. Educators in the 55–64 age group tend to feel less comfortable with technology than the 35–44 age group and are less likely to have received a moderate or a lot of training in technology through their teacher-prep programs. They are, however, the most open to learning new technology (**Figure 6**).

Overall, it is important to note that regardless of age, the majority of educators report feeling at least somewhat comfortable with technology, and the majority are open to learning new technology. However, it is also clear that there are differences in the level of technology proficiency and training across different age groups, which should be taken into consideration when providing technology support and professional development opportunities for educators. With that in mind, we sought to determine what (if any) AI tools educators had personally used from a list of popular options (**Figure 7**). Scikit Learn had the highest percentage of usage at 22.18%,

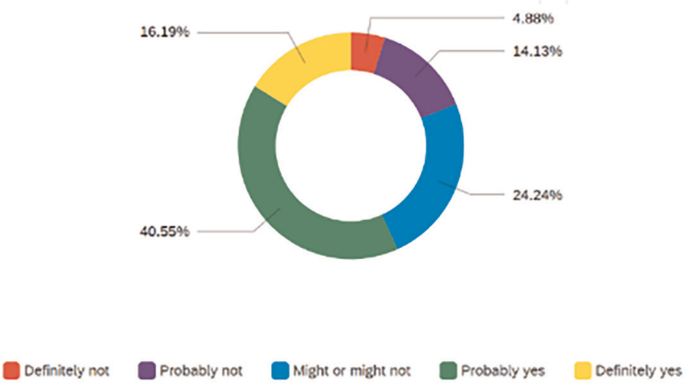

Figure 6.
Educator openness to learning new technologies.

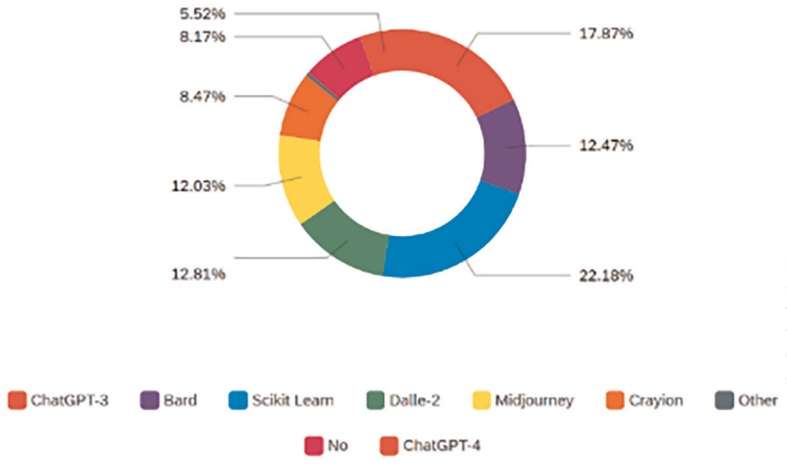

Figure 7.
Educator experience with types of AI tools.

followed by ChatGPT-3 at 17.87 and Dalle-2 at 12.81%. Bard and Midjourney were also used by a significant portion of respondents at 12.47 and 12.03%, respectively. Crayion had the lowest percentage of usage at 8.47%, with ChatGPT-4 being 17.87% and less than 3% respondents indicated that they had not used any of the listed generative AI tools. There is a negligible difference between grade levels of tool usage.

Again, broken down by age, there appears to be some differences in the generative AI tools used. Specifically, for ChatGPT-3, the youngest age group had the highest usage at 30.85%, while the oldest had the lowest usage at 15%. The same trend can be seen for the use of Bard and Scikit Learn. Overall, the data suggests that younger age groups (between 18 and 34), have a higher usage of these tools than older age groups (45–64). Considering male and female respondents, the most commonly reported AI tool used by both genders was Scikit Learn. Both genders also reported using ChatGPT-3 and Dalle-2, but male educators reported slightly higher usage of ChatGPT-3 and female educators reported slightly higher usage of Dalle-2.

In order to address upskilling, participants were asked what current access to technology and technology training were available to them. A significant portion of educators reported having average to good access to technology and technology training. 32.04% of respondents reported average access, while 33.24% reported good access. 15.31% of respondents reported excellent access to technology and technology training. However, a smaller proportion of respondents reported poor or terrible access, with 12.54% reporting poor access and 6.87% reporting terrible access. This suggests that while many educators have adequate access to technology and training, there is still room for improvement in ensuring that all educators have equitable access to these resources (**Figure 8**).

5.5 Perceptions of AI

We asked participants about their general perception of Artificial Intelligence (AI) technology (**Figure 9**). The majority of respondents had a positive view of AI technology, with 39.26% reporting somewhat positive and 19.51% reporting extremely positive perceptions. A significant minority of respondents had a negative perception of AI, with 13.10% reporting somewhat negative and 4.28% reporting extremely

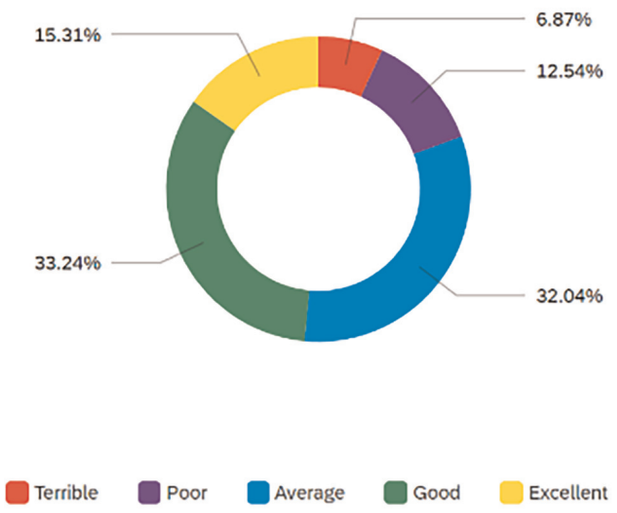

Figure 8.
Educator current access to technology and training.

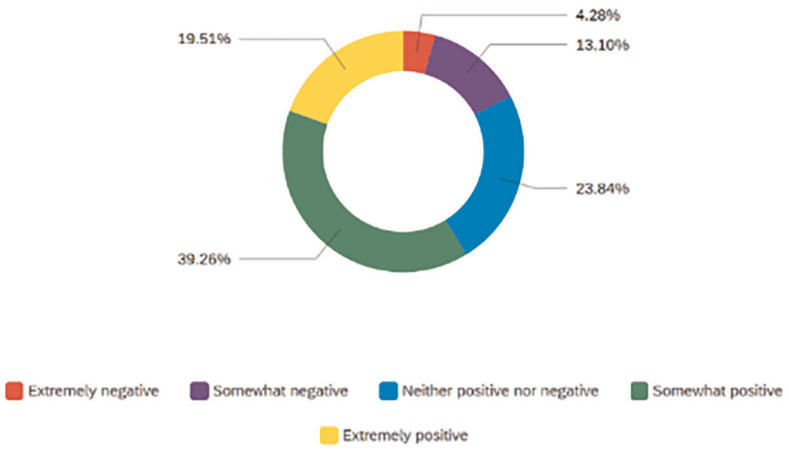

Figure 9.
Educator general perception of artificial intelligence (AI) technology.

negative perceptions. A sizeable proportion of respondents (23.84%) reported having a neutral view, neither positive nor negative, towards AI technology.

Looking at the last set of data, there are some differences in the perception of AI by age group. The youngest age group had a slightly more negative perception of AI, with 12.90% reporting an extremely negative perception and 16.13% reporting a somewhat negative perception. The oldest age group had the highest percentage of respondents reporting a neutral perception of AI, with 33.33% reporting a neither positive nor negative perception. The middle age groups all had a higher percentage of respondents reporting a somewhat positive perception of AI, ranging from 40.60% to 44.21%. It therefore seems that the perception of AI is generally positive among K-12 educators, with only a small percentage of respondents reporting an extremely or somewhat negative perception.

When asked if they had knowledge of the types of resources that would be necessary to implement AI into their classrooms, the majority of respondents (75.26%) answered "Yes" (**Figure 10**). This suggests that many educators perceive the

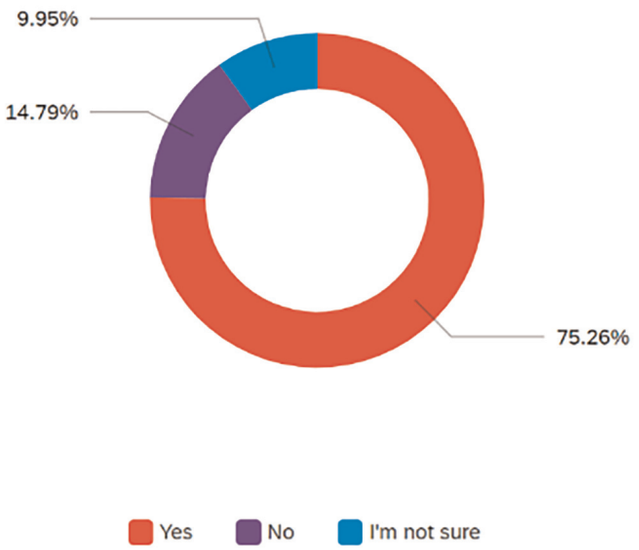

Figure 10.
Educator perception of resources required to implement artificial intelligence (AI) in classrooms.

implementation of AI in their classrooms to require a significant number of resources. On the other hand, a smaller proportion of respondents (14.79%) answered "No", indicating that they do not believe they would need a great deal of resources to implement AI. A small percentage of respondents (9.95%) were not sure whether or not implementing AI would require a great deal of resources. These results suggest that many educators believe that implementing AI in the classroom would require a substantial investment in resources.

5.6 Infrastructure and integration

Considering the logistics of integration, the next set of questions dealt with access and infrastructure. We asked educators if the majority of their students had access to the internet at home (**Figure 11**). The results show that 67.23% of educators reported

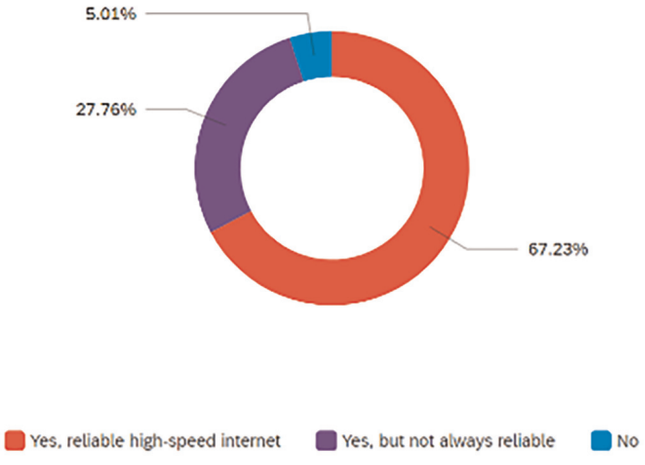

Figure 11.
Student access to reliable internet at home.

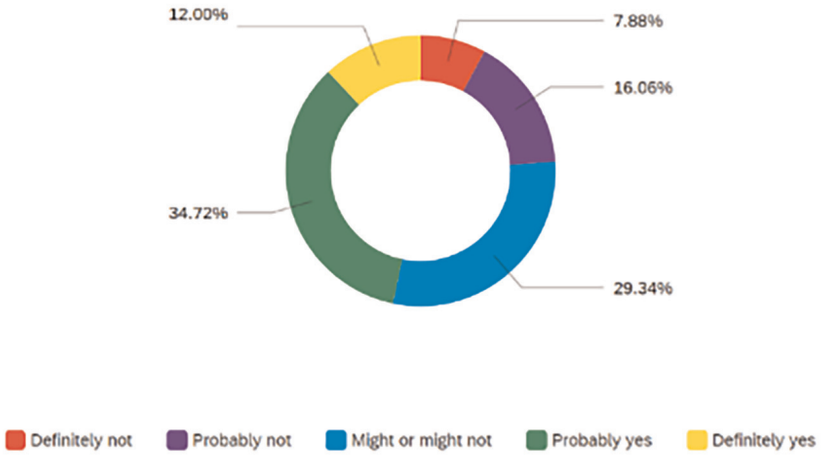

Figure 12.
Educator familiarity with free tools requiring little to no training.

that their students have reliable high-speed internet access at home. 27.76% reported that their students have access to the internet at home, but it is not always reliable. Only 5.01% reported that their students do not have access to the internet at home. These results indicate that a large majority of students have access to the internet at home, with only a small minority lacking access.

Educators reported that access to reliable high-speed internet is highest in urban districts, with 76.10% reporting that their students have such access. Suburban districts also have relatively high access, with 58.94% of educators reporting reliable high-speed internet access. Rural districts lag the other two, with only 47.49% of educators reporting reliable high-speed internet access. Rural districts have the highest percentage of educators reporting that their students do not have access to the internet at home, with 17.86% reporting no access compared to 2.49% in urban districts and 5.02% in suburban districts.

Next, teachers were asked if they were familiar with the free tools that could be used with little or no training (**Figure 12**). We asked how familiar they were with free tools that may be available to them that would allow them to utilize AI technologies with little to no training required. The majority of respondents (34.72%) said probably yes, while 29.34% of respondents said they might or might not be familiar with these tools. A smaller percentage of respondents said they were definitely not familiar (7.88%) or probably not familiar (16.06%) with these free AI tools. Only 12.00% of respondents said they were definitely familiar with these tools.

6. Recommendations

Based on the nationwide survey responses, educators generally seem to have an overall positive perception of artificial intelligence (AI) technology. The majority of educators reported being open to integrating AI into their classrooms, with many reporting that they would be willing to learn and adopt new technologies. However, the results also indicate that educators have concerns about the cost and time required to implement AI in their classrooms, as well as the availability of necessary resources, such as reliable high-speed internet and hardware. In order to address these concerns, we recommend responding to educators' needs across the field.

First, there should be targeted efforts to increase the comfort level of educators in the 45–64 age range, likely those who have been teaching for 20 or more years, with technology and AI. Training programs, workshops, and other resources should be made available specifically for educators to help them feel more comfortable and confident in using AI tools in the classroom. Additionally, younger educators could be encouraged to take on leadership roles in their schools or districts to help support older colleagues with integrating AI into their teaching.

Second, different grade levels have varying levels of access to AI tools and technology. To address this, districts should consider implementing a more equitable distribution of resources across different grade levels. For example, younger students may benefit from simpler and more accessible AI tools, while older students may require more advanced resources. Additionally, school districts should prioritize the allocation of resources to those schools in rural and remote areas where students have less access to reliable internet and other technology resources.

Third, the data suggests that there are significant differences in access to technology and AI tools, across regions, with respect to gender, and diversity. School districts should work to ensure that all students, regardless of geographic location, have access to the same resources and opportunities for AI education. This may require increased funding for technology infrastructure in certain regions, as well as partnerships with local businesses and organizations to provide additional resources and support. Gender representation must be addressed in the field of AI and technology. School districts should work to encourage girls and young women to pursue careers in technology and AI and provide mentorship and other resources to support their success. Additionally, schools should strive to create an inclusive and welcoming environment for students of all genders and backgrounds to encourage engagement and interest in AI and related fields. Therefore, to effectively address the integration of AI in education, it is important to consider the varying needs and circumstances of different age groups, grade levels, regions, and gender representations. By implementing targeted efforts to support educators, ensuring equitable access to resources, and creating an inclusive environment for all students, we can help ensure that every student has the opportunity to engage with and benefit from AI education.

6.1 Applications of AI in integrated STEM

We recommend that the barriers to effective AI integration identified in this study be addressed with an integrated approach. The hallmark of education today includes student learning experiences that are integrated, providing connections across subject areas, with real-world authentic applications to students' everyday lives. State and national standards across the STEM content areas, value student centered pedagogical approaches that allow students to engage in data collection, analysis, synthesis, and application [51].

The integrated STEM education approach values student engagement in collection and analysis of data. Teachers and students can use AI tools to collect data. For example, when engaged in a science activity, students can collect weather data—temperature, humidity, pressure, wind speed and other parameters—on their own and with AI. They can use AI to make sense of the data and the trends over time. Use of AI tools allows students to spend time applying their knowledge to solving problems. When attempting to code large data sets, AI can help students identify common

themes and trends in the data so they can spend time applying knowledge to address problem-based challenges.

Experiments can be simulated, moving teacher practice away from canned procedures and allowing students to engage in authentic experiences. AI-powered simulation software to create virtual experiments in a safe and controlled environment. AI tools can help students create and test prototypes. For example, students can use AI-powered design software to create 3D models of their ideas, which can then be tested using AI-powered simulation software. This can help students develop their creativity and innovation skills, while also giving them hands-on experience with engineering design.

A key component of STEM education is communication and collaboration. AI tools can support project work, idea sharing, brainstorming—all stages of the collaborative problem-solving process. AI can be integrated across all subject areas to enhance learning, shifting the time spent in classrooms from rote work to application of skills and ideas. These skills have the potential to better prepare students for the STEM workforce—a priority of K-12 education across the nation.

7. Conclusion

Teachers are the most crucial element in achieving effective teaching and learning through selected pedagogy, processes, and tools for enhancing instruction (52,53). This study emphasizes the need to prepare teachers for AI learning, demonstrating their openness and willingness to integrate AI into classrooms. Data analysis revealed that AI is viewed as a crucial concept for all students, regardless of their grade level. However, the results identified several gaps in AI policies, technology training, and awareness of AI tools among educators. To address these issues, recommendations are proposed, including the need to enhance technology and AI training in teacher-prep programs and provide continuous professional development opportunities for current educators. It is also essential to increase awareness of AI tools and resources through workshops, seminars, and hands-on demonstrations. The fostering of positive perceptions of AI among educators is vital, emphasizing the benefits of AI in improving teaching and learning outcomes and addressing any misconceptions or concerns that educators may have. Additionally, improving access to technology and infrastructure is essential, including the provision of reliable internet access, hardware, and software. Lastly, developing comprehensive AI policies that outline ethical and responsible practices for AI implementation in the classroom is necessary, addressing issues such as data privacy, algorithmic bias, and digital equity.

By implementing these recommendations, schools and districts can create a supportive environment for the successful integration of AI technologies in K-12 education across content areas. This will enhance teaching and learning outcomes, prepare students for a future increasingly shaped by artificial intelligence, and ensure that AI technologies are employed in a manner that benefits all students. Moving forward, it is crucial to identify resources and training programs to provide teachers with the skills to effectively incorporate AI into the classroom, while also addressing potential data privacy concerns. Adherence to district policies, state-level Individual Education Acts, and HIPAA regulations is vital to protect student privacy and ensure ethical AI usage in the classroom. Therefore, it is imperative for all stakeholders to collaboratively establish clear guidelines and best practices for data storage and management, enabling beneficial use of AI integration in education while protecting student privacy and centering the perspectives of professional educators.

Appendix. Survey instrument

You are being asked to participate in a survey conducted by Drs. Kathryn Arnone and James Hutson at Lindenwood University. We are conducting this survey to learn about your perceptions and the perceived impact AI will have on education in your district. It will take about 5 minutes to complete this survey.

Your participation is voluntary. You may choose not to participate or withdraw at any time by simply not completing the survey or closing the browser window. There are no risks from participating in this project.

WHO CAN I CONTACT WITH QUESTIONS? If you have concerns or complaints about this project, please use the following contact information: Dr. James Hutson jhutson@lindenwood.edu. If you have questions about your rights as a participant or concerns about the project and wish to talk to someone outside the research team, you can contact (Institutional Review Board) at irb@lindenwood.edu.

By clicking the link below, I confirm that I have read this form, and decided that I agree to participate in the project described above. I understand the purpose of the study, what I will be required to do, and the risks involved. I understand that I can discontinue participation at any time by closing the survey browser. My consent also indicates that I am at least 18 years of age. You can withdraw from this study at any time by simply closing the browser window. Please feel free to print a copy of this information sheet.

I currently teach

PreK
Kindergarten
First Grade
Second Grade
Third Grade
Fourth Grade
Fifth Grade
Sixth Grade
Seventh Grade
Eight Grade
Ninth Grade
Tenth Grade
Eleventh Grade
Twelfth Grade

Is your institution public or private?

Public Private
Other

What is your age?

18–24
25–34
35–44
45–54

55–64
65 or older

What is your gender identity?

Male Female
Non-binary/third gender Prefer not to say

Are you Hispanic/LatinX?

No
Yes

Please identify your race/ethnic heritage (check all that apply)

American Indian or Alaskan Native Asian
Black or African-American
Native Hawaiian or Pacific Islander
White/Caucasian
Other

Which best describes your school district?

Urban
Suburban
Rural

Which state do you teach in?

AK AZ AR CA CO CT DE DC FL GA HI ID IL IN IA KS KY LA ME MD MA MI MN MS MO MT NE NV NH NJ NM NY NC ND OH OK OR PA PR RI SC SD TN TX UT VT VA WA WV WI WY

Does your district have policies on the use of artificial intelligence (AI) and its use?

Yes
No
Not sure

If so, what are they?

Does your district have a policy to teach technology in an ethical and responsible way?

Yes
No
I'm not sure

In general, how comfortable are you with technology?

Extremely uncomfortable
Somewhat uncomfortable
Neither comfortable nor uncomfortable

Somewhat comfortable
Extremely comfortable

As part of your teacher-prep program, how much training did you get on technology in general?

None at all
A little
A moderate amount
A lot
A great deal

How open would you say you are with learning new technology?

Definitely not
Probably not
Might or might not
Probably yes
Definitely yes

Have you personally used any of the following generative artificial intelligence (AI) tools?

ChatGPT-3
Bard
Scikit Learn
Dalle-2
Midjourney
Crayion
Other
ChatGPT-4
No

What is your current access to technology and technology training?

Terrible
Poor
Average
Good
Excellent

What is your general perception of Artificial Intelligence (AI) technology?

Extremely negative
Somewhat negative
Neither positive nor negative
Somewhat positive
Extremely positive

Do you feel as though you would need a great deal of resources to implement AI into your classroom?

Yes
No
I'm not sure

Do the majority of your students have access to the internet at their homes?

Yes, reliable high-speed internet
Yes, but not always reliable
No

How familiar are you with free tools that may be available to you that would allow you to utilize AI technologies with little to no training required?

Definitely not
Probably not
Might or might not
Probably yes
Definitely yes

How familiar are you with free tools that may be available to you that would allow you to utilize AI technologies with little to no training required?

Conflict of interest

The authors declare no conflict of interest.

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