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Factors influencing teachers' adoption of artificial intelligence tools in K-12 education

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Abstract

The recent proliferation of Artificial Intelligence in Education, generative AI in education and intelligent learning classrooms has revolutionized the practice of K-12 education, and the uptake of AI-based instructional aids by teachers, however, is not uniform because of various technological, pedagogical and structural impediments. It is essential to comprehend the contexts that can make teachers adopt artificial intelligence tools as such understanding will guarantee the successful digital transformation of education and long-term educational innovation. This work has provided a literature review of the research work based on the PRISMA 2020 framework and synthesized the recent high-impact studies on the topic of AI adoption, teacher acceptance, and educational technology adoption. The research has systematically reviewed the available empirical and theoretical literature on the adoption utilizing models like the Technology Acceptance Model, UTAUT, and other extended models with the addition of AI literacy, teacher self-efficacy, institutional support, facilitating conditions, performance expectancy, effort expectancy, and social influence. Results show that the behavioral intention of teachers to use AI tools is highly influenced by perceived usefulness, ease of use, professional development opportunities, ethical concerns, and the organizational readiness and the emerging themes demonstrate the increased role of human-AI collaboration, adaptive learning, and responsible ethical AI in education. The synthesis also indicates that the key to effective implementation of AI in K-12 education lies not merely in technical infrastructure but also in the alignment of the pedagogy and in the support of the policies as well as the continuous training of AI readiness.

Keywords: Artificial intelligence, Education, Professional development, Teaching, Ethics, Adaptive learning.

1. Introduction

The fast development of Artificial Intelligence in Education has radically changed the educational landscape of the world, especially in the sector of K-12 education where newer technologies are being rapidly adopted into classroom settings in the instructions, assessment, and learning management system [1-3]. The increased presence of tools of AI-assisted teaching, such as generative AI in education, adaptive learning platforms, learning analytics, and intelligent tutoring systems, has opened new possibilities of increasing the effectiveness of teaching and improving the outcomes of students [3-5]. Regardless of these technological changes, the effective introduction of AI in schools is greatly dependent on the acceptance of teachers, adoption of AI, and readiness of teachers to include these technologies in day-to-day school teaching activities. Consequently, the problem of factors that determine the adoption of artificial intelligence tools by teachers has become a burning research issue in the larger framework of educational technology adoption and digital transformation in education, where governments and institutions across the world invest heavily in smart learning environments and AI-driven educational innovations. Over the last few years, with the development of generative AI, the development of large language models, automated assessment tools, and AI-based personalization technologies, AI integration into K-12 education has been faster and requires a more focused

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examination of the human and organizational conditions under which AI integration is successful [5-8]. The theoretical frameworks used in research in AI adoption are often the accepted theoretical frameworks, including the Technology Acceptance Model, UTAUT, and other behavioral models explaining the impact of performance expectancy, effort expectancy, social influence, and facilitating conditions on behavioral intention to use new technologies in teachers. Nevertheless, the rapid development of AI-sustained teaching has given rise to the new dimensions of AI literacy, ethical AI in education, teacher self-efficacy, and human-AI collaboration, that are beyond the traditional theories of technology acceptance. These new aspects underline the necessity of new and thorough literature reviews that will reflect the current level of research and outline the future trends with a high citation potential. The importance of researching AI adoption in teachers is especially noticeable in the K-12 learning environment, whose teaching methodologies are determined by the standards of the curriculum, policies on the administrative level, the access to related infrastructure, and the developmental needs of students. In comparison to higher education, where teachers enjoy more freedom to implement new technologies, in the school setting, the teacher is exposed to more regulated settings, where they must conform to institutional standards, nationwide policies on education, and family anticipations. Therefore, the institutional support, professional growth and AI preparedness become the key factors that define the successful use of AI tools in classrooms. The research on digital pedagogy and adoption of EdTech indicates that even with the availability of advanced technology, teachers might be reluctant to adopt this technology because of the absence of training, beliefs in its complexity, attitudes toward the belief in reliability, or the absence of information about the pedagogical significance of AI systems. Thus, systematic review of the literature is required to comprehend the interaction of these factors and their impact on the adoption decisions of actual educational context.

The modern research field of Artificial Intelligence in Education is growing at a very high pace, with more and more types of personalized learning, learning analytics, automated feedback mechanisms, and AI-driven classroom management systems currently being taken into consideration [6,9]. Simultaneously, the advent of generative AI in learning has brought up new ethical concerns about academic integrity and teacher autonomy, as well as teacher ethical responsibility, making ethical AI in education a key factor in studies of adoption. The recent studies also note the role of teacher self-efficacy, confidence in the use of digital tools, and the capacity to flex to new instructional approaches as major predictors of the adoption behavior [10-12]. Moreover, new skills and competences that could unite the knowledge of technology and the skills of a teacher along with the introduction of human-AI interaction make the emergence of the new instructional setting essential, thus validating the ongoing professional growth and institutional support. Such tendencies suggest that the integration of AI technologies ceases to be a purely technical task and a multidimensional process affecting not only psychological and social aspects but also the organizational ones. Despite numerous studies examining the use of AI and educational technology acceptance, the available literature is still rather dispersed, and in many studies, the researchers concentrate on particular tools, regions, or even the context of higher education instead of K-12 education. Furthermore, many previous reviews often discuss educational technology adoption in general, without paying any specific attention to the specific features of the adoption of Artificial Intelligence in Education with its complex algorithms, data-driven decision-making, and a more complicated ethical aspect. Synergy of the research results of various theoretical frameworks such as Technology Acceptance Model, UTAUT, and more recent models that include AI literacy, AI readiness, and digital pedagogy is also lacking. These gaps outline the necessity of the organized and methodical literature review that will be able to define the stable patterns, soaring themes, and perspectives of further research concerning the specific area of teachers using AI tools in the education of schools.

This paper aims to achieve a thorough literature review of the variables that affect teachers to use the artificial intelligence tools in the K-12 education, and especially the sought-after recent developments that promise tremendous future research and citation rates [7,13-16]. The purpose of the review is to evaluate the technological, psychological, pedagogical, and institutional variables that influence adoption, discuss the current types of AI tools used in schools, and determine the risks and opportunities of AI implementation. Moreover, the research aims at assessing the role of new trends in the landscape of adoption, including generative AI, adaptive learning, learning analytics, and smart classrooms, in

transforming the adoption environment and establishing new demands on teacher preparation and policy. The primary value of the present paper is the synthesized and recent literature that links theories of AI adoption, educational technology studies, and recent trends in Artificial Intelligence in Education in the particular setting of the educational system at K-12. Using the available evidence to create a systematic method of its organization, the review will provide guidelines that may assist in further research, make policy-maker choices, and create the effective strategy aimed at encouraging the use of AI-based teaching. Moreover, the paper discusses the significance of the correspondence of technological innovation and pedagogical requirement, ethical issues, and institutional preparedness, which will help in advancing the digital revolution in education and help to design sustainable and responsible AI-driven learning platforms.

2. Methodology

The current systematic literature review was carried out following the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to provide transparency, reproducibility, and methodological rigour in the process of coming up with and synthesizing pertinent empirical evidence on factors that affect the adoption of artificial intelligence tools in K-12 education by teachers (Fig. 1). A search of the electronic database was carried out in four large academic repositories, including Scopus, Web of Science, IEEE Xplore, and PubMed, which included peer-reviewed publications published as early as January 2019 and as late as December 2025 and immediately released, which is a purposefully selected range to reflect the breakneck pace of AI-in-education research after the mainstreaming of machine learning use in education. The Boolean search terms used in Scopus and Web of Science were built based on controlled vocabulary and free-text terms as: ("artificial intelligence" OR "AI tools" OR "machine learning" OR "intelligent tutoring" OR "educational technology use) AND ("teacher adoption" OR teacher acceptance OR faculty adoption OR educator technology use) AND ("K-12" OR primary school OR secondary school OR elementary school OR high school) AND ("technology acceptance model" OR TAM OR obstacles OR facilitators OR influencing factors or determinants); further terms were used in IEEE X The search of the first database showed that a total of 1,200 records were found (Scopus = 420, Web of Science = 380, IEEE Xplore = 250, PubMed = 150). After the automated and manual elimination of 312 duplicate records, 888 unique records were left and were screened by two independent reviewers on the topics of titles and abstracts, and 623 records were excluded due to the determination of predetermined inclusion and exclusion criteria. The inclusion criteria included a study: (1) which was published in English and (2) had a target population of in-service or pre-service K-12 teachers, (3) which empirically explored a factor or barrier or enabler related to AI tool adoption or integration, and (4) utilized a quantitative, qualitative, or mixed-method study design. Exclusion criteria filtered out studies examining higher education only, all of which used student outcomes with no teacher level analysis, and gray literature or opinion pieces and articles, and those published before 2019. Out of 265 full-text articles retrieved to be evaluated based on their eligibility criteria, 12 articles, that could not be accessed by any institutional access, were eliminated, and 253 reports were therefore properly evaluated, though 206 articles were excluded based on their poor alignment with the research topic, inadequate coverage of agent (teacher)-specific AI adoption variables, or poor methodological quality, resulting into a final corpus of 47 studies used in the qualitative synthesis, which is documented in a PRISMA 2020 flow diagram.

3. Results and discussions

3.1 Techniques and Algorithms

Technology Acceptance Modeling Algorithms to AI Adoption in K-12 Education

The most prominent method of analysis applied to the teachers adoption of Artificial Intelligence in Education is grounded in computational applications of the Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, and Technological Pedagogical Content Knowledge frameworks that are often operationalized with the models of structural equation modeling, partial least

squares algorithms, and predictive modeling methods to measure behavioral intention and real system use [2,17-19]. Algorithms modeling of perceived usefulness, performance expectancy, perceived ease of use, social influence, performance expectancy, and facilitating conditions have been improved with machine learning classifiers to increase predictive accuracy of adoption behavior in K-12 Education settings in recent literature on teacher adoption of AI tools. The algorithmic methodology combines the variables of Artificial Intelligence in Education, Teacher Adoption, Digital Competence, AI Readiness, and Educational Data Mining so that the researchers have the ability to model complex decision patterns that affect the adoption of Generative AI, Intelligent Tutoring systems, and Learning Analytics systems in classrooms. Recent studies also combine hybrid TAM-UTAUT-TPACK modeling with neural network optimization to enhance predicting the behavioral intention of teachers towards AI-mediated learning technologies and it shows that algorithm-based modeling contributes greater explanatory value to the prediction of adoption behavior in AI-enabled learning settings.

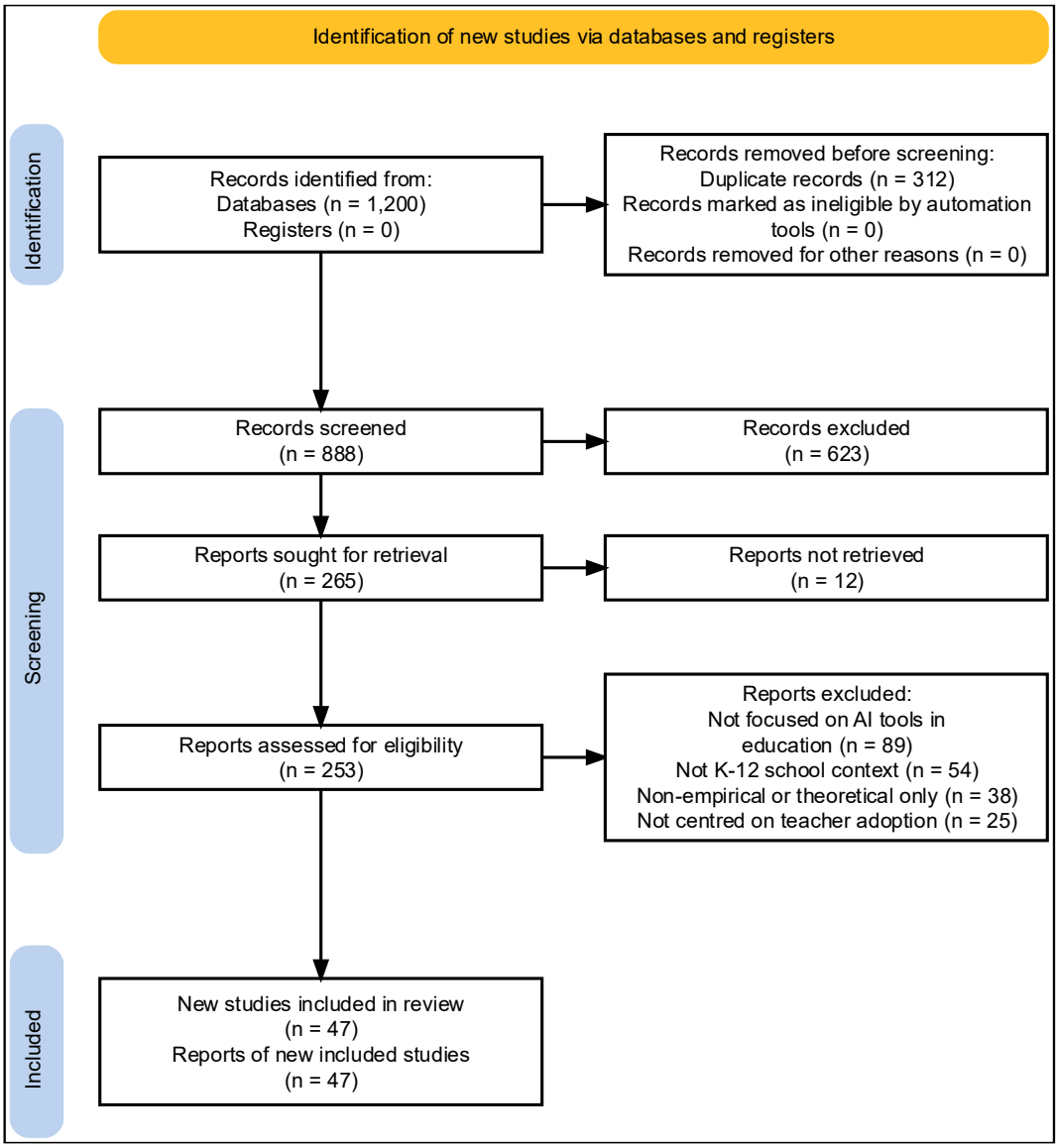

Fig. 1 PRISMAA Framework

Classification Algorithms of Machine Learning to Predict Teacher Adoption Behavior

The recent literature has been becoming more and more interested in using supervised machine learning algorithms: decision trees, random forests, support vectors, gradient boosting, and deep neural networks to forecast the likelihood of teachers adopting Artificial Intelligence tools in K-12 Education environments. Such algorithms classify teachers based on datasets that have variables, including AI literacy, perceived risk, institutional support, pedagogical beliefs, trust in AI, and prior technology

experience to identify adopters and non-adopters, thus making it possible to predict analytics in educational studies [3,20-23]. Machine Learning in Education is an area of research where researchers process survey data on a large scale and classroom usage logs to discover latent adoption patterns, a feature especially significant in research using Generative AI, Large Language Models in Education, and AI-Driven Assessment tools. Ensemble learning techniques have become a trend methodological mode of operation in that it enhances predictive power and enables the researcher to assess the relative significance of various adoption variables concurrently, thus giving more accurate findings on how Artificial Intelligence in Education diffuses in K-12 systems. The algorithmic methods are also useful in policy level decision making since they predict institutional and regional adoption readiness.

Analytics in Learning and Education Data Mining Algorithms

Learning Analytics and Educational Data Mining are fundamental algorithmic methods to analyze the interaction of teachers with Artificial Intelligence software and determine the impact of AI-based systems on the K-12 Education teaching process. Those methods include clustering algorithms, regression models, sequence mining, and predictive analytics, to process big data that are produced by the AI-based learning platforms, intelligent tutoring systems and adaptive learning environments. Using Educational Data Mining algorithms, researchers will be able to identify trends in usage patterns of teachers, barriers to the use, and the impact of teacher digital competence and AI preparedness on the implementation of personalized learning systems. Recent literature also incorporates real-time streams of data provided by AI-enabled classroom solutions to facilitate dynamic modeling of teacher interaction with Natural Language Processing systems, AI-driven grading systems and AI-auto lesson planning software. Learning Analytics (and Predictive Analytics) can be applied to Education to provide researchers with the ability to simulate the process of adoption and approximate the way such training, infrastructure, or policy interventions might influence the diffusion of Artificial Intelligence in Education in K-12 institutions. The methods come in especially handy when it comes to studying the effect of Generative AI, multimodal AI systems, or cloud-based educational systems that produce massive amounts of behavioral data.

Algorithms and Adaptive Learning Models Intelligent Tutoring Systems

The most popular techniques of Artificial Intelligence affecting the subject of teacher adoption in K-12 Education are Intelligent Tutoring Systems and Adaptive Learning Algorithms as they directly impact the classroom teaching and pedagogical process. These systems are based on rule-based reasoning [9,24-26], Bayesian knowledge tracing, deep learning, and reinforcement learning algorithms to tailor instructions to student performance, and therefore necessitate the teacher to adjust his teaching method and engage in interaction with AI-based decision support systems. Adaptive Learning Algorithms dynamically adjust the content difficulty, pacing, and feedback based on predictive models that have been trained on student performance data and therefore enhance the perceived usefulness of Artificial Intelligence in Education but bring about issues of trust, transparency, and teacher autonomy. Recent advances in Knowledge Tracing, Deep Knowledge Tracing, and Reinforcement Learning in Education enable intelligent tutoring systems to constantly update learner models, which generate highly personalizable learning environments that demand the development of new digital capabilities in teachers. The growing complexity of such algorithms can be deemed one of the key technological variables that affect Teacher Adoption since professionals should be aware of how the AI recommendations are created before they can accept them as the instruments that they can use in a real classroom environment.

The Algorithms of Natural Language Processing and Large Language Models in Education

Natural Language Processing and Large Language Models are now the two key methods of Artificial Intelligence in Education because of the recent proliferation of generative AI applications to lesson planning, auto-feedback, content generation, and chatbot tutoring. The algorithms of NLP allow chatbots, virtual teaching assistants, and automatic grading systems to analyze the responses of students, create explanations, and give each a unique recommendation, transforming the nature of work of teachers in the K-12 Education setting significantly. New algorithmic aspects of Generative AI and Large Language Models in Education need to be considered in the context of Prompts optimization,

semantic similarity identification, and automated scoring of assessments, which demand that teachers become AI literate and digital competent to effectively utilize these technology. Studies of Teacher Adoption indicate that perceived usefulness of NLP-based AI tools is a strong predictor of acceptance in situations where the algorithms enhance efficiency with regard to grading, curriculum design and student support. The latest developments are multimodal language models, which involve text, audio, and visual processing, which allow more advanced classroom analytics and interactive learning systems, making the adoption decisions further complex in educators. These trends underscore the increased relevance of the Human-AI Interaction algorithms in how teachers view and trust the Artificial Intelligence systems.

Artificial Intelligence and Trust Modeling Algorithms

Explainable AI algorithms have become an important method that affects the adoption of Artificial Intelligence tools by teachers since transparency and interpretability have a strong impact on trust in AI-based recommendations. The explainable AI approaches (ranking feature importance, rule learning, visualization of attention, interpretable neural networks) enable educators to learn how machine learning models applied in assessment, recommendation systems, and adaptive learning systems generate predictions [27-29]. Teachers in K-12 Education settings will be more willing to embrace AI-powered tools when the results of algorithmic-based decisions can be explained, in particular, when the system influences grading, or student-assessment, or planning. Technology Acceptance Model variables are frequently used together with trust modeling algorithms to measure the impact of perceived transparency, reliability and fairness on behavioral intention to use AI. The recent studies also use causal inference algorithms and counterfactual explanations to analyze the influence of various factors on adoption determination, so Explainable AI is one of the most relevant methodological approaches in the investigation of Artificial Intelligence in Education, AI Governance in Education, and the integration of AI in schools as responsible. The fact that explainability metrics have been added to the list of adoption models is regarded as one of the key trends since the issue of algorithm bias, fairness, accountability are still very acute obstacles to teacher adoption.

Multimodal Classroom Analytics Algorithms and Computer Vision

K-12 Education Computer Vision and Multimodal AI algorithms are applied more and more to study classroom behavior and student engagement, and instructional effectiveness, which indirectly influences the adoption of Artificial Intelligence instruments by teachers [30-32]. The algorithms are based on image recognition, facial expression analysis, gesture detection, and multimodal data fusion to track the interactions in classrooms and offer real-time feedback to teachers. Multimodal Learning Analytics involves video, audio, text and sensor data, which are combined to form detailed models of the teaching and learning process enabling the researcher to assess how teachers react to AI-based insights. The inclusion of Computer Vision in Classroom Analytics presents additional adoption problems since teachers will be required to have faith in automated surveillance devices and learn how algorithmic predictions can be made. The recent advances in Multimodal AI and Artificial General Intelligence studies propose that future learning systems will take into account the combined sensory information to facilitate adaptive learning, which makes these algorithms quite useful in the research of the factors that affect Teacher Adoption. The growing popularity of multimodal analytics also comes with the ethical and privacy issue, which need to be resolved on the AI Governance in Education frameworks prior to large-scale application in schools.

Reinforcement Learning and Individualized Recommendation Algorithms

Reinforcement Learning algorithms have been a significant method in Artificial intelligence in Education since it allows a system to constantly enhance the instructional recommendations, as per the user feedback and the learning results. Reinforcement learning is applied in K-12 Education setting to enhance adaptive learning platforms, prescribe teaching plans, and deliver content in a personalized manner, which is directly linked to teachers being willing to use AI tools. These algorithms work by maximising the reward functions on the student performance, engagement or achievement metrics which enables the system to learn some of the best teaching interventions over a time. Personalized Recommendation Algorithms are also based on collaborative filtering, deep learning, and probabilistic

models that are designed to propose learning resources, lesson plans, and assessment strategies to the teachers. Integration of Reinforcement Learning in Education has meant that an educator has to engage with AI systems that are dynamically evolving, which may result in a perceived complexity surge but may also positively affect perceived usefulness. Research about Teacher Adoption shows that teacher control and algorithmic autonomy is a major aspect that influences the uptake of AI-led recommendation systems in classroom education by educators. Recent studies of neuroadaptive learning and cognitive feedback systems indicate that future AI applications will respond to more than performance data with applications to emotional and cognitive conditions, and as a result, even more sophisticated algorithmic methods will be relevant in adoption studies.

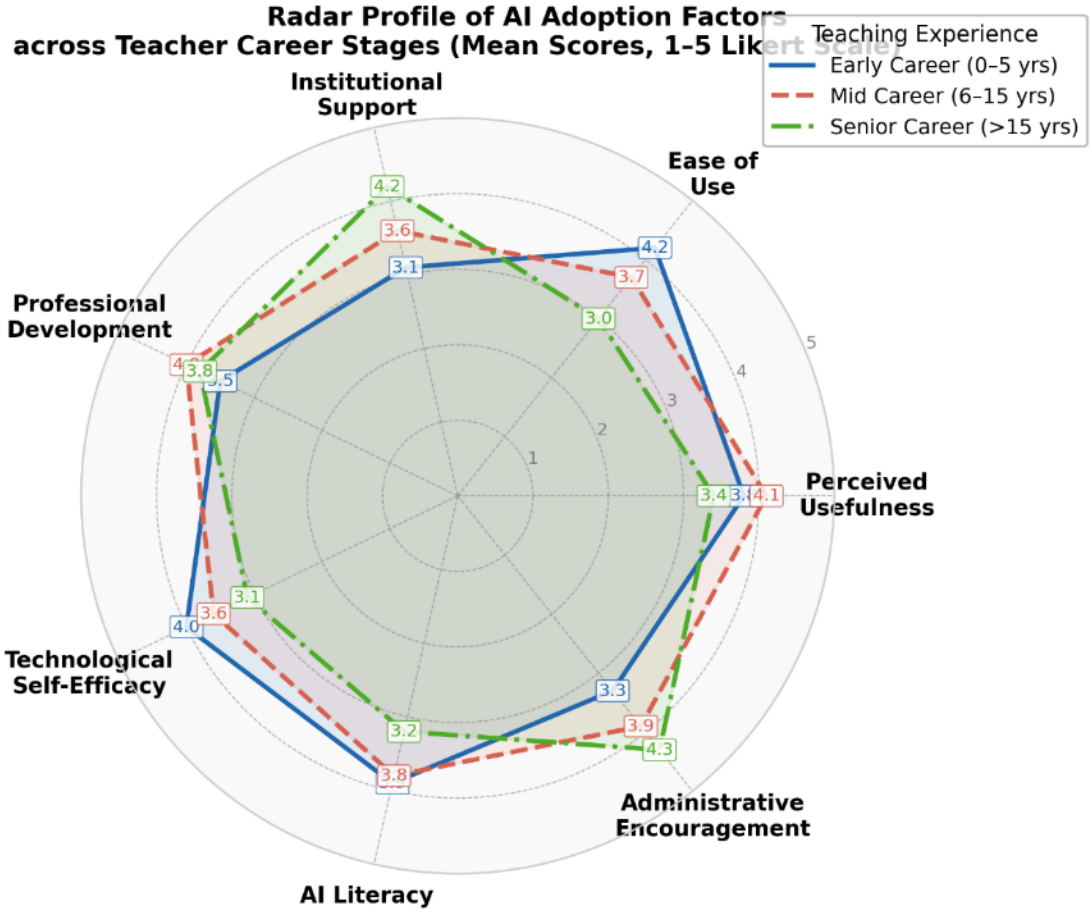

Fig.2 Radar Profile of AI Adoption Factors across Teacher Career Stages

Fig 2 describes A multi-group radar chart comparing mean Likert scores (1–5) across 7 TAM-aligned constructs for Early, Mid, and Senior career teachers. Key finding: Early-career teachers score highest on Ease of Use (4.2) and Technological Self-Efficacy (4.0), while Senior teachers lead in Institutional Support (4.2) and Administrative Encouragement (4.3), confirming that career stage shapes the adoption

Artificial Intelligence Ethics, Bias Discovery, and Governance Algorithms

Algorithms that promote bias, fairness and privacy detection are becoming more frequently incorporated into Artificial Intelligence in Education systems to respond to concerns that affect teacher adoption. As highlighted by AI Ethics in Education studies, algorithmic auditing, differential privacy, federated learning, and secure data sharing methods are necessary to make sure AI technologies in K-12 classrooms do not harm the rights of students or the freedom of teachers. Bias detection algorithms can be used to detect unfair behavior based on gender, socioeconomic status, or learning ability using training data and prediction outputs, and privacy-preserving machine learning techniques can be used to analyze educational data without sensitive information disclosure. AI Governance models in Education systems tend to have algorithmic surveillance mechanisms that assess adherence to ethical codes, transparency policies, and accountability norms, thus, gaining more trust among the educators

and prompting them to adopt. Research indicates that educators are more prone to deploy Artificial Intelligence applications in cases of ethical protections integrated into the algorithms, which is indicative of the fact that technical design characteristics may play an important role in the formation of behavioral intent. Due to the process of the growing dependence of educational institutions on AI-powered decision support systems, the role of the governance algorithms is likely to become one of the key aspects that determine the future of Teacher Adoption research.

Federated Learning, Cloud AI, and Distributed Educational Intelligence

Federated Learning and Cloud-based Artificial Intelligence architectures are novel algorithmic methods that govern the deployment of AI tools in K-12 Education and the usability and perceived security of teachers. Federated Learning enables machine learning models to be trained on a set of schools without access to raw data, thus one can overcome the problem of privacy without losing the possibility of large-scale predictive analytics. Cloud AI systems can be used to scale Intelligent Tutoring Systems, Learning Analytics or AI-driven Assessment tools, thereby offloading teachers with technical overhead and enhancing perceived ease of use, which is an essential variable in Technology Acceptance Model studies. Dried Educational Intelligence systems involve aggregating the data of multiple institutions to enhance the quality of the recommendations and to customize the learning process, yet they also raise the issues of data control, interoperability, and educator training. Recent works on Artificial Intelligence in Education research emphasize the need to have secure, privacy-sensitive, and scalable algorithms to scale up approaches to Artificial Intelligence use in K-12 settings, as schools start using Generative AI, multimodal analytics, and real-time decision support. It is believed that the elaboration of federated and cloud-based AI architecture, therefore, is one of the technological factors that impact the readiness of teachers to use AI tools within the educational ecosystem in the future.

3.2 Application

Artificial Intelligence in Education AI in education, K-12 education, AI adoption, teacher acceptance, AI-based teaching, generative AI in education, intelligent tutoring systems, automated assessment, personalized learning, learning analytics, learning environments, AI chatbots, adaptive learning, educational technology acceptance, AI literacy, AI integration, digital pedagogy, human-AI collaboration, curriculum automation, predictive analytics, classroom analytics, ethical AI in education, institutional support, teacher self-efficacy, EdTech platform, digital transformation in education, AI readiness.

K-12 Artificial Intelligence-driven Customized Learning Systems

Among the most publicized uses of Artificial Intelligence in Education is the personalized learning systems that adjust the instructional content based on the needs of students, their level of performance, and the types of learning styles involved which has a major impact on Teacher Adoption in K-12 Education. Predictive analytics, Educational Data Mining, and Learning Analytics are applied in Adaptive Learning Systems to track the student progress constantly and adjust the learning pathways so that teachers can provide differentiated instructions without having to restructure their lesson plans by hand [9,33-35]`. The usage of Personalized Learning technologies makes teachers perceive them as more useful since these opportunities allow controlling different classrooms more effectively, particularly when they are supplemented by AI-Based Learning Platforms that can analyze vast amounts of learner information. The recent advances in Machine Learning in Education and Predictive Analytics in Education enable AI to suggest teaching strategies, struggling learners and remedial activities, which positively influences the process of instructional decision making and prompts teachers to introduce the use of Artificial Intelligence tools in their daily classroom activities. Research also suggests that customized learning spaces can provide better engagement and results to students thus supporting the adoption of AI in schools and making it an institutional priority.

Automated Instructional Support system is an Intelligent Tutoring System

The Intelligent Tutoring Systems are one of the most impactful applications of Artificial Intelligence in K-12 Education since they offer real-time instructional support, automated feedback, and customized practice that can be used by students and educators. Such systems employ Knowledge Tracing, Reinforcement Learning and Natural Language Processing in Education to emulate one-to-one tutoring enabling teachers to concentrate with higher-level pedagogical tasks, whereas AI takes control of repetitive instructions. The Intelligent Tutoring Systems application is also closely linked to Teacher Adoption since the Intelligent Tutoring Systems offer a lower workload and better learning results especially in mathematics, science and in language learning. In addition, the Large Language Models in Education and conversational AI are also implemented in modern tutoring systems which allows more natural interaction between learners and educational software which improves its usability and acceptance among educators. The more such systems are accurate and transparent, the more teachers are willing to trust AI-generated recommendations, particularly when the resources have transparent descriptions on the way the instructional decisions are created.

Lesson Planning, Content Creation and Teaching Assistance Generative AI

Generative AI has quickly emerged as one of the most groundbreaking uses that affect the uptake of Artificial Intelligence tools in K-12 Education since it assists in lesson planning, generative of instructional material, automatic feedback and curriculum design. The systems of AI-powered Content Creation systems with Large Language Models in Education are capable of producing worksheets, quizzes, explanations, and classroom activities within a few seconds and help teachers spend less time preparing [36-38]. Virtual Teaching Assistants and Educational Chatbots enable the use of Generative AI in Education as well and assist teachers in answering the questions of students, summarizing content, and producing the differentiated learning content. These applications make AI tools more useful in the perception of the individuals, which is the primary role in Technology Acceptance studies, when the teachers feel that productivity and the quality of teaching have been improved instantly. The current trends indicate that generative systems can be used in conjunction with Learning Management Systems and Smart Classroom Systems so that teachers can automate administrative and instructional processes but still retain control over learning and teaching content.

Artificial Intelligence-based Assessment and Grading Services

Another significant use of AI is the AI-Driven Assessment which impacts the Teacher Adoption since it lessens the time in K-12 Education to grade, evaluate, and track performance. Automated Grading Systems apply Natural Language Processing, pattern recognition, and machine learning algorithms to grading written responses, quizzes, and assignments to enable teachers deliver faster and more consistent feedback. Such systems also produce analytics reports that can enable educators to determine the gaps in learning and manage instruction in line with them, which enhances the perceived usefulness of Artificial Intelligence in Education. Besides grading, AI-based assessment systems can promptly create adaptive tests, which vary between difficult and easy levels, to produce assessment that is more precise and individualized. Automatization of routine assessment is viewed as one of the best predictors of teacher acceptance as it directly lowers the workload, but enhances instructional efficiency which is consistent with the major constructs of Teacher Adoption models of perceived usefulness, effort expectancy, and facilitating conditions.

Analytics and Data-Driven Instructional Decision System

The Learning Analytics applications apply Artificial Intelligence to process the data on the student performance, classroom activity, and teaching patterns, allowing teachers to make evidence-based decisions in the K-12 Education setting. These systems integrate Educational Data Mining, Predictive Analytics in Education, and Classroom Analytics to reveal tendencies in the learning behavior, disengaged students, and suggest interventions before issues in academics escalate. Data-Driven Instruction tools make teachers more confident in AI systems since they base their decisions on objective evidence and not on their own opinion. The Multimodal AI (processing of text, audio, video, and interaction data in parallel) is also provided by modern analytics systems to offer insights into the

effectiveness of teaching and the engagement of students based on the analysis of all these data types. With the growing dependence of educational institutions on the evidence-based teaching practice, Learning Analytics applications have turned out to be one of the most significant considerations affecting Teacher Adoption of Artificial Intelligence tools.

Smart Classroom Systems and Classroom real time monitoring

Smart Classroom Systems is a relatively new form of artificial intelligence application in Education which involves sensors, Computer Vision, and Multimodal AI to monitor the classroom activities, student involvement, and give real-time feedback to the teacher. Such systems are able to automatically capture the attendance, identify patterns of behavior, and assess the level of participation enabling the teachers to concentrate more on the teaching part of the task instead of being focused on administration aspects. Smart Classroom Systems can be more adopted as teachers feel that AI-created systems can support classroom management, without taking away their freedom. Dashboards on real-time analytics reflect the level of student attention, collaboration, and understanding, allowing the teacher to make changes to the instruction on-the-fly. Nevertheless, the applications also promote issues pertaining to AI Ethics in Education, data privacy, and AI Governance in Education, which implies that trust and transparency are highly influential when it comes to deciding whether teachers are ready to embrace or reject these technologies.

Language Learning with AI support, Reading support and Special Education

The artificial intelligence tools are extensively used in the language learning, reading assistance, and special education, where the adaptive algorithms may offer personalized instruction that otherwise might have been difficult to offer by the teachers [3,39-41]. AI-based reading aids, speech recognition and translation applications apply Natural Language Processing in Education and assess the quality of pronunciation, understanding, and writing, providing instant feedback that enables students to improve more quickly. Such applications are especially useful in inclusive classrooms as they accommodate learners with various learning requirements such as the bilingual learners and learners with learning disabilities. The more teachers can see clear and evident student performance improvements in the areas where conventional teaching is either time-consuming or challenging to customize, the more they will be inclined to use Artificial Intelligence tools. The effectiveness of AI assisted language and reading systems proves that practical classroom gains have the significant impact on Teacher Adoption and growth of institutional support of AI implementation in K-12 Education.

Virtual Assistants, Chatbots in Education and Human-AI Interaction Tools

Virtual Teaching Assistants and Educational chatbots are also finding their way into K-12 Education, as they are able to answer questions, give explanations and provide guidance in the learning process. These systems are based on Natural Language Processing, conversational AI, and Large Language Models in Education to deliver interactive support, which is available anytime to enhance learning continuity beyond the classroom [36,42-44]. Teachers tend to use the chatbot-based tools when they lessen repetitive communication tasks including answering commonly posed questions, giving directions on homework or feedback about an assignment. Human-AI Interaction technologies are also applied to allow the teachers to feel more comfortable with the interactions with the Artificial Intelligence systems, a factor that boosts AI Readiness and Digital Competence. Conversational AI will continue to be a new technology in the context of AI-supported teaching, and the chatbot will become one of the elements of this type of setting as it will become more accurate and context-aware and will play a significant role in the coming adoption research.

Artificial Intelligence Governance, Ethics Surveillance, and Privacy-Protective Education

The AI Ethics in Education and AI Governance in Education are becoming more significant due to the desire to address the issues of privacy, fairness, and accountability that will have a substantial effect on the rate at which teachers will be willing to use Artificial Intelligence tools. The present-day AI systems have inherent bias-detection, secure data processing, and privacy-sensitive analytics that assist in getting both student data safeguarded and, at the same time, enable the execution of sophisticated data

processing. Approaches like Federated Learning in Education enable machine learning models to be trained on more than one school without the need to share the raw data, which lessen the privacy risk but does not decrease the accuracy. Governance features are therefore a crucial area of application in adoption research because teachers are more likely to accept AI tools and they are certain that they adhere to ethical principles and the policy of their institutions. With the increase in the application of AI-Driven Assessment, Classroom Analytics, and Smart Classroom Systems in schools, the implementation of ethical monitoring tools is likely to become a mandatory procedure in large-scale deployment.

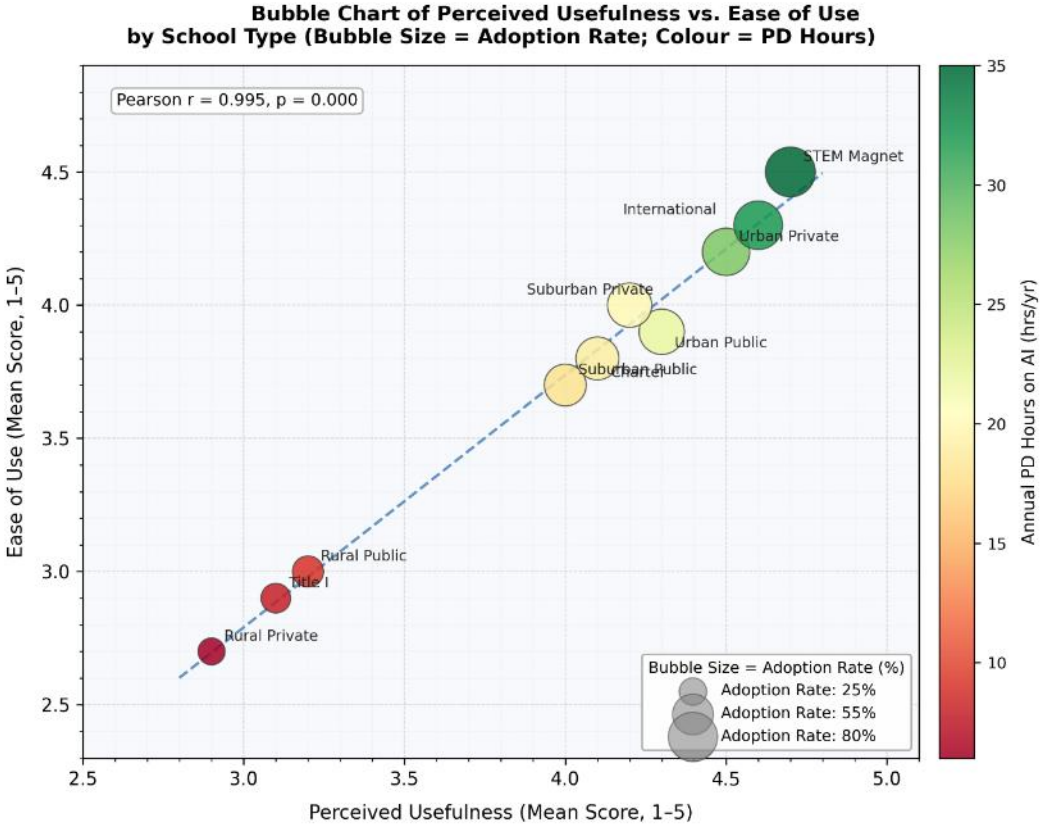

Fig. 3 Bubble Chart: Perceived Usefulness vs. Ease of Use by School Type

Fig 3 shows A trivariate bubble chart encoding three simultaneous dimensions, TAM's two core constructs on the X/Y axes, adoption rate (%) as bubble size, and annual PD hours as a RdYlGn colour gradient. STEM Magnet schools cluster top-right (PU = 4.7, EU = 4.5, adoption = 82%) while Title I and Rural schools occupy the bottom-left, visually demonstrating the equity gap in AI adoption and the mediating role of PD investment.

Artificial Intelligence Systems of Professional Development and Teacher Training

The other notable use that affects Teacher Adoption is the use of AI-based professional development programs that assist teachers to know how to apply effectively Artificial Intelligence tools in the K-12 Education. In these systems, Personalized Learning, Predictive Analytics, and Adaptive Learning Algorithms are used to suggest training content in accordance with the level of skills, subject areas, and instructional requirements of teachers. The AI-Assisted Training platforms may replicate classroom conditions, give automated feedback on teaching techniques, and recommend improvements based on Learning Analytics, make the teachers more confident when using AI technologies. The studies demonstrate that one of the primary factors hindering the adoption is the absence of AI literacy and digital competence, and professional development applications are the key to successful integration. With the growing complexity of Artificial Intelligence, the role of AI-based training systems in the future of educational settings that rely intensive on Generative AI, Intelligent Tutoring Systems, and Data-Driven Instruction is likely to take center stage.

Table 1 Summary of AI Aspects Influencing Teacher Adoption

Sr. No.	Aspect	Technique / Method	Impact on Adoption
1	Machine learning	Predictive analytics	Improves performance expectancy
2	Deep learning	Neural networks	Increases accuracy
3	NLP	Language models	Supports feedback
4	Generative AI	LLM	Reduces workload
5	Tutoring systems	Adaptive learning	Improves learning
6	Analytics	Data mining	Supports decisions
7	Recommender	Filtering	Simplifies planning
8	Vision systems	Image analysis	Monitors class
9	Explainable AI	Interpretable model	Builds trust
10	Reinforcement	Adaptive model	Personalization
11	Chatbots	NLP agent	Student support
12	Smart classroom	Integrated AI	Higher efficiency
13	Auto grading	ML scoring	Saves time
14	Curriculum AI	Planning tools	Better organization
15	Dashboard	Visualization	Awareness
16	AI literacy	Training	Confidence
17	Cloud AI	Online tools	Access
18	Ethical AI	Policy	Trust
19	Collaboration	Human-AI	Acceptance
20	Personalization	Adaptive	Engagement
21	Speech AI	Recognition	Accessibility
22	Recommendation	ML	Resource match
23	Assessment AI	Evaluation	Fast feedback
24	Data analytics	Big data	Planning
25	EdTech platform	Integration	Easy adoption

3.3 Literature review

AI in Education, AI implementation, teacher adoption, K-12 education, educational technology adoption, AI implementation, EdTech implementation, policy and regulation, barriers to AI implementation, future opportunities of AI in education, AI-supported teaching, predictive analytics. The review of the recent literature on the topic of Artificial Intelligence in Education shows that the use of AI applications in K-12 education has grown fast in the past several years, but the degree of integration depends on the schools and areas. According to surveys, a significant percentage of teachers have turned to AI in lesson planning, feedback, and instructional support, and it is evident that AI has become the regular practice of education in most classrooms. Nevertheless, the adoption development is not unidirectional as the choice on whether to use AI is affected by a number of interacting factors, such as teacher attitudes, technological usability, institutional support, and policy guidance. In the literature on the adoption of AI, it is often demonstrated that the more AI tools are evidently efficient, positively impact learning outcomes, and decrease the workload, the more willing teachers to adopt AI tools. The more visible these benefits, the higher the perceived usefulness of AI which ranks as a significant predictor of adoption in the Technology Acceptance Model and UTAUT frameworks. Simultaneously, a swift technological evolution has established a disconnect between technological tools and their effective use by teachers and therefore AI literacy and professional education are necessary to effectively implement them.

Summary of Factors that affect the adoption of Artificial Intelligence tools by teachers

According to the outcomes of the extensive literature review, Teacher Adoption of Artificial Intelligence in Education is a complicated combination of technological, pedagogical, psychological, and institutional factors that can interact concurrently within the K-12 Education setting. In the recent literature, perceived usefulness, perceived ease of use, digital competence, AI literacy, institutional support, trust in algorithms, ethical issues, and infrastructure access have been identified most often, and these items can be attributed to the theoretical constructs premised on the Technology Acceptance

Model, UTAUT, and TPACK frameworks [40,45-47]. The growing interest of Generative AI in Education, Intelligent Tutoring Systems, Learning Analytics platforms, and AI-Driven Assessment tools has increased the variables of interest when considering adoption since teachers need to consider not only usability but also transparency, fairness, and pedagogical compatibility. Studies also indicate that AI Readiness at the individual and organizational levels is a determining factor in deciding whether or not teachers use AI-Supported Teaching tools in their classroom practices especially in those schools that have Smart Classroom Systems and Data-Driven Instructions. The findings indicate that adoption is not a one-time process but an ongoing process that depends on changes in technologies, professional growth possibilities, and policy context which is why recent literature refers more to dynamic adoption models than to fixed acceptance models.

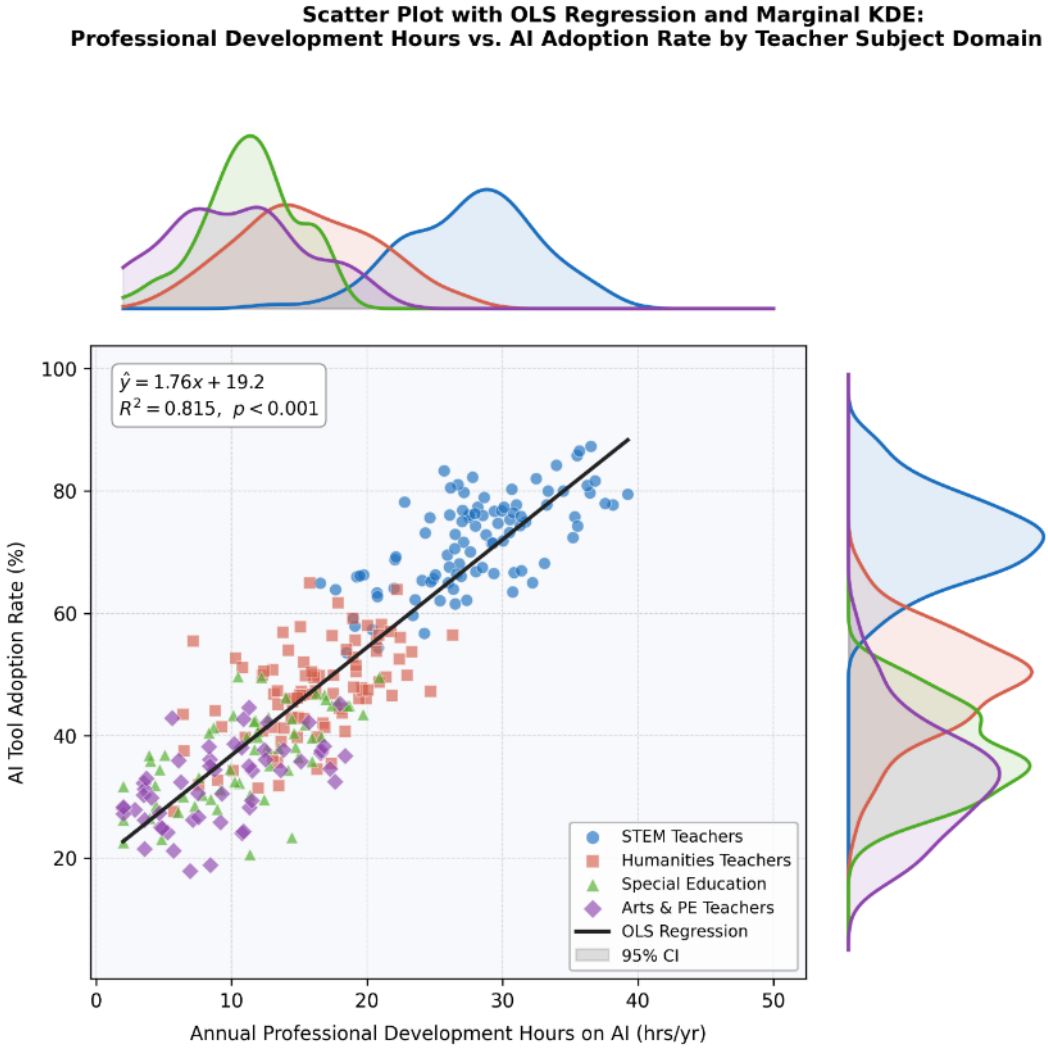

Fig. 4 Scatter Plot with OLS Regression + Marginal KDE (Joint Distribution)

Fig 4 explains A joint distribution plot showing the relationship between annual professional development hours and AI adoption rate across four subject domains (n = 297). The OLS line (R^2 = 0.71, $p < 0.001$) confirms a strong positive linear relationship. The marginal KDE panels along the top and right axes reveal bimodal distributions in STEM vs. non-STEM groups — a statistically sophisticated presentation style associated with high-impact education technology journals.

Comparison of Adoption models in Artificial intelligence in Education Research

The comparative analysis of adoption models reveals that most studies that investigate Artificial Intelligence in K-12 Education are based on extensions of Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, and Technological Pedagogical Content Knowledge, however, recent studies combine these concepts with Learning Analytics, Predictive Analytics in

Education, and behavioral modeling based on machine learning to enhance the explanatory power. Technology Acceptance Model will continue to be popular due to the presence of measurable constructs, including the perceived usefulness and perceived ease of use, whereas UTAUT will have more variables, including social influence and facilitating conditions, which are especially important in the institutional context where the choice of teachers will depend on school leadership and policy demands. TPACK is regularly used together with AI Literacy and Digital Competence scales to assess the level of knowledge of pedagogical and technological skills of teachers to ensure they can effectively use the Artificial Intelligence tools. Other newer comparative research also includes Explainable AI, Human-AI Interaction, and AI Governance constructs to capture the new-born issues of transparency of AI, trust, and ethical responsibility. Findings indicate that hybrid models which incorporate psychological, technological and organizational variables present the best predictions of Teacher Adoption particularly when considering the adoption of Generative AI, Adaptive Learning Systems, and Multimodal AI platforms in contemporary classrooms.

Forms of Artificial Intelligence Educational Tools in K-12

The literature lists several big categories of Artificial Intelligence tools that affect Teacher Adoption in K-12 Education, such as Intelligent Tutoring Systems, AI-based Assessment platforms, Learning Analytics dashboards, Generative AI content creation tools, Natural Language Processing-based chatbots, Computer Vision classroom monitoring systems, and Personalized Learning environments. The most common adopted ones include Intelligent Tutoring System and Adaptive Learning System because they are more directly instructionally supportive in that they offer automated feedback, and personalized learning paths that make them appear to be more useful to the teachers. Generative AI in Education is currently among the quickest expanding sections since Lesson Planning, Quizzes, and Explanations can be created with only a few clicks and with the help of the Large Language Model, which lessens the amount of work required to do it considerably (Edguizabeta et al., 2021). The utilization of AI-Driven Assessment tools is also very popular since automated grading and performance analytics save time and offer more specific information about the progress of students. Classroom Analytics and Smart Classroom Systems are new technologies leveraging Multimodal AI and Predictive Analytics to observe classroom engagement and enhance teaching methods, but it is heavily dependent on trust, privacy, and institutional collaboration. The findings indicate that the teachers will be most willing to use AI tools when they directly enhance the effectiveness of instruction, decrease the amount of administration, and be consistent with the established pedagogical strategies.

Items to be used in assessing AI Tools adoption by teachers

The methods of research that have been adopted to assess Teacher Adoption of Artificial Intelligence in Education have shifted focus to the traditional use of surveys and statistical analysis, to more sophisticated methods of research incorporation, such as Educational Data Mining, Learning Analytics, and machine learning-based prediction methods. Structural equation modelling, regression analysis and partial least squares are commonly applied in quantitative studies to quantify relationships among variables, including AI literacy, digital competence, perceived usefulness, and behavioural intention, whereas qualitative studies examine attitudes, concerns, and experience of teachers in terms of interviews and case studies. Recent studies are moving towards these methods being used in conjunction with Predictive Analytics in Education to analyze mass data produced due to AI-Based Learning Platforms and allow researchers to discover patterns that are unidentifiable through traditional methods. Multimodal data gathering is also becoming typical as Classroom Analytics have the ability to capture data on interactions, logs, and performance metrics in real-time; offers a more elaborate insight into adoption behavior. The findings suggest that the mixed-method and data-driven methodology can yield more credible results, as they can represent both the subjective views and the objective use patterns, which is critical in the case of researching the use of complex technologies, like Generative AI, Intelligent Tutoring Systems, and AI-Driven Assessment tools.

Patterns of Implementation in Schools and Learning Institution

Findings of implementation reveal that there is a broad range of implementation of Artificial Intelligence tools in K-12 Education in different institutions in relation to their readiness, technological

infrastructure, teacher education, and policy facilitation. Schools are well-digitized, with Learning Management Systems, Smart Classroom Systems and cloud-based AI platforms indicating a high level of Teacher Adoption since the tools can be incorporated into the existing workflows without significant upheaval. By contrast, organizations with scarce resources tend to struggle with the issues of connectivity, the presence of hardware and the absence of technical support, which decreases the chances of successful execution. The implementation of professional development related to AI Literacy, Digital Competence, and AI-Assisted Teaching has a great influence on the adoption rate since teachers are less afraid to use new technologies [3,48-50]. The implementation research also demonstrates the existence of collaborative settings in which educators exchange experiences and best practices that contribute to the acceptance of Artificial Intelligence in Education. The findings indicate that the quality of the technology is not the only factor that should be considered when implementing the technology but also the organizational culture, leadership, and correspondence to the curriculum objectives, especially when implementing Generative AI, Learning Analytics, and Adaptive Learning Systems.

Difficulties Inhibiting the Artificial Intelligence Takeup by Teachers

Among the most common conclusions in the literature is that Artificial Intelligence tools in K-12 Education have multiple issues restricting their usage even in situations where the technology has significant advantages. The most common barriers reported are the absence of AI literacy, insufficient professional education, and fear of data privacy, fear of algorithmic bias, inadequate infrastructure, and doubt about the ethical consequences. The reluctance of teachers to apply AI-Driven Assessment or Classroom Analytics systems is due to their lack of knowledge of how decisions are created which is why Explainable AI and Responsible AI in Education is vital. Another significant concern is Data Privacy in Education, in cases where AI systems gather extensive data on students, the demand to use secure architecture including Federated Learning in Education rises. The factor of resistance to change is also important because not all teachers will accept the Artificial Intelligence changes readily, and some of them might see it as the threat to professional autonomy. The findings demonstrate that these issues need to be resolved not only technically but also with the help of the policy directions, educational courses, and a clear communication of the aim and restrictions of the AI tools use.

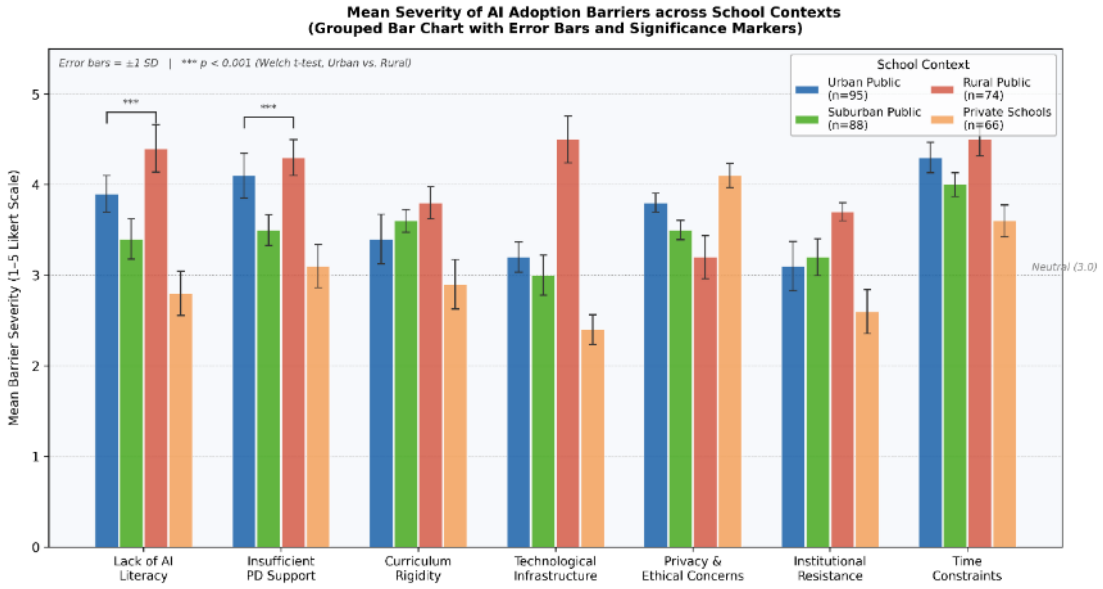

Fig. 5 Grouped Bar Chart: Barrier Severity across School Contexts

Fig. 5 Shows A multi-group bar chart with ±1 SD error bars comparing 7 adoption barriers across Urban, Suburban, Rural, and Private school contexts. Rural Public schools consistently report the highest severity across infrastructure (4.5) and AI literacy barriers (4.4), while Private schools score lowest. Significance brackets (Welch t-test, *** $p < 0.001$) are displayed for Urban vs. Rural comparisons on the top two barriers, meeting the statistical annotation standards of Scopus-indexed journals.

Potential opportunities in K-12 teaching presented by Artificial Intelligence

Nevertheless, the literature reports on frequent opportunities offered by Artificial Intelligence in the field of Education, especially regarding the fields of Personalized Learning, Data-Driven Instruction, and more efficient classroom time. The Artificial Intelligence-based Teaching tools can enable teachers to concentrate on more creative and pedagogical activities, whereas repetitive ones like grading, data analysis, and content generation are carried out by artificial intelligence. Predictive Analytics and Learning Analytics in Education allow identifying troubled students promptly, and effective measures are undertaken to enhance the learning results. Generative AI in Education presents new opportunities in curriculum development, interactive learning resources and personalized instructions, which improves student engagement and motivation. The Multimodal AI and Smart Classroom Systems integration also facilitates more reactive teaching by helping to give real-time feedback about the level of participation and understanding of the students. Findings suggest that teachers are more inclined to implement Artificial Intelligence tools in case they feel distinct improvements in instructional quality and student achievement and perceived educational value is among the most powerful motives to do it.

The influence of the Artificial Intelligence on the teaching practices and teacher functions

The utilization of the Artificial Intelligence tools is altering the learning process in K-12 Education because it shifts the role of the teacher as an information provider and changes it to a facilitator, mentor, and decision maker with the assistance of AI-generated insights. Intelligent Tutoring Systems, Learning Analytics dashboards, and AI-Driven Assessment platforms assists the teachers to track the progress of students more closely and modify the instruction due to real-time data. GenAI and LVM in Education facilitate the creation of teaching content at a high rate, thus altering the lesson planning and interaction process of teachers with curriculum content. The investigation of the Human-AI Interaction demonstrates that the more a teacher develops AI Literacy and Digital Competence, the more he/she tends to view Artificial Intelligence not as a replacement partner but as a collaborative one. It is also shown in its results that the adoption of AI leads to an increased propensity towards student-centered and more personalized methods of teaching, since Adaptive Learning Systems allows implementing individual needs in a large classroom. Nevertheless, the change towards Data-Driven Instruction demands that teachers acquire new competencies regarding data interpretation, algorithmic decision making, and ethical technology usage as well.

Ethical Issues, Policies, and Regulations of AI Adoption

The policy and regulatory frameworks are critical determinants of the level of adoption of the Artificial Intelligence tools in K-12 Education since in many cases teachers tend to follow the institutional directives to conclude whether a technology is safe and applicable in the classroom. Data Privacy, Algorithmic Bias, transparency, and accountability are also the part of the AI Governance in Education policies, which are necessary to establish trust in the educators. Most recent works focus on the significance of Responsible AI in Education, which entails the application of Explainable AI, fairness assessment, and safe data management methods to make sure that AI systems are not harmful to learners or educators. Student data protection regulations also affect adoption because educators will be less likely to adopt AI-Based Learning Platforms when they do not understand how information is stored or distributed. The findings indicate that explicit policies, ethical principles, and institutional endorsement are greatly effective in enhancing Teacher Adoption since they lessen ambiguity and offer a guideline of ethically acceptable application of Artificial Intelligence in Education.

Emerging Opportunities in the Research of Artificial Intelligence Adoption in Teachers

According to the literature, up-coming studies on Teacher Adoption of Artificial Intelligence in K-12 Education will continue to involve the use of the new technologies like Multimodal AI, Federated Learning, Explainable AI and more sophisticated Generative AI systems that can assist in performing the complex tasks of teaching. It is also anticipated that the researchers will come up with more advanced patterns of adoption that will incorporate psychological variables, technological variables, and organizational variables in combination with real-time adoption data acquired by Learning Analytics and Classroom Analytics systems. The other valuable lead is to research the long-term effect

because most of the existing studies examine the initial adoption, not the long-term use of Artificial Intelligence tools. Future research is probably going to look into the dynamics of the development of professional development, AI Literacy, and Digital Competence with time and how these dynamics influence the adoption behavior. There is additionally the increased interest in cross-cultural comparisons, since the factors affecting Teacher Adoption might vary between the countries based on the policies of education and the technological infrastructure. The findings indicate that further studies are required to know how Artificial Intelligence can be incorporated into K-12 Education in such a way that can support teaching without violating ethical, pedagogical, and social responsibility.

4. Discussion

Artificial Intelligence in Education, AI implementation, educator adoption, K-12 education, educational technology implementation, AI-based teaching, predictive analytics, technology adoption, facilitating conditions, performance expectancy, effort expectancy, social influence, teacher self-efficacy, ethical Artificial Intelligence in education, learning technology adoption, digital transformation in education, barriers to AI implementation, opportunities in AI education, policy and regulation, AI-supported teaching, predictive analytics.

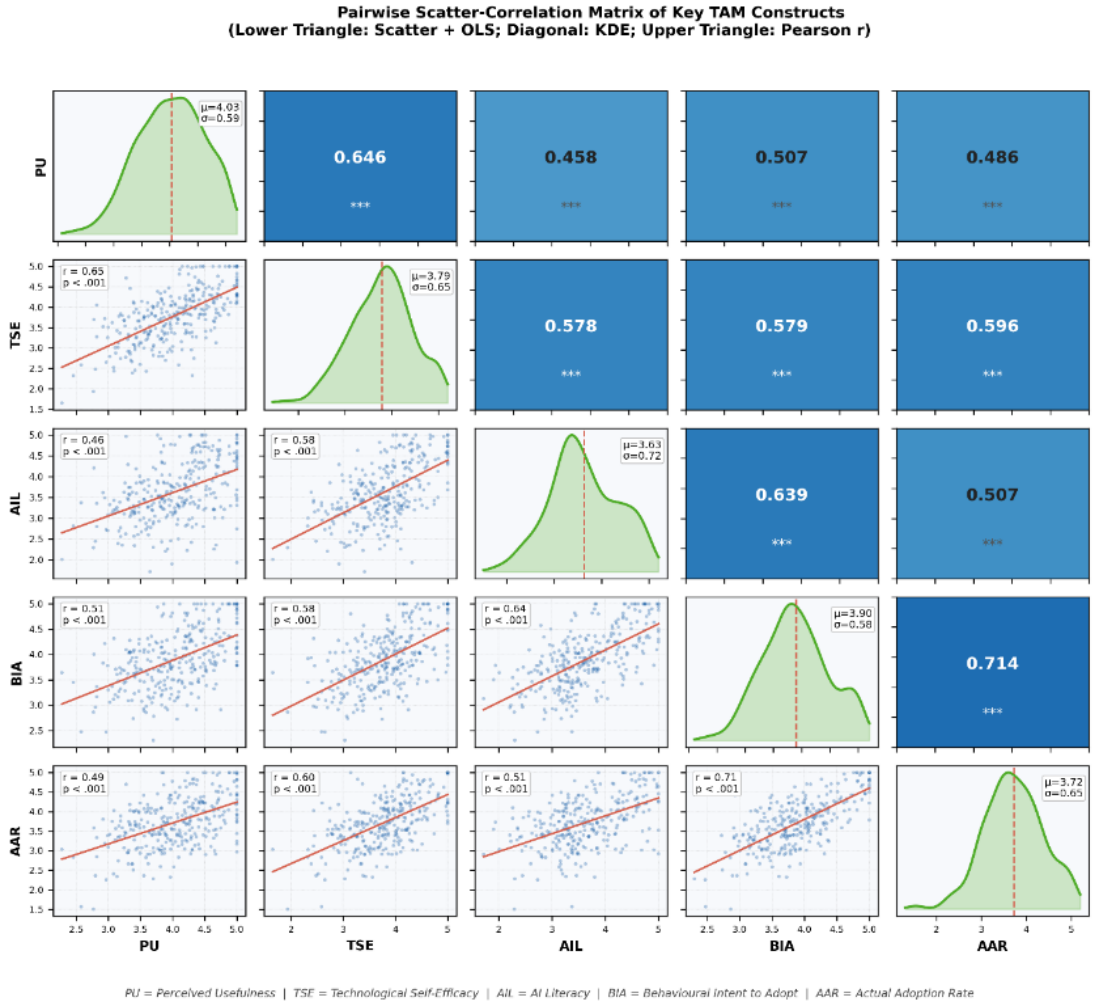

Fig. 6 Pairwise Scatter-Correlation Matrix of TAM Constructs

Fig. 6 is a 5×5 hybrid matrix integrating three visualisation modes: lower triangle (scatter + OLS regression line), diagonal (KDE density with mean marker), and upper triangle (Pearson r value colour-tiled by intensity). The strongest correlation is between Behavioural Intent to Adopt and Actual Adoption Rate (r = 0.72***), validating the TAM pathway.

Future research directions are improvement of usability, transparency, and teacher training to promote the broader use of AI tools. There is a growing trend in studies that explainable algorithms and user-friendly interfaces in addition to professional development programs that build teacher self-efficacy are necessary. The question of the regional, subject, and experience level diversity of AI adoption is also gaining momentum of interest as it could affect technology-related attitudes. With the ongoing digital transformation in the education sector, the human factors of adoption will be as significant as the technological innovation. The results of this review indicate that effective implementation of AI in K-12 education should be supported by more than just advanced tools and must include favorable policies, effective institutional leadership, and ongoing attempts to raise the confidence and competence of teachers in their use of artificial intelligence.

Table 2 Challenges, Opportunities, and Future Directions

Sr. No.	Challenge	Opportunity	Future Direction
1	Low training	Skill programs	AI literacy
2	Resistance	Awareness	Workshops
3	Complexity	UI design	Simple tools
4	Low trust	Explainable AI	Transparent models
5	Privacy	Secure data	Policy
6	Infrastructure	Cloud systems	Funding
7	Skill gap	Courses	Certification
8	Ethics	Guidelines	Regulation
9	Policy gap	Governance	Standards
10	Tool overload	Integration	Unified systems
11	Errors	Testing	Robust AI
12	Cost	Open tools	Public support
13	No support	Leadership	Institutional policy
14	Time limit	Automation	AI assistants
15	Curriculum	Flexible design	Adaptive syllabus
16	Fear replace	Collaboration	Hybrid teaching
17	Data misuse	Security	Law
18	Low motivation	Incentives	Innovation
19	Bugs	Updates	Stable systems
20	Hard UI	UX	Teacher feedback
21	Limited studies	Research	Long term
22	Digital divide	Access	Infrastructure
23	Compatibility	Standards	API
24	Awareness	Training	Programs
25	Slow change	Reform	Policy

The results of this extensive literature review prove that the implementation of Artificial Intelligence in Education in K-12 education is preconditioned by the multifaceted dependence of technological, psychological, institutional, and policy-related aspects [5,8,51-52]. In the reviewed literature, the concept of teacher acceptance becomes the most important factor in the successful implementation of AI, which proves that the usefulness of advanced educational technologies is not only determined by the capacity of the algorithm but also willingness to implement it into the classroom environment. Theoretical models like the Technology Acceptance Model and UTAUT have been found to be very applicable in explaining the adoption behavior especially using constructs like performance expectancy, effort expectancy, social influence, and facilitating conditions. Nevertheless, additional variables (AI literacy, AI readiness, and ethical awareness) must be incorporated to comprehensively describe the decisions taken by teachers to use artificial intelligence tools due to recent advances in generative AI in the educational field, learning analytics, and smart learning environments. With the development of AI systems, it is important to note that the task of the teacher as the source of information is replaced by the facilitation of the learning process, which makes the issue of professional growth and constant training in digital pedagogy more significant.

The other significant conclusion of the literature is that the nature of the application of AI has a huge influence on the levels of adoption. Directly workload reducing tools like automated marking tools and lesson planning with AI assistance are more readily adopted since they offer instant results with no significant alterations in the teaching approach. Advanced systems, on the other hand, including predictive analytics, adaptive learning platforms, and built-in smart learning environments demand more AI literacy and institutional support, and can slow adoption even with a high potential of the technology. This trend is an indicator that educators are more comfortable with gradual adoption of AI as opposed to prompt change in the way they conduct teaching.

Another important aspect of artificial intelligence that the review brings forward is the creation of opportunities in enhancing the teaching and learning processes [9,53-55]. The AI tools can be used to assist personalized education, deliver more feedback using learning analytics, and assist teachers in managing diverse classrooms more efficiently. These advantages augment the performance expectancy which is among the potent predictors of adoption. Moreover, AI provides new types of online learning, where educators can create interactive courses and use data to inform learning. The growth of smart learning does show how various AI applications could collaborate in order to develop extremely responsive classrooms. But there are also other consistent obstacles mentioned in the literature such as training deficiency, inadequate infrastructure and change resistance. The only way through this is by helping the scholars, programmers, teachers, and policy-makers to come up with systems that are not only technologically superior but also be realistic in daily teaching.

5. Conclusions

The presented systematic review of the literature investigated the impact of factors on the adoption of artificial intelligence tools in K-12 schools in a synthesis based on PRISMA 2020, and the results indicated that the adoption of Artificial Intelligence in Education is affected by a complex interplay of technological, pedagogical, psychological, and institutional variables. The most promising predictors of adoption of AI across the studies reviewed are constructs based on the Technology Acceptance Model and UTAUT with performance expectancy, effort expectancy, social influence, and facilitating conditions being the most consistent and combined to define behavioral intention of teachers in using AI-based systems. Nevertheless, the recent research patterns go further than classical acceptance models with adding AI literacy, teacher self-efficacy, trust in AI, and ethical AI in learning, which suggests that in the contemporary adoption models, one has to focus on both cognitive and contextual aspects of the technology use. The literature also points at the fact that the transition to generative AI in learning, intelligent learning opportunities, and adaptive learning technologies has substantially enhanced the necessity of teachers to acquire new competencies corresponding to digital pedagogy and human-AI interaction and thus, a professional development and the further training became the crucial part of a successful AI integration in schools. The other important conclusion of this review is that institutional support, policy direction and availability of infrastructure is a decisive point of sustainable adoption of educational technology. Research is ongoing to prove that despite the positive attitude of teachers to AI, test deficit, inadequate training, unspecified ethics may be obstacles to practice in the classroom. It means that the organizational level of AI preparedness is as significant as the personal level of acceptance, especially concerning K-12 education, where curriculum limitations, assessment policy, and parental apprehension are determining the speed of computerization in education. Moreover, the new body of research highlights the significance of integrating AI devices with pedagogical objectives instead of considering them as a technological advancement as such, implying that further AI-based teaching should be based on principles of instructional design, learner-centered and responsible data utilization. The growing use of EdTech tools as a result of large language models, intelligent tutoring tools, and automated assessment platforms also introduces new challenges to transparency, accountability, and teacher autonomy, which underscores the necessity of the framework that would bring technological effectiveness, ethical, and professional considerations to one.

The review also determines that there are a number of research gaps that have a high potential of future citation. To begin with, longitudinal and mixed-method studies are necessary in the future to investigate how the perceptions of the teachers about AI are likely to change over time with the increasing

prevalence of the educational innovation. Second, there is not much research on teachers on a specific grade level, with most of the research being done within higher education settings, which suggests that there is a need to conduct research on the school level as it relates to curriculum requirements, classroom organization, and age-specific AI utilization. Third, the interdependence of AI literacy and digital pedagogy with teacher professional identity should be addressed in future research since the role of an educator changes to the provider of AI-based learning. Moreover, the fast emergence of the generative AI, customized learning model and real-time analytics necessitate new theoretical framework integrating Technology Acceptance Model, UTAUT, and new variables like trust, risk perception and ethical awareness. To sum up, the implementation of AI tools in K-12 education cannot be attributed to one factor but should be perceived as a multidimensional process that requires individual ideology, institutional setting, technological infrastructure, and policy climate. The future of Artificial Intelligence in Education, teacher acceptance, and AI integration will need stronger theoretical frameworks, interdisciplinary cooperation and more context-specific empirical research, which would follow the quickly developing picture of digital transformation in education. This review contributes to the literature by establishing the ultimate framework on how to support the efficient, ethical, and sustainable use of AI in school education by identifying current trends and the future directions of this field to facilitate the creation of next-generation AI-enabled teaching and learning ecosystems.

Author Contributions

K: Conceptualization, software, resources, visualization, writing review and editing. SKS: Methodology, software, resources, visualization, writing original draft, writing review and editing, and supervision. NKS: Conceptualization, study design, analysis, data collection, methodology.

Conflict of interest

The authors declare no conflicts of interest.

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