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# Utilizing data mining tools to explore the digital reality of artificial intelligence in Saudi education

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**Abstract**

This research aimed to explore the digital reality of using artificial intelligence (AI) in Saudi education using data mining tools. A qualitative approach was adopted, with data collected from X platform posts during 2023. A total of 15,603 tweets were retrieved from the beginning to the end of 2023, based on the hashtags and keywords identified within those hashtags. The results show that X users have demonstrated the practical application of AI in creating customized lesson plans, developing interactive content, and providing real-time assessments. The findings also indicate widespread digital engagement and interest in AI applications that can contribute to improving education, highlighting the most important AI applications available in education and the main challenges hindering the integration of AI into education. The results highlighted the critical importance of science, technology, engineering, and mathematics (STEM) education, given that these disciplines inherently rely on algorithmic thinking, complex problem-solving, and continuous digital adaptation. Although STEM fields are at the forefront of sectors capable of technological adaptation, an analysis of data from the X platform revealed a significant contextual and practical gap between the theoretical frameworks of AI and the reality of daily practices and actual challenges within educational environments. The results indicate that addressing these gaps provides an actionable plan—along with practical, evidence-based guidelines—for educators, curriculum designers, and decision-makers in STEM fields. This includes leveraging AI applications to create personalized lesson plans, develop interactive content, and provide immediate assessments that cater to individual student needs. The study recommends future research that goes beyond simply analyzing public opinion trends. This research should explore the practical educational impact of AI tools on student learning outcomes, systematically investigate ethical dimensions such as algorithmic bias and data privacy in adaptive learning environments, explore applications that can effectively contribute to curriculum development, and focus on finding solutions to overcome obstacles to integrating AI into education.

**Keywords:** data mining, digital reality, AI in education, AI applications, AI challenges, X platform

## INTRODUCTION

Today, the massive digital flows accompanying the big data boom represent a fundamental pillar for building societal knowledge and guiding strategic planning and decision-making processes (Khan & Al-Qahtani, 2020; Luan et al., 2020; Sarker, 2021). This importance is underscored within the framework of national visions for sustainable development, with Saudi Arabia emerging as a global leader in investing in this field (Saudi Authority for Data and AI, 2022).

The digital activities of those affiliated with the education sector, including teachers and students, constitute a vital source for generating this data via social networks and mobile phones, creating rich digital footprints with analytical insights for developing the education system (Al-Zain, 2020; Jones, 2024; Rahmani et al., 2021). In this context, the X platform stands out as an interactive environment and a distinguished information repository that enables the application of data mining techniques to explore future trends, monitor the reality of educational practices, and support


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**Contribution to the literature**

- Providing empirical evidence from a rapidly digitizing educational environment: This study offers real-world insights into the perception and utilization of AI applications within the Saudi education sector, moving beyond the purely theoretical frameworks that characterize existing literature.
- Methodological innovation through data mining: This study introduces a methodological innovation that transcends traditional self-report surveys by employing data mining tools to analyze live discussions and practices on the X platform; this approach minimizes bias and yields more accurate insights into the digital landscape.
- Bridging the theory-practice gap in STEM education: This study contributes to the literature on STEM education by highlighting the gap between theoretical AI frameworks and actual field practices. It provides decision-makers and curriculum designers in STEM fields with an evidence-based, actionable roadmap for integrating AI tools into lesson planning, interactive content development, and the assessment of students' algorithmic thinking.

evidence-based institutional decision-making (Al-Baba et al., 2021; Liu, 2015; Urban, 2021; Valenzuela et al., 2017). Saudi educational institutions have adopted this platform as a tool for gathering opinions and fostering community dialogue on general educational issues (Alhamad et al., 2025; Ministry of Education, 2022; Shtiwi et al., 2019; VEODATA, 2023).

In parallel, the integration of artificial intelligence (AI) has fundamentally transformed educational environments by enhancing teaching methods, providing personalized learning pathways, and promoting equitable and interactive learning environments (Vesna et al., 2025). AI is defined as information processing technologies that rely on modeling and algorithmic correlations to perform cognitive tasks with varying levels of autonomy (UNESCO, 2021, 2025). These global trends are reflected in regional plans, such as the European Commission's (2017, 2023) digital education action plan, which focused on developing teachers' digital competencies and providing practical scenarios for integrating AI to enrich the educational experiences of academic groups and enhance student motivation and cognitive performance (Dhawan & Batra, 2022).

From an educational perspective, the integration of AI represents a structural shift in learning theory and curriculum design. This intersects with connectionism, which views learning as a networked process distributed across human and digital platforms (Alexander & Murphy, 2024), and constructivism, which emphasizes learner autonomy and the construction of self-knowledge through direct, adaptive interaction (Richter et al., 2025). Analyzing texts across social media platforms allows us to understand how these theories are actually implemented and their impact on transforming traditional environments into dynamic learning systems.

Despite the wide range of research on AI in general education, there is a critical need for science, technology, engineering, and mathematics (STEM) education researchers and policymakers to rigorously examine these applications, given the nature of these disciplines, which rely heavily on algorithmic thinking, complex problem-solving, and continuous digital adaptation. While STEM fields are assumed to be at the forefront of technological adaptation, the reality of how these tools are perceived, integrated, or hindered within the daily practices of rapidly evolving, open educational systems (such as the Saudi system) still needs in-depth exploration based on big, non-interactive behavioral data.

To date, current research points to three key gaps in the literature: a methodological gap, as previous research in educational AI relies heavily on self-reported questionnaires and local interviews, which are susceptible to social desire bias and do not allow for the real-time monitoring of dynamic professional discourse on AI (Gidiotis, 2026; Ursavaş et al., 2025); a contextual gap, as while conceptual frameworks advocate for the integration of AI, there is a lack of data-driven studies linking macro-level digital sentiment to AI-specific educational applications, particularly in STEM learning environments (Althubyani, 2026; Zawacki-Richter et al., 2019); and an application gap, as while extensive discussions highlight the theoretical benefits of AI, research systematically reveals the practical constraints, technical challenges, and ethical concerns that hinder its smooth implementation in Saudi Arabia's national education reform (Almethen, 2019). Addressing these gaps is crucial for all those involved in STEM fields. STEM educators need practical, evidence-based insights. Furthermore, understanding the "digital reality"—public awareness, educational trends, and institutional barriers—enable STEM curriculum designers and decision-makers to move beyond simply adopting tools toward strategies for integrating AI into the educational process.

However, when evaluating educational innovations through social media data analysis, it is theoretically essential to recognize that digital spaces reflect an "intermediate reality," not a true reality. Online discussions often embody professional aspirations,

public discourse, or technological optimism more than they focus on direct classroom behaviors. Therefore, monitoring educational reality via the X platform requires a precise conceptual framework that treats digital data as an indicator of public awareness and professional attitudes, rather than a direct reflection of actual classroom processes.

### Research Problem

To conduct a systematic study of the digital reality of AI in Saudi education, this study adopts a three-tiered analytical approach: First, the study examines general professional awareness and digital trends to monitor public discourse among users of the X platform. Second, the study focuses on specific AI tools and programs used by teachers to bridge the gap between theoretical capabilities and practical application. Third, the study identifies the underlying technical, organizational, and human obstacles or challenges that hinder the practical application and optimal use of AI in education, providing practical insights for decision-makers. Accordingly, the research problem is defined by answering the following main question: How can data mining tools be effectively utilized on social media platforms to reveal the digital reality of AI employment in Saudi education? This question expands further into the following sub-questions:

1. What the perceived state of AI implementation is as reflected in the digital discourse of X platform users?
2. What are the most popular and widely used AI applications in today's digital education environment?
3. What are the challenges that hinder the practical application and optimal use of AI in education?

### Research Objectives

This research aims to use data mining tools on social media platforms (specifically the X platform) to uncover the reality of employing AI applications in the educational system in the Kingdom of Saudi Arabia, and to monitor the current reality to reveal the level of spread of use of AI technologies in educational environments by analyzing the digital content available on social media platforms, identifying the most prominent applications and tools of AI that are most used and circulated in current educational practices, and attempting to investigate the challenges (technical, human, and organizational) that prevent the optimal use of AI in education, in addition to adopting an analytical vision based on big data to help decision-makers in the Saudi Ministry of Education to draw up development strategies that support digital transformation.

### The Importance of the Research

The findings of this research will assist policymakers within the Ministry of Education and educational institutions in enhancing educators' digital competencies—particularly for employing AI technologies in education.

Furthermore, this research explores methods for harnessing vast social media datasets to formulate actionable recommendations and propose practical initiatives aimed at refining the educational process.

On the X platform, the relevant hashtags include:

- #TheArtificialIntelligence,
- #With_ArtificialIntelligence,
- #The_Artificial_Intelligence,
- #Artificial_Intelligence_in_education,
- #Artificial_Intelligence, #Education_Intelligence,
- #TheGenerativeIntelligence,
- #The_Generative_Intelligence,
- #With_Generative_Intelligence,
- #Generative_Intelligence_in_Education, and
- #Generative_Intelligence.

### Defining Key Terms

**AI:** "Building machines capable of emulating human cognitive processes, including reasoning, forming opinions and judgments, and the capacity for development and learning" (Helal, 2021).

**Digital reality of AI:** collective trends, conceptual awareness, professional attitudes, and perceived challenges documented in Arabic tweets extracted from the X platform. This operational definition represents the online educational discourse and public awareness regarding the adoption of AI in education, and it differs significantly from experimental behavioral practices in traditional classrooms.

**Data:** Defined as collections of information appearing across diverse and numerous applications, growing continuously, and exceeding the capacity of traditional database software for acquisition, storage, and management.

## LITERATURE REVIEW

This section presents a review of the literature surrounding the topic of data mining and AI in education.

### Data Mining

Data is the primary source of value creation. Data mining is defined as the process of analyzing vast amounts of information and databases (Ramakrishnan, 2023) to uncover unknown patterns and unexpected relationships (Sarker, 2021; Zarrabeitia-Bilbao et al.,

2023). Its techniques range from statistics to AI (Mahadevkar et al., 2024), and it aims to support sound decision-making and problem-solving (Divya et al., 2023; Li et al., 2017).

These techniques matter because they provide a precise quantitative understanding of human behavior, predict future trends, and manage risks (Ramakrishnan, 2023; Sinha, 2018). They also enable the analysis of public opinion and interactions across digital platforms to enhance understanding of national issues (Abdel-Khaleq, 2020; Al-Jazzaf, 2022). With the rise of "big data" and the development of modern marketing (Chopra et al., 2020), these technologies have enabled organizations to prioritize and monitor public awareness to achieve strategic goals (Gustiana, 2024; Li et al., 2017). Moreover, they are characterized by their speed in processing complex queries, providing proactive recommendations, and predicting outcomes (Abdel-Khaleq, 2020; Al-Juhani & Khedyous, 2023; Asaad & Abdulhakim, 2021), which reinforces the importance of big data mining in conjunction with technological development (Saura et al., 2023).

### Data-Mining Techniques in Education

Data mining is important for improving decision-making in the education sector, a data-rich environment (Luan et al., 2020). Educational data mining aims to uncover hidden knowledge to improve educational processes and help decision-makers make smarter choices (Ang et al., 2020; Fischer et al., 2020; Khan & Al-Qahtani, 2020).These data are collected from learning management systems, student information systems, libraries, and social media platforms (such as Facebook, X [formerly Twitter], and YouTube) that have enabled students and teachers to share their experiences and opinions outside of traditional classrooms (Ang et al., 2020).

Social media networks provide vast and diverse datasets (text, images, and videos) characterized by their speed and variety (Rahmani et al., 2021). The applications of this data are numerous, including monitoring trends, analyzing sentiment (positive, negative, neutral), measuring employee satisfaction, and evaluating the success of innovations and e-learning systems developed by educational institutions (Ghani et al., 2019).

### AI in Education

The concept of AI has garnered increasing attention with the Fourth and Fifth Industrial Revolutions and the development of its applications. It is defined as the transfer of computing capabilities that mimic human intelligence to make decisions and achieve educational goals efficiently (Al-Hanaki & Al-Harthi, 2023; Gao et al., 2024; Imran et al., 2024a). AI encompasses advanced skills such as abstract reasoning, natural language processing, rapid learning, and the design of educational interventions based on cognitive simulation and environmental adaptation (Al-Khaibari, 2020; Nisioti & Moulin-Frier, 2020; Vesna et al., 2025; Zarouki & Falta, 2020).

Educational literature classifies educational AI into two main types: general AI, which is characterized by collecting and analyzing data and accumulating experiences to make independent decisions, as is the case with chatbots (Hassan, 2022), and super-AI, which mimics human complexity and predicts emotions based on the theory of mind model (Southgate et al., 2018).

The core value of AI lies in preserving and automating human experience, and its educational roles are evident in the following areas (Aswin et al., 2022; Fayzullina et al., 2025; Hennekeuser et al., 2024; Imran et al., 2024b; Kumar, 2021; Rajesh et al., 2022; Săseanu et al., 2024; Southgate et al., 2018):

- Large-scale educational applications: Managing adaptive learning systems and academic analytics beyond the capabilities of traditional systems.
- Adaptive and personalized learning: Providing tailored learning experiences that suit the learner's pace and prior knowledge.
- Self-directed learning: Enhancing independent learning and project-based activities through interactive tools that frame student participation.
- Flexible digital environments: Providing comprehensive learning environments, particularly in higher education.
- Teaching and administrative efficiency: Automating assessment tasks and administrative work and updating educational strategies.
- Communication and professional success: Supporting continuous interaction to reduce dropout rates and enhance graduate competitiveness.
- Professional development and scientific research: Training teachers on modern applications and assisting researchers in formulating hypotheses and designing experiments.

### The Importance of Educators' AI Awareness

The rapid development of AI applications has fundamentally transformed the educational system, prompting academic institutions worldwide to adopt these technologies to develop learning objectives, assessment methodologies, and teaching methods, with a focus on preparing human resources to effectively implement the digital education system (Al-Hakami & Mudawi, 2023; Gesnot, 2025; Hennekeuser et al., 2024; Southgate et al., 2018; Vieriu & Petrea, 2025).

The importance of AI is evident in its ability to empower educators to design flexible learning

experiences that align with learners' abilities and needs, as well as in automating academic monitoring and facilitating daily assessments (Fayzullina et al., 2025; Gabli & Al-Qahtani, 2022). This directly contributes to increasing teacher productivity by reducing the time spent on administrative tasks and grading, and by directing strategic effort towards academic planning and educational innovation (Al-Mahdi, 2021; Holmes & Tuomi, 2022; Vesna et al., 2025).

Furthermore, field experience—particularly during the COVID-19 pandemic—has demonstrated the ability of smart tools to accurately diagnose performance levels, support collaborative learning, and enhance continuous professional development (Holmes et al., 2023; Ibrahim et al., 2025). This transformation necessitates an institutional and individual commitment from teachers to enhance their technological awareness and effectively integrate AI to ensure the sustainability of academic excellence (Al-Hanaki & Al-Harethi, 2023).

## Applications of AI in the Educational Process

AI applications represent a qualitative shift in the development of learning methodologies and the provision of innovative learning environments that foster creative thinking and interaction among learners. These applications take many forms, ranging from expert systems that mimic human behavior and knowledge representation to analyze complex problems and make decisions (Asemi et al., 2021; Salmanova, 2024). Hassan (2022) classified AI deployment patterns into three main models based on the level of interaction and dependability:

**Supportive model:** Limited to assisting the learner in analyzing tasks and breaking them down into their components.

**Peer model:** Relies on active interaction, continuous dialogue, and adjustment of learning paths.

**Expert learning model:** Represents the most advanced stage, where the learner directly adopts the system's instructions without the need for interactive discussion.

These patterns give rise to what are known as "intelligent learning systems," which mimic the human teacher by providing flexible content that can be added to or removed from the learner's learning needs (Imran et al., 2024a; Létourneau et al., 2025; Tomi, 2025). "Learner-centeredness and individualization" are the cornerstones of these systems, providing customized learning experiences through continuous assessment of abilities and immediate feedback (Al-Mahdi, 2021). These systems have witnessed significant development with the emergence of intelligent chatbots capable of accurately mimicking human interaction (Fayzullina et al., 2025; Shanaa & Ghalioun, 2023). The ChatGPT model, launched by OpenAI in 2020, stands out as one of the most important large-scale language models based on deep learning and natural language processing, due to its ability to understand different contexts and generate logical responses that improve time efficiency and achieve targeted learning outcomes.

Virtual reality technologies have also undergone a qualitative leap with the integration of AI, transcending their origins in the late 20th century. They have moved towards creating intelligent avatars and generating dynamic environments that are visually and aurally simulated, allowing learners to interact with virtual objects as if they were tangible realities (Gao et al., 2024; Wang et al., 2025). In contrast, augmented reality (AR) literature is distinguished by its integration of digital information within the real environment, rather than isolating it from it. Al-Harbi (2021) explained its reliance on smart devices to provide additional contextual information, enhancing the accuracy of visual projection and facilitating the comprehension of complex concepts. Literature comparisons demonstrate AR's superiority in stimulating group participation and developing practical skills due to its ease of access to information.

Educational institutions are striving to leverage these technologies to build individualized learning pathways, improve academic performance, and empower teachers to perform their roles more efficiently by automating assessment processes and optimizing time and effort (Al Nabhani et al., 2025; Pasupuleti et al., 2026). The key advantages of AI in education, according to the International Forum on AI and Education (2021), are summarized as follows:

- **Automation of grading and assessment:** reducing human error and assessment bias, providing immediate results, and designing personalized remedial plans.
- **Performance analysis and feedback:** monitoring student interactions and providing teachers with accurate insights into performance and thinking levels.
- **Enhancing personalized and adaptive learning:** designing learning pathways based on the needs of individuals or groups and providing diagnostic reports to address learning difficulties.
- **Securing remote education and assessment:** providing intelligent monitoring environments that ensure the integrity and accuracy of tests.

## Requirements for Employing AI in Education

The effective application of AI in the education system requires a comprehensive approach to structural, human, and ethical requirements that are integrated to ensure its sustainability. Material and financial requirements stand out as a structural pillar determining the efficiency of its implementation. A study by Al-Ahmadi and Al-Qahtani (2022) confirms a direct correlation between the size of allocated budgets and the

development of software and operational hardware, a relationship that can be strengthened through strategic partnerships with the private sector. Simultaneously, operational success depends on human and administrative readiness through staff training and the refinement of their digital skills. Al-Besher (2020) emphasizes the importance of diversifying these applications to ensure their continuity and adaptability to emerging trends.

Regarding technological enablement, Berry (2022) points to the crucial role of a flexible and stable infrastructure, comprising wired and wireless communication networks, advanced computing, and specialized technical support. This framework is complemented by adherence to ethical and legal standards to ensure fairness, privacy, and equal opportunities (Spathopoulou et al., 2025). This necessitates the formulation of targeted policies that protect the data of all parties involved in the educational process and guarantee the responsible use of technology (Lund et al., 2025).

Despite the promising potential of AI in personalizing learning and improving academic outcomes (Vieriu & Petrea, 2025), its successful implementation remains contingent upon addressing concerns about cognitive dissonance and its impact on critical thinking and academic integrity. In this context, the Saudi Authority for Data and AI (2022) established ethical guidelines aligned with international standards and national values. These guidelines include promoting integrity and fairness, combating bias, ensuring reliability and security, and achieving transparency and accountability under human oversight to guarantee the quality of education (Alhamad et al., 2025; Shtiwi, 2019; VEODATA, 2023).

Conversely, the expansion of AI implementation faces numerous developmental and technological obstacles. Maguluri (2025) and Barczak (2023) both pointed to educators' limited familiarity with modern applications, inadequate digital infrastructure, a shortage of specialized personnel, and institutional resistance stemming from a lack of awareness of the importance of these technologies.

Contemporary literature agrees that the desired aspirations are hampered by a digital divide and disparities in resources among educational institutions, exacerbating socioeconomic inequalities in student achievement (Baker & Hawn, 2022; Boateng & Boateng, 2025; Miao et al., 2021; Vesna, 2025). This is further compounded by weak institutional coordination and partnerships with the technology sector in curriculum development (Ibrahim et al., 2025). From a human perspective, a severe shortage of digital skills and a lack of sustainable training programs stand out (Al-Khaibari, 2020; Ang et al., 2020; Barchak, 2023; Faizulina et al., 2025; Fischer et al., 2020; Gabli & Al-Qahtani, 2022; Imran et al., 2024b; Khalil, 2023; Lund et al., 2025; Magulori, 2025; Spathopoulou et al., 2025; Turki, 2023). Furthermore, concerns about algorithmic bias and weak acceptance within the educational community hinder the full adoption of technology.

Overcoming these challenges requires a concerted effort from all stakeholders to develop educational outcomes that meet labor market demands and keep pace with global developments (Jones, 2024; Rajesh et al., 2022).

### Contribution to the Literature

This study makes a valuable contribution to the growing body of knowledge on the importance of integrating AI into educational contexts in Saudi Arabia. These contributions can be summarized as follows:

1. Providing insight into a rapidly evolving educational context. While current literature focuses on the theoretical potential of AI, this study offers real-world evidence on how AI is perceived and utilized in the rapidly digitizing Saudi education sector.
2. Employing data mining as a methodological innovation. Traditional educational research often relies on self-reported data, which can be susceptible to social desirability bias. This study utilizes data mining tools to obtain specific insights from social media (X platform), which represent lived reality.
3. Fostering an effective dialogue on the "digital divide" by identifying the material and human challenges (such as teachers' technical skills gaps and limitations of the existing technological infrastructure) that hinder the integration of AI into the Saudi Arabian educational context. This study adds depth to the literature on the challenges facing—and hindering—the integration of AI in education.
4. Identifying context-specific barriers: This study contributes to the ongoing dialogue on educational technology by categorizing social and technical barriers, highlighting the lack of technical skills among teachers and the limited infrastructure. It thus provides a roadmap for policymakers and curriculum designers to move from simply "adopting tools" to "systematic integration."
5. Bridging theory and practice: This involves demonstrating the potential for using AI tools to create personalized learning plans tailored to each learner's characteristics, to build and develop interactive content that motivates learners to participate and engage in the learning process, and to provide students with immediate feedback on their learning outcomes.

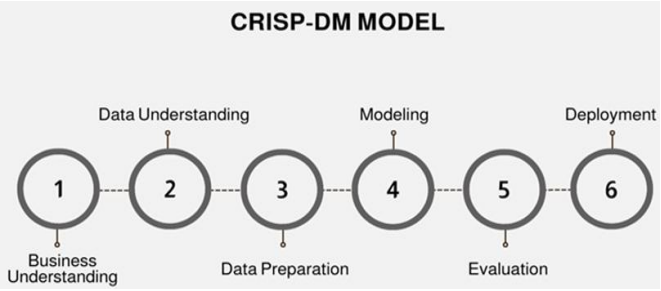


**Figure 1.** CRISP-DM data flow model by Schröer et al. (2021)

## RESEARCH METHODOLOGY

The current research project followed a qualitative research design and relied on the descriptive analytical approach to reveal the on-ground use of AI in education. This research is based on the cross-industry standard process for data mining (CRISP-DM) model, a widely used and established methodology in big data-mining projects owing to its structured, accessible, and reliable process for mining big data (**Figure 1**). This model comprises six stages outlining the flow of big data (Schröer et al., 2021):

- **Business understanding:** This stage involves gathering requirements, understanding business goals and big data-mining objectives and defining data-mining tools and techniques.
- **Data understanding:** In this stage, primary data are collected, detailing the methods used for data collection and the challenges addressed with applied solutions. Subsequently, the data are explored and described and their quality assessed to uncover initial insights.
- **Data preparation:** This stage focuses on selecting the final dataset from the initial raw data based on criteria relevant to data-mining objectives. The data are then processed and refined through cleaning to enhance its quality.
- **Modeling:** In this stage, various modeling techniques are selected, applied, and evaluated.
- **Evaluation:** This stage entails examining and reviewing all preceding steps and evaluating the results within the context of the research objectives.
- **Deployment:** Knowledge must be organized and presented in a manner that enables stakeholders to understand and utilize it. The deployment phase can range from simple, involving report generation, to complex, encompassing the creation of a software component.

### Research Data

The research data comprised X users' tweets, chosen based on diversity in categories, regenerative knowledge, and variety in trends.

### Research Sample

The research sample comprised from X users within the Kingdom of Saudi Arabia, specifically those published containing keywords or hashtags related to AI in education. These hashtags included the following:

- #TheArtificialIntelligence,
- #With_ArtificialIntelligence,
- #The_Artificial_Intelligence,
- #Artificial_Intelligence_in_education,
- #Artificial_Intelligence,
- #Education_Intelligence,
- #TheGenerativeIntelligence,
- #The_Generative_Intelligence,
- #With_Generative_Intelligence,
- #Generative_Intelligence_in_Education, and
- #Generative_Intelligence.

The selection was intentionally limited to tweets published in Arabic in 2023.

### Research Methods

To address the research objectives, the X platform was utilized for data collection. X was selected as it is a prominent modern data-collection tool, providing an open forum for data circulation and a platform for presenting and exchanging ideas. It is also a reliable instrument for exploring opinions on phenomena and events, having contributed significantly to research advancement across diverse fields owing to its rich information resources (Al-Khalifa et al., 2025).

The X platform is among the largest social networking systems—a microblogging platform launched in 2006 that enables user communication through "tweets" (Khan & Al-Qahtani, 2020). It is the most widely adopted microblogging system and a primary source of statistics, offering clear insights into current trends. The X platform also incorporates numerous features facilitating user interaction, such as retweeting, liking posts, hashtags, and comments, which Kim (2020) termed "sharing metrics".

Furthermore, the X platform is distinguished by hashtags, or tags, which categorize tweets by topic. Tweets are grouped around specific themes by highlighting keywords within the tweet, preceded by the (#) symbol. Hashtags also function as search terms for topics, issues, or events, connecting individuals interested in the same subject. They resemble public addresses or gatherings for participants unknown to one another (Khalil, 2023). In education, Trust et al. (2020) posits that hashtags on the X platform serve as spaces for educators to facilitate professional networking and interaction among individuals with shared interests. These hashtags also provided avenues for gauging public sentiment during the COVID-19 pandemic,

addressing the cognitive, social, and emotional needs of educators during remote teaching and fostering the exchange of daily experiences and mutual encouragement. These tags also disseminate news and information related to education and educational events.

The researchers employed the Python programming language for data extraction, analysis, and presentation, utilizing a suite of tools and libraries essential for machine learning. Python was chosen as a high-level language renowned for its simplicity in writing and reading and its ease of learning. Python utilizes a modifiable, open-source, object-oriented programming approach—a versatile interpretive language widely applied across numerous domains (Kabir et al., 2024; Saabith et al., 2021).

### Research Procedures, Collecting, and Analyzing Information

The researcher adhered to the CRISP-DM model's six data stages, as outlined in the research methodology above:

- **Business understanding:** This stage defined research objectives to understand the application of big data-mining techniques in uncovering AI applications in education, comprehend business and exploration objectives, and identify data-mining tools and techniques by specifying tweet counts and percentages within each hashtag.
- **Data understanding:** Raw data were collected at this stage from tweets relevant to the field of AI in education. This included documenting the libraries used for data collection from tweets, the challenges encountered, and the solutions implemented. Subsequently, the data were explored and described, and their quality determined to derive initial insights.

#### *Key libraries utilized in this stage*

- **Selenium:** This library was employed within the Python programming language to automate the browsing process on the "X" platform. The purpose was to collect tweets associated with selected hashtags within the defined timeframe. The methodology involved simulating manual interaction with the platform's user interface using Selenium's WebDriver. This process included searching for hashtags via the platform's internal search engine and then automatically scrolling down the page to activate the Infinite Scroll feature, enabling the collection of the maximum possible number of tweets.

### Data Collection

The following data were collected: the text of the X in Arabic, number of times the X was liked, number of retweets, date of posting the X as specified in 2023, and latitude and longitude of the tweet. The search was limited to the borders of the Kingdom of Saudi Arabia, and crucially, the hashtag of the tweet was also collected. All of this was accomplished using a dictionary containing the following extracted values:

- **All_data:** This included all collected and stored data derived from interactions on the X platform. These data included the text of tweets, links, images, or any other extracted content. all_data was used within Selenium to efficiently organize and manage the collected data, facilitating subsequent analysis or utilization.
- **Hashtag:** Tags or hashtags that were searched for.

It should be noted that all data was written in Arabic and translated to English for the purpose of publishing.

### Challenges in the Data-Collection Stage

The emergence of tweets originating from outside the borders of Saudi Arabia.

### Data Preparation

At this stage, the final tweets were selected from the initial set by specifying criteria relevant to the objectives of data mining. Data quality was then enhanced through a cleaning process, which included formatting dates in the dd/mm/yyyy style to remove tweets lacking a clear publication date. Subsequently, tweets were filtered to include only those posted between the beginning and end of 2023. Finally, duplicate tweets and tweets originating from outside the latitude and longitude coordinates of the regions within the Kingdom of Saudi Arabia were removed.

#### *Key libraries utilized in this stage*

- **Datetime:** A specialized library for handling date and time data and performing calculations on them.
- **Start_data:** Used to define the start date of the search and format the date in dd/mm/yyyy style.
- **End_data:** Specifies the end date for the search.
- **Geocode:** Used to determine the geographical location (coordinates) of the Kingdom of Saudi Arabia.

### Modeling

At this stage, a deep learning-based modeling technique was chosen—specifically, transfer learning. Transfer learning, in this context, refers to utilizing a pre-trained model to perform a specific task by transferring knowledge gained from another model to solve a new, specific task. The bidirectional encoder representations from transformers (BERT) model was employed to analyze meanings and contexts within tweet texts,

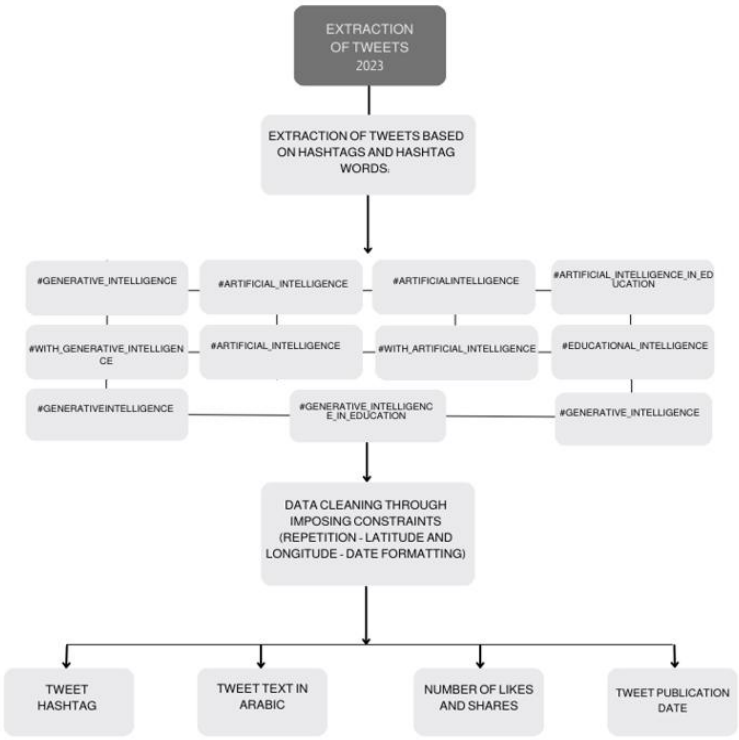


**Figure 2.** Data extraction and cleaning flowchart (Schroer et al., 2021)

making it an ideal choice for categorizing tweets related to the reality of AI use in education. Since the tweets were in Arabic, pre-trained, Arabic-specific BERT models, such as AraBERT, were used to process conversational texts. BERT is distinguished by its ability to understand texts with a high degree of proficiency, processing sentences in both directions (right-to-left and vice versa), which aids in better capturing semantic correlations. Through this, the model can categorize tweets into three main categories—"reality of AI use," "circulating applications," and "bottlenecks"—even in cases where tweets contain indirect expressions or coded language. Employing the BERT model in this context contributes to achieving accurate and reliable results. These categories are defined as follows:

- **Reality of AI use:** Tweets that describe current practices, adoption rates, or actual experiences within educational institutions.
- **Circulating applications:** Tweets that mention specific tools or software (such as ChatGPT, adaptive learning systems, automated assessment tools) and how to utilize them.
- **Bottlenecks:** Tweets that focus on challenges, digital divides, ethical issues, resistance to change, or weak infrastructure.

After BERT categorized the uncategorized big data, a representative random sample of tweets (1,600) was drawn and humanly reviewed by education technology experts to ensure there were no "biases" or "typical errors" in the AI categorization, especially in cases of indirect expression or figurative language. Agreement rate using Cohen's kappa coefficient was 0.87.

### Evaluation

All steps are examined and reviewed, and results are evaluated in the context of the research objectives.

### Deployment

Knowledge is organized and presented in a way that enables members of the educational community to understand AI and utilize it in education. The deployment phase can be simple, including the creation of educational resources demonstrating the use of AI in education, or complex, involving the creation of educational software components for AI applications in education.

### Data Analysis

The data analysis phase commenced with the design of a flowchart (**Figure 2**) to illustrate the various operations executed using Python to extract data. A total of 15,603 tweets were retrieved from the beginning to the end of 2023 based on the specified hashtags and keywords within those hashtags. Subsequently, the data underwent cleaning, which involved applying a set of restrictions, including removing duplicates, accurately identifying the latitude and longitude of the Kingdom of Saudi Arabia, and standardizing dates to the dd/mm/yyyy format. **Table 1** presents tweet data for each hashtag. The hashtag "#artificial_intelligence" is the most dominant, with 6,249 occurrences, 20,087 retweets, and 84,809 likes. This constitutes 40.05% of the total tweets across all hashtags, followed by "#artificial_intelligence_in_education" at 20.36% and

**Table 1.** Data table before cleaning

| Tags | Frequency | Retweet count | Number of likes |
|---|---|---|---|
| #ArtificialIntelligence | 326 | 193 | 867 |
| #With_ArtificialIntelligence | 2,089 | 9,184 | 41,605 |
| #The_Artificial_Intelligence | 6,249 | 20,087 | 84,809 |
| #Artificial_Intelligence_in_Education | 3,176 | 17,250 | 42,943 |
| #Artificial_Intelligence | 905 | 1,316 | 4,783 |
| #Education_Intelligence | 563 | 7,503 | 11,096 |
| #GenerativeIntelligence | 1 | 1 | 6 |
| #The_Generative_Intelligence | 1,789 | 10,703 | 24,651 |
| #With_Generative_Intelligence | 164 | 374 | 1,416 |
| #Generative_Intelligence | 99 | 143 | 711 |
| #Generative_Intelligence_in_Education | 242 | 8,605 | 4,872 |

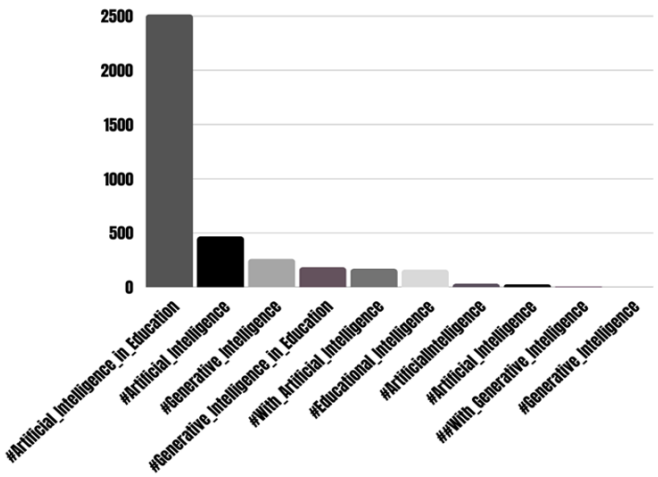


**Figure 3.** Statistical analysis of hashtags before data cleaning (X platform)

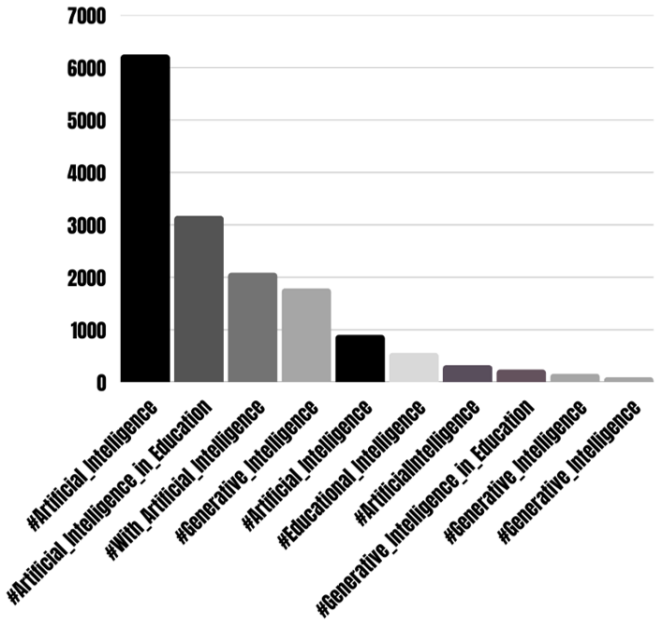


**Figure 4.** Statistical analysis of hashtags after data cleaning (X platform)

"#with_artificial_intelligence" at 13.39%. The remaining hashtags appear much less frequently (**Figure 2**), indicating that the term "artificial intelligence" is more widely circulated within the context of tutorial education than "generative intelligence." Variations in retweet and like counts across hashtags are also noticeable, potentially suggesting differences in the level of engagement and participation among interested individuals. Despite the data-cleaning process, the "artificial intelligence in education" hashtag continues to outperform, exceeding 2,500 tweets, as depicted in **Figure 2**.

These quantitative data serve as an essential starting point for understanding the reality of AI use in education. These data were further enriched by a qualitative analysis of tweet content, aimed at fostering a thorough and accurate understanding. This analysis seeks to provide a clear perspective on how AI is being utilized in educational contexts, based on data extracted from the X platform, thus contributing to a precise depiction of the reality of this utilization.

**Figure 3** depicts the statistical analysis of hashtags before data cleaning

**Figure 4** shows the statistical analysis of hashtags after data cleaning.

## STUDY RESULTS

This section presents the final findings from the research.

### The Perceived State of AI Implementation as Reflected in the Digital Discourse of X Platform Users

The analysis of hashtags on the X platform revealed widespread interest among educators and specialists in the field regarding the role of AI in advancing the educational process. Educators' opinions and perceptions varied concerning AI's potential to enhance efficiency and save time on educational tasks. Prominent themes discussed extensively included the preparation of personalized study plans tailored to student needs, the creation of engaging presentations, and efficient and accurate design of assessments that meet curriculum requirements.

Qualitative analysis of extracted texts revealed that the most common application of AI is its ability to design customized lesson plans and interactive content.

Transforming this capability from a mere technological feature into an educational dimension represents a radical shift towards differentiated instruction and holistic learning design. Creating AI-powered content allows educators to consider diverse learning styles and varying learning paces, something that traditional, rigid curricula cannot accommodate. This aligns with contemporary curriculum development trends that advocate for "living and adaptive curricula" that foster students' cognitive interaction and individualized learning paths.

While integrating AI into education offers unprecedented opportunities for personalized and individualized learning, it also necessitates a re-evaluation of the concept of "learning styles." Traditional educational models have attempted to categorize learners into fixed learning styles; the emergence of generative AI and adaptive learning systems demands moving beyond these rigid classifications toward dynamic and context-responsive learning environments. In this regard, Selamet (2026) offers a critical review and conceptual discussion to rethink learning styles in the age of AI. He argues that AI-powered educational platforms should not merely reinforce the traditional, rigid differentiation of learning styles, but should continuously adapt to learners' evolving cognitive needs, their direct interactions, and their personalized learning paths.

Teachers' tweets and opinions on social media platforms highlighted the role of AI as an effective tool for facilitating and modernizing the educational process. AI directly contributes to reducing the administrative and pedagogical burdens related to lesson planning and preparation. By simply entering a main idea or topic title, lessons can be prepared, presentations created, tests designed, educational content organized, and interactive activities suggested. These technologies also enable the generation of innovative educational images and their conversion into 3D designs, as well as the creation of interactive concept maps in seconds. This helps connect ideas logically and facilitates student comprehension. This impact extends to simplifying learning and improving learning outcomes by converting PDFs and lectures into interactive flashcards and creating explanatory educational videos.

Regarding classroom interaction and performance evaluation, analyses of teachers' feedback revealed widespread praise for AI's ability to enhance interaction among all stakeholders in the educational process and deepen understanding of concepts. Automated assessment systems for tests and assignments provide immediate and comprehensive feedback that identifies areas needing support. This shifts the focus of teachers and professors from the burden of continuous evaluation to guiding and mentoring. Furthermore, these technologies and robots contribute to analyzing individual student needs to provide customized learning paths and programs based on each student's proficiency level and prior performance, ensuring a unique learning experience that meets learners' aspirations.

The benefits of AI are not limited to supporting mainstream students; they extend to the inclusion of students with special needs. AI contributes to the development of educational tools that accommodate various disabilities, particularly visual and auditory impairments, and the design of interactive programs that serve those with learning difficulties such as autism and attention deficit disorders. It also facilitates the learning of Braille and provides comprehensive technical support for the blind. Finally, discussions among educators revealed a strong desire to expand the integration of AI in education, emphasizing the need to redesign curricula and assessment tools to align with the demands of the Fourth Industrial Revolution. This is because the majority of future high-paying jobs are linked to skills in AI, machine learning, the Internet of things (IoT), and robotics, necessitating that education be geared towards preparing and equipping students for the future job market.

### The Most Popular and Widely Used AI Applications in Today's Digital Education Environment

The analysis of tweets revealed widespread interest in AI applications that could contribute to enhancing educational quality and enriching the learning experience. Among the tools garnering attention were those focused on text processing across various languages. These included tools that generate ready-made texts to assist learners in efficiently completing tasks. Numerous programs and websites were mentioned, notably the Aithor program (Aithor, the scientific writing giant that supports the Arabic language and authentic references #Artificial_Intelligence http://aithor.com), which enables users to transform simple written descriptions into professional-quality text, and the araby.ai website, designed for analyzing and processing the Arabic language, offering features such as translation, summarization, and improved handling of Arabic content using AI techniques (a site needed by educators and university students that converts any video or audio file into written text using the technique of #Artificial_Intelligence. The site link is the first Arab AI site that reaches half a million users within 3 months. It is linked to the global site ChatGPT and Arabic and writes any content to you with AI in a few minutes https://araby.ai #Scientific_Research #Artificial_Intelligence). Users also discussed tools for converting written text into images, videos, and spoken audio using AI-powered programs such as Generate, detailing the steps and options available (Convert written text into a voice clip (speech) using #Artificial_Intelligence in a fast and creative way. Select

the speaker's voice. Select language. Write the text. Press Generate. The website is free).

Additionally, educators expressed interest in websites employing AI for designing comics. Users can input a title with minimal details, and the tool automatically designs a story with images and text tailored to the content, such as storybird.a (storybird.a site above imagination to design comics with AI after writing title of story or its details. https://storybird.ai supports Arabic, but it is particularly cool in English because of its feature of reading aloud).

Regarding the most frequently mentioned and utilized programs, with nearly 500 mentions, numerous educators voiced positive opinions about ChatGPT in education. They consider it a valuable tool to support teaching and learning, expedite information access, and stimulate critical thinking (how can educators use #ChatGPT in classrooms? #Technology #Artificial_Intelligence #World_Teacher_Day [https://zurl.co/FwF]).

Educators also conveyed their admiration for AI applications that deliver diverse educational content, interactive lessons, and play-based exercises, and enhance various learner skills (Educators can use AI to improve teaching methods. AI is not intended to replace the educator but acts as an additional tool to support and enhance students' learning experience). Furthermore, some educators employed AI to enhance personalized learning experiences for students, noting that AI enabled them to provide customized support to each student based on their academic level and individual needs. Tweeters believe that these intelligent systems assist educators in delivering precise and immediate guidance and feedback, which contributes to continuously improving student performance. Educators' tweets also praised certain AI-powered websites that can be enriching for achieving learner objectives (a site called learn anything powered by AI (free) that helps in learning what you want. All you have to do is write down the topic you want to learn, and it will show you the lessons you need to enter the site and benefit from its services).

### Challenges That Hinder the Practical Application and Optimal Use of AI in Education

An analysis of analysis of hashtags, Twitter users' opinions revealed a number of challenges and limitations hindering the education system's ability to fully utilize AI technologies. These obstacles range from technical software issues to the rigidity of existing educational systems. On the programming and technical level, AI is linked to the intelligence of algorithms developed by humans. This means that any software shortcomings directly impact the quality and accuracy of educational outcomes. Participants highlighted a clear gap between AI's theoretical frameworks and its practical applications, along with difficulties in operating virtual systems, a lack of Arabic-language software, and language barriers in e-learning tools.

At the educational system level, traditional assessment methods, which focus on memorization and grades rather than critical thinking skills, pose a significant obstacle. These methods encourage some students to rely excessively on smart devices to complete assignments without genuine understanding. Furthermore, current curricula fail to measure the practical skills required by the job market and lack the flexibility to keep pace with technological advancements, a deficiency particularly evident in fields such as medical education. On the other hand, concerns have been raised about the potential for AI bias due to its reliance on potentially biased human input, which could compromise the integrity of assessments. There are also worries about the diminishing role of teachers and the erosion of the indispensable human element in education.

Despite these software and structural obstacles, many agree that AI presents a promising opportunity for educational development, provided these concerns are addressed through teacher training, curriculum modernization, and the development of innovative and realistic educational frameworks (Ang et al., 2020; Imran et al., 2024a; Khalil, 2023; Magulori, 2025; Spathopoulou et al., 2025; Turki; 2023; Vesna et al., 2025).

## DISCUSSION AND RECOMMENDATIONS

### Educator Awareness of AI in Education

The empirical analysis of the text collection revealed a distinct sub-theme: teachers themselves reported a clear discrepancy between online conceptual frameworks and field-level constraints. This underscores that while the digital discourse on the X platform demonstrates high levels of enthusiasm and a sophisticated understanding of AI capabilities, it also represents an ambitious space. The widespread positive sentiment towards personalized lesson plans reflects professional awareness, but many practitioners noted a clear gap between the discussion of AI on social media and its institutional application in schools, due to infrastructure and assessment limitations. Educators' opinions and perceptions regarding AI's potential to enhance efficiency and save time in teaching tasks varied.

These findings align with Alfaleh's (2026) analysis of Arab millennials' attitudes toward AI-powered media and educational content. He noted that the consumption of these digital media involves interactive mechanisms that transcend passive reception, fostering awareness and active engagement, as exemplified by uses and gratifications theory and interaction theory.

Consequently, the impressionistic image and heightened awareness evident in digital discussions on the platform (X) represent a "media and interactive awareness" that individuals develop through continuous exposure to smart media content. This explains the occasional gap between cognitive digital interaction on platforms and the actual behavioral and practical application of smart applications within classrooms and educational institutions.

An X hashtag analysis shows AI improves education by personalizing study plans, creating interactive content, and offering instant assessments. This supports Holmes et al. (2023) and Al-Mahdi (2021), proving AI boosts productivity by automating exam grading and questionnaire evaluation, freeing educators to focus on lesson planning and innovative teaching methodologies.

To maximize these benefits, the study recommends specialized teacher training programs that include:

- Coverage of fundamental AI concepts, illustrative examples of its applications in education, practical guidance on using specific AI tools (e.g., content creation tools, learning assessment, and personalization), and strategies for integrating these tools into lesson plans.
- Adoption of interactive teaching methodologies, practical workshops, and case studies to deepen educators' understanding and practical application of knowledge.
- Continuous updating of the programs to keep pace with rapid developments in the field of AI and incorporating useful AI application tools to help students learn independently and enhance their motivation and self-confidence.
- Improving teachers' readiness and willingness to integrate AI into the classroom and empowering them to foster a culture of AI adoption in the educational environment by raising awareness of its importance, providing integrated professional development pathways, and offering flexible and user-friendly technological tools.

This underscores the imperative of investing in educator capacity building and providing the necessary resources for integrating AI technologies into the educational process, moving beyond superficial training courses. The ultimate goal is to empower educators to effectively leverage these technologies to enhance educational quality and personalize learning to meet each student's unique needs.

Analysis indicates users view AI as a vital tool for personalizing education by tailoring recommendations and adapting content to individual performance and needs. This aligns with findings by Imran et al. (2024a) and Al-Mahdi (2021), which highlight intelligent learning systems' ability to assess current knowledge, deliver customized content and feedback, and continuously monitor progress. Consequently, this study advocates applying AI-driven personalized learning to transition from a standardized, one-size-fits-all curriculum to dynamic, differentiated pathways matching each student's abilities, pace, and interests. By leveraging performance data, AI adapts content difficulty, adjusts learning speed, and selects targeted activities.

Additionally, AI systems dynamically modify learning paths without requiring constant teacher intervention. They offer immediate performance assessments, direct feedback to correct errors, and relevant resources to enhance skills. Serving as cognitive supports, these tools transform traditional assessment of learning into dynamic assessment for learning. This significantly reduces the feedback loop, resolves misconceptions before hindering cognitive development, and boosts student motivation through encouraging reinforcement.

The findings reveal that AI enhances student engagement and creates more effective learning experiences, particularly for students with special needs, by offering tailored tools. This aligns with Al-Harbi (2021), confirming that AI fosters peer collaboration, curiosity, access to information, and better learning outcomes. Consequently, the study recommends developing interactive learning tools—such as educational games and virtual simulators—that shift students from passive receivers to active participants. Furthermore, AI facilitates inclusive education for diverse backgrounds and learning levels. To fully realize this potential, continuous research and development are essential. The study emphasizes the need for increased R&D funding and strong partnerships among researchers, software developers, and educators to create innovative educational solutions.

### AI Applications Employed in Education

The discussions also advocated for considering tools that process texts in multiple languages as these facilitate the completion of study tasks and overcome learners' language barriers. These tools assist students in transforming simple descriptions into professional texts, facilitating effective communication. Furthermore, AI technologies enable the conversion of written texts into audio and video clips, which enhances the learning experience. Moreover, applications contribute to interactive design, fostering creativity and expressive abilities. This finding is consistent with the study by Aqili et al. (2022), which posits that these applications exemplify expert systems employable in the educational process. Expert systems are computer programs capable of simulating expert human behavior and leveraging knowledge and reasoning, enhancing the efficiency of education and its outcomes. With their capacity for reasoning and judgment, these systems offer constructive suggestions and pertinent solutions to

learners' challenges. These systems represent a valuable augmentation to the educational environment. Therefore, this study recommends emphasizing the vital role of AI in improving the quality of education and learning environments, and enriching the learning experience (Al Nabhani et al., 2025; Barczak, 2023; Fayzullina et al., 2025; Imran et al., 2024a). To realize this potential, clear strategies for integration must be formulated, encompassing the establishment of priorities, allocation of resources, and enhancement of cooperation among stakeholders (ministries, software developers, researchers, educators), alongside continuous evaluation to ensure effectiveness and measure the impact on educational quality and educators' and students' satisfaction.

The analysis revealed considerable user appreciation for AI applications that provide diverse educational content and enhance student engagement through interactive lessons and game-based exercises. It was also found that these applications are effective tools for improving the educational process without replacing teachers; rather, they support and enrich their teaching practices. This observation aligns with the findings of Al-Harbi (2021), which indicated that these tools encourage learner participation and collaboration with peers during the learning process, stimulate their curiosity and performance, and facilitate access to essential information. Furthermore, these applications contribute to enhancing and developing learning skills and their application within educational institutions, demonstrating a positive impact on learner performance. This underscores the necessity of adopting a comprehensive and integrated approach to effectively integrating AI applications, ensuring they become an integral part of the educational process, enhancing rather than complicating learning.

### Challenges to Employing AI

The study highlights significant barriers to AI adoption in education—such as cultural hurdles, resource limitations, and regulatory challenges—aligning with previous research (e.g., Al-Khaibari, 2020; Ang et al., 2020; Barchak, 2023; Faizulina et al., 2025; Fischer et al., 2020; Imran et al., 2024b; Khalil, 2023; Lund et al., 2025; Magulori, 2025; Spathopoulou et al., 2025; Turki, 2023; Vesna et al., 2025). Addressing these issues requires modernizing legislative frameworks, upgrading technical infrastructure, and establishing robust protocols to protect privacy, data security, and confidentiality. Moreover, policy guidelines must guarantee transparency, ethical use, clear accountability, and equitable access to AI tools for all learners.

These findings support the core premise that educational leadership must prioritize developing educators' digital competencies. While teachers increasingly recognize AI's potential to enhance efficiency and learning outcomes, harnessing these benefits necessitates targeted, intensive professional training. Such professional development empowers educators to integrate AI seamlessly into daily instruction while assuming roles as mentors who foster critical thinking. Ultimately, establishing supportive policies and structured training enables both institutions and educators to leverage AI for safer, more interactive, and effective learning environments

## CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Field analyses and academic discussions on social media platforms (such as X) reveal growing professional optimism regarding AI's potential to reshape the educational landscape and save time and effort. However, this digital ambition runs up against implementation gaps and structural obstacles within school environments—primarily inadequate infrastructure, a lack of advanced digital skills among some educators, and a persistent reliance on traditional assessment methods. This challenge extends beyond general education to impact STEM disciplines, which inherently require algorithmic thinking and continuous digital adaptation. To bridge this gap, we need to move beyond surface-level training and build sustainable digital capabilities for teachers. These capabilities will strengthen their role as learning facilitators and help them turn rigid curricula into flexible, adaptive learning pathways that fit the nature of scientific disciplines and meet individual learner differences.

This study opens avenues for future research into AI applications and their impact on curriculum development and the modernization of assessment methods. Key areas include the potential to personalize educational content to meet individual learner needs and continuously monitor student progress, as well as a shift from rote learning and traditional test-based assessments to skill-based, continuous performance evaluations that measure critical and creative thinking. The study also recommends integrating Fourth Industrial Revolution skills—such as machine learning and the IoT—into curricula, training teachers in the pedagogical and ethical integration of these technologies into daily instruction and developing interactive platforms that offer immersive learning experiences and real-time analytics on student performance.

Overcoming current challenges—such as inadequate infrastructure, the digital skills gap among teachers, and concerns regarding the displacement of human educators—requires research focused on practical solutions. These include upgrading infrastructure and preparing teachers to serve as mentors and facilitators. Furthermore, expanding the scope of research to include data collection from diverse platforms, alongside the application of feature and social network analytics,

would help identify trends in technology adoption. Additionally, it is essential to examine algorithmic bias in AI tools to ensure fairness and prevent the entrenchment of socio-economic biases, while also addressing the digital divide between urban and rural areas to ensure equitable technology implementation.

Finally, future research directions should encompass the integration of structured and unstructured data (such as images and videos), the conduct of field studies—utilizing interviews and surveys—to gauge the perspectives of teachers and students, and the execution of comparative studies across different countries or educational levels. It also highlights the importance of evaluating the effectiveness of AI tools in special education (such as emotion recognition for students on the autism spectrum), examining the impact of technology on teachers' job satisfaction and their relationships with students, and applying time-series forecasting to anticipate the trajectory of AI in the future of education.

### Limitations

There are several limitations: First, geographical limitations or the risk of demographic bias;; the study was limited to the borders of Saudi Arabia in analyzing tweets, excluding any tweets originating from outside these borders. This means the results reflect the local context and public opinion within Saudi Arabia. Therefore, future research should consider AI-related tweets from outside Saudi Arabia to ensure the results reflect the local, regional, and global context. Second, time limitations; the research was limited to a specific period, namely 2023. Data published before or after this period was not included in the analysis. Therefore, it is important for future research to cover a longer timeframe for collecting data from multiple platforms, such as Facebook, LinkedIn, and educational forums. Third, linguistic and tweet content limitations; data collection was limited to tweets written in Arabic, and excessive reliance on hashtags introduces bias into the sample and may exclude relevant conversations. Fourth, platform-specific limitations (X platform); the research relied exclusively on X platform (formerly Twitter) as the sole data source. While X is important as a platform for public discourse, other platforms exist as social media tools used by educators, potentially excluding the perspectives of teachers or users on these platforms. Fifth: Limitations related to hashtags or keywords; the study was limited to a specific set of hashtags (such as #AI_in_Education), which may limit the comprehensiveness of the dataset. Finally, there are methodological constraints; it becomes crucial to conduct multi-method field studies—using direct classroom observations, questionnaires, and semi-structured interviews with teachers and policymakers—to bridge the gap between digital discourse and actual practice.

Conducting multi-method experimental field studies – using direct classroom observations, standardized questionnaires, and semi-structured interviews with teachers and policymakers – with the aim of bridging the gap between digital discourse and actual practice.

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**Ethical statement:** This study was approved by the Ethical Committee of Imam Abdulrahman Bin Faisal University with approval number IRB- 2024-15-663. This study adheres strictly to ethical standards regarding privacy, confidentiality, informed consent, dignity, protection, and voluntary participation. All processes and procedures followed in this research are consistent with the ethical principles set forth in the Declaration of Helsinki (1964). There are no privacy concerns, as the study was limited to tweets published in Arabic in 2023 about AI. This study affirms its commitment to ethical standards in dealing with tweets, and since the data consists of publicly available tweets that do not require access or follow restrictions; the study has been exempted from the traditional informed consent requirement.

**AI statement:** Generative AI tools were used to improve the clarity and fluency of the English in this manuscript and to correct grammar. The authors confirm that AI made no substantive contributions to the research; all presented research components, theoretical frameworks, methodological design, analysis, and conclusions are entirely the authors' work.

**Declaration of interest:** No conflict of interest is declared by the authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

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