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Enhancing problem-based learning with QR codes in the context of the Everglades

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Abstract

Enhancing problem-based learning (PBL) in the context of the Florida Everglades through QR code is addressed in this paper. Students in an elementary classroom received mentoring by high school peers to develop QR codes in a project involving the Florida Everglades. Results suggest that elementary students' knowledge of science in society is enhanced, and their curiosity of science raised when using QR code embedded problem-based learning in their classrooms. Implications for enhancing QR code enhanced PBL environments within the classroom is discussed.

Keywords: Problem-based learning, QR code, Everglades, mentor

Introduction

The integration of QR codes into problem-based learning (PBL) connects classroom science to real-world applications. In the twenty-first century, most students are proficient users of technology to navigate their academic and personal learning experiences. Finding ways to turn content-rich science topics with societal relevance into effective lessons presents a teaching challenge. One of the difficulties is the scarcity of clearly defined easily accessible tools that link classroom science to practical applications and real-world scenarios. Although commercially developed software solutions exist in this area, they frequently fail to be adopted by teachers in a way that aligns with state standards, the individual teaching styles of educators, and the varying learning styles of students. One educational strategy to address this issue is to create Problem-Based Learning (PBL) activities linked to QR codes for use in the K-12 classroom.

Quick Response (QR) codes are two-dimensional squares made up of black and white pixels that can store up to one hundred times more data than a conventional barcode (find

, 2024). These QR codes can be scanned using a smartphone, which subsequently redirects the user to a designated web address, providing access to additional information about the associated product or service. QR Codes are used widely in all sectors of society (Pillai, Prakash, Al-Marhoobi, & Shrivastava, 2017). Since their inception, QR codes have expanded in use beyond the automotive sector and are recognized as a valuable technological advancement across multiple fields, including education (see Fig 1).

Figure 1. Sample QR code developed with QRstuff.com

QR codes for educational purposes

The utilization of QR code technology has begun to make significant strides in education. Teachers face increasing demands from various stakeholders to ensure that students are prepared to enter the job market and succeed in a tech-driven environment. Research shows that incorporating computer technology in classrooms boosts student learning (Tsoukala, Lefkos, & Fachantidis, 2024; Yusof, Goolamally, Latif, & Fadzil, 2012). Equipping students with advanced cognitive skills will enhance our economic competitiveness relative to other nations (Darling-Hammond, 2011).

With advancements in QR code technology by computer designers for SMART phones, educators are now integrating this technology into school curricula as a learning tool to enrich student understanding. Rather than being limited by conventional classroom teaching methods, teachers and learners recognize the significant impact that technology can have in fostering an interactive learning atmosphere. Students are motivated to engage as active learners by effectively linking classroom science to real-world applications through engaging, practical activities. Studies show that regular interaction with technology from an early age encourages students to learn more effectively. In research conducted by Yusof et al. (2012), students were instructed to gather pertinent information about plants and animals while generating QR codes.

Students discovered how to create QR codes to improve their understanding of different plants and animals. The research showed that QR technology enhanced students' motivation and engagement in the learning process. QR technology proved effective in enhancing students' engagement and stimulating their interest in various science-related topics. Active learning is frequently employed via significant learning tasks like inquiry-based learning and problem-centered learning.

QR codes may enhance educational activities by motivating students to generate and distribute learning materials (Yusof et al., 2012) and by involving students with diverse learning requirements (Chen, Teng, & Lee, 2010). Crompton et al. (2012), Robertson and Green (2012), Pérez-Sanagustín et al. (2016), Kumar and Lapp (2019) and Tsoukala et al. (2024) assert that QR codes could enhance active learning both within and beyond the classroom.

Learning through problem-solving

Problem-based learning (PBL) focuses on addressing problems in real-life situations to enhance higher order thinking and problem-solving abilities among students (Gallagher & Gallagher, 2013). In PBL, students are tasked with using subject knowledge to address a problem in a real-world setting. One benefit of PBL is that it offers students a well-organized learning journey through a sequence of steps aimed at helping them cultivate skills. Throughout the planning phase, PBL educators create a series of community-oriented problem-solving tasks that increasingly escalate in complexity. Every task ought to enhance skills acquired in earlier assignments. In the end, the tasks will equip students with the expertise and abilities to tackle a genuine, real-world issue. In PBL, students are encouraged to adopt a scientific mindset to devise

innovative solutions for societal issues related to science and technology (Kumar & Yurick, 2018; Puricia, 2015). When students participate in real tasks connected to society while "doing science," they acquire skills and knowledge that are transferable to future scenarios, equipping themselves with the academic and professional tools necessary for success. This also allows them to understand the relationship between science, technology, and society. For insights into the theoretical basis of employing multimedia anchors to enhance the context of problem-based learning in science through the integration of real-world applications, refer to CGTV (1997) and Kumar and Sherwood (2007), and Kumar (2010).

Problem-based learning, QR code technology and the instructional environment

Problem-based learning (PBL) may be effectively implemented to address real-world challenges, thereby cultivating students' inquiry skills within the classroom. This objective can be further supported through the integration of QR code technology in instructional practices. QR code technology addresses genuine issues within the realm of real-world scientific content and science culture. Students are mentally involved in investigating significant issues, which necessitate them to tap into their existing knowledge to devise effective answers for real-world obstacles.

A significant limitation of the PBL instructional method is the feasibility of presenting genuine problem-solving scenarios that develop cognitive abilities alongside conceptual comprehension. Integrating PBL with QR code technology establishes a blended learning setting that can introduce real-world science and culture into the educational space. In this way, science gains significance and pertinence in students'

lives, fostering an understanding of science within their own experiences and consequently, an appreciation of Science in Society.

QR codes are integrated into the classroom environment. QR code scanners allow students to digitally scan images that link to pertinent websites, thereby fostering engagement in student learning. Students can create their own QR codes with free QR code generator websites like QRstuff.com (Lapp & Draginoff, 2017). After students choose a research topic, they perform an online search to find suitable websites that address and respond to their research queries. The students take the URL from the website, insert it into the QR stuff.com field, and a QR code is generated automatically. Refer to Figure 1 for an example of a QR code created with QRstuff.com for the research subject: How LCD projectors operate?

Utilizing QR codes in the classroom has advantages, especially for students who perceive academic reading materials as excessively daunting and mentally challenging in both vocabulary and subject matter. Educators can tailor learning by choosing websites suited to students' reading levels (Newsela) or by opting for the most suitable literacy techniques to improve and aid student comprehension (Lapp & Draginoff, 2017).

Establishing the educational groundwork for the QR code inquiry project

A QR code project was conducted in an Ohio classroom involving third-grade elementary students and high school mentors (Lapp & Draginoff, 2017; Kumar & Lapp, 2019). The elementary students participated in project-based learning (PBL) activities designed to deepen their understanding of scientific content, while the high school students served as mentors. Prior to working with the third graders, the mentors met with elementary teachers over several weeks to select appropriate learning approaches,

standards, technologies, and instructional strategies tailored to the students' needs. Motivated by recent media coverage on invasive plant species in Everglades National Park, the mentors aimed to help students explore how science can drive positive societal change. Drawing from their high school science courses, the mentors researched online resources and discovered engaging video segments from the Discovery Channel's *Dirty Jobs* featuring Mike Rowe. These clips aligned with the third-grade curriculum and offered a compelling way to introduce the topic.

Classroom teachers were supportive of the engaging media and technology but emphasized the importance of creating lessons that were also age-appropriate, aligned with grade-level standards, and supported by effective teaching strategies. With these goals in mind, the classroom teachers partnered with high school mentors through a series of weekly meetings to identify the most suitable learning approaches, standards, tools, and instructional strategies to support the elementary students' needs.

Role of state standards in the instructional planning process

The classroom teachers urged the high school mentors to reflect on the importance of state academic standards in choosing activities and assignments for K-12 classrooms prior to designing and developing science activities for the elementary students. The mentors agreed that they wanted the elementary students to undertake research projects in science focusing on the issues posed by exotic, invasive plant species in the Everglades. They searched online for Ohio science standards (Grade 3) and they chose the Ohio State Standard (Ohio Learning Standards: Science: Grade 3: Life Science (LS) Behavior, Growth and Change which emphasizes that all living organisms, plants and animals, have unique life cycles shaped by their environments, which affect their

physical and behavioral traits, survival, and reproduction. These life cycles vary globally, influencing how organisms grow, adapt, and sustain themselves in diverse habitats.

Equipped with the knowledge on the role of state standards in science lessons, the teachers and mentors expanded their discussions on how to get the elementary students excited and engaged in discussions about invasive species in the Everglades National Park and began to discuss lesson plan designs including the use of applicable instructional strategies to help the third graders gain greater interest in learning about the new content.

Role of instructional strategy selection in the instructional planning process

Classroom teachers led most of the discussions on the use of instructional strategies to support student learning. The high school mentors were amazed at the innovative techniques that teachers used to help students engage with reading and make sense of complex concepts. Drawing from the work of Daniels and Zemelman (2014), the teachers explained that strategies are not just tools, but pathways that guide students through the process of thinking as they read, helping them organize new information and connect it to their own experiences. The teachers shared some of their favorite strategies including brainstorming strategies such as *Think Aloud*, *KWL charts and clustering techniques, vocabulary tress and using multimedia resources* as examples of ways to engage student learning.

Role of technology integration in the instructional planning process

As planning meetings between classroom teachers and high school mentors progressed, a shared insight emerged: many third-grade students in Ohio were likely unfamiliar with Everglades National Park. To bridge this gap, the mentors proposed a

virtual field trip that would bring the park's unique ecosystem to life. This concept became the foundation for a technology-rich learning experience designed to deepen scientific understanding through interactive media.

The high school mentors had recently completed a specialized course at their high school which focused on mobile technology and digital communication tools. Equipped with skills in using iPads, navigating educational websites, and generating QR codes, they were eager to apply their training. They revisited a series of YouTube video clips from *Dirty Jobs*, featuring Mike Rowe's visit to the Loxahatchee wetlands in the Everglades. These clips showcased researchers working to remove invasive species like Melaleuca and Lygodium, which threaten native vegetation. Recognizing the relevance of this content, the mentors conducted further research on habitat conservation and curated a collection of online resources to present in a format that would be both engaging and accessible to younger learners.

Meanwhile, the elementary teachers had secured a technology grant that provided iPads and instructional apps for their classrooms. Through professional development workshops, they gained expertise in integrating technology into instruction and had pre-installed QR code tools such as QRstuff.com. This positioned them to fully support the mentors in delivering a tech-enhanced learning experience.

The use of QR codes proved especially effective for students who found traditional reading materials challenging due to complex vocabulary and content. By linking QR codes to curated websites, such as Newsela, which adjusts reading levels, educators were able to personalize instruction and reinforce literacy strategies (Lapp & Draginoff, 2017). During joint planning sessions, teachers guided mentors through the

process of generating QR codes: mentors simply pasted URLs into the generator, instantly creating scannable codes that could be projected or accessed via iPads. This seamless integration of technology not only made scientific content more approachable but also empowered students to explore, question, and connect with real-world environmental issues in a meaningful way.

Learning Strategies in the Project

After several weekly meetings with classroom teachers, the mentors were anxious to teach their science lessons to the third-grade students. The classroom teachers remained on the periphery of the classroom, but only served to assist the mentors when necessary. The mentors welcomed the elementary students by introducing themselves and outlining the project. The mentors initiated the lesson by presenting a map of the United States to the elementary students and inquired if anyone could find the state of Florida. After identifying the state, the mentors asked the students to describe any physical characteristics of the state. Students shared several observations: *Florida has many beaches and is close to the ocean. The ocean is home to many fish.* Following further discussion, the mentors shifted the young students' attention to the Everglades, and once more invited them to share their knowledge about the Everglades and the animals that inhabit the region.

Students replied with remarks like *numerous alligators and snakes*. One student noted that the terrain appeared *brown while flying above*, but it was *green with plenty of water, swamps, and vegetation once you were in the Everglades*. Every student comment was noted on the whiteboard at the front of the classroom. As the students continued to share their ideas, the mentors introduced

specific scientific vocabulary terms such as species, native and non-native (plants), invasive (plants and animals), and habitat and asked if the students recognized these terms. Several of the students were familiar with the words, but most students seemed baffled by them. The mentors presented YouTube video snippets from a TV show, *Dirty Jobs* featuring Mike Rowe. After watching the video clips, the students were familiarized with the new vocabulary and added this additional vocabulary to the whiteboard. Vocabulary terms displayed on the whiteboard included: *conservation efforts, melaleuca trees, airboats,* and *firefighters*. As participants became increasingly familiar with these terms, they began categorizing them into thematic groups. This process encouraged students to explore relationships among the concepts.

Student-generated connections included the roles of Everglades firefighters, such as burning melaleuca trees and operating airboats. Building on these insights, mentors created a visual organizer that reflected the students' contributions during the vocabulary clustering activity (see Fig. 2).

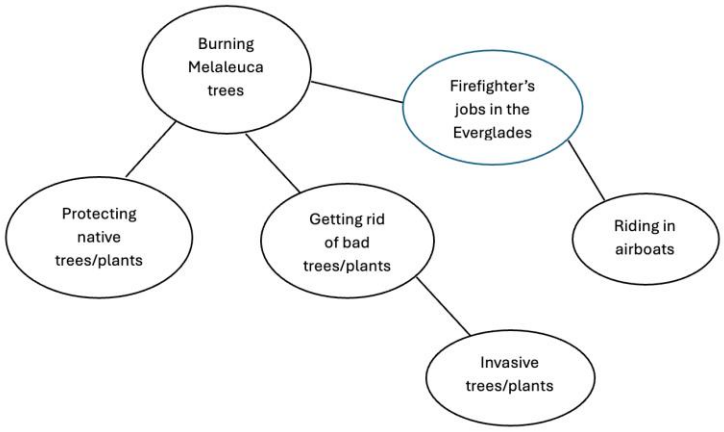

Figure 2. Example of clustering strategy

Following the completion of that strategy, the mentors informed the elementary students that they would dedicate the remaining time to investigating the process of eliminating harmful (invasive) plants and trees (in the Everglades). The mentors decided to use the KWL reading strategy which they had discussed with the classroom teachers and developed a KWL chart which they titled, *Invasive species in the Everglades*. Elementary students were invited to share what they (K) knew about invasive plants in the Everglades, what they (W) wished to learn more about, and what they (L) learned and discovered about invasive plants in the Everglades after completing the project. The mentors assured the students that each column would be completed. The students were informed that scientists in the field often approach similar questions using comparable methods. They were reminded that the techniques they were learning are actively employed by researchers investigating invasive plant and tree species in the Everglades.

The third graders were divided into small groups of 3–4 students, each guided by a high school mentor. Working collaboratively, each group selected a question from the KWL chart under the title "What do I want to learn about invasive plants in the Everglades?" section. After conducting research on their questions, each group presented their findings to the class, sparking lively discussion and deeper inquiry into the Everglades and its unique biosphere. Students explored questions such as: *What problems might occur if invasive plants like Melaleuca or Lygodium grow faster than native plants?* This question led to thoughtful conversations about how invasive species disrupt ecosystems. Another group asked, "*How are animals in the Everglades affected when invasive plants change their environment?*" This question prompted concern about

wildlife survival and food sources. The third group investigated the question, "*What tools and technologies could scientists use to locate and remove invasive plants?"* Their question encouraged imaginative thinking about fieldwork tools used by professionals in the field including the use of iPads, cameras, and GPS devices. The final group focused on the question, "*What can people do to protect the Everglades from harmful plants?"* Their question reinforced themes of conservation and stewardship which had been adopted as a school goal throughout the school year. By combining inquiry-based learning with digital research tools, students were empowered to explore real-world environmental issues in a meaningful and age-appropriate way.

Each student had their own laptop and felt at ease using the devices to browse websites for information. As each group began to explore the internet for information, they were inundated by the vast amount of information online concerning the subject. Students began moving around the room, eager to compare the various kinds of invasive species discovered in the Everglades with each other. They examined all the distinctive characteristics of the plants and were especially focused on the specific traits of the Melaleuca trees, which they had studied in YouTube video clips. Students were eager to observe the locations of the invasive plants in the Everglades and contrasted that map from the website with the real map of Florida. The third graders also urged their mentors to revise the KWL chart so that each group's unique findings on invasive plants and trees could be reflected. Students also shared their research findings with members of other groups if it helped them answer important questions.

As they continued reading the websites many of the elementary students appeared overwhelmed by the complicated text and the unfamiliar scientific terminology;

however, they remained enthusiastic about learning as much as possible regarding their line of research. Mentors remembered the procedures related to the think aloud techniques and chose to implement this approach with their groups to aid in understanding the websites. Mentors reviewed the chosen website by the group while the students looked at their own copies. The mentors paused their discussion to allow the elementary students to examine new vocabulary and relate it to their evolving understanding of scientific content. Whenever a new vocabulary word was recognized and explained, it was included in the elementary students' vocabulary learning logs and subsequently added to the classroom Word Wall, which was displayed on a large sheet of paper. The Word Walls were large enough to allow for the addition of new vocabulary items stemming from students' reading. The mentors similarly showcased how they questioned the text for deeper insight or made notes to prompt themselves to revisit the section or passage. Students were also reminded that if neither of these strategies worked and their confusion still persisted, they were always welcome to consult with the teacher. Elementary students took part in reading a part of the website and mirrored the mentors' reading styles by predicting the upcoming paragraph, questioning the content, and noting any possible questions that were left unanswered.

While the elementary students were reading, the mentors noticed how frequently many of them toggled between the website and the Google Search Engine as they typed in new vocabulary terms, often becoming frustrated while trying to retype the lengthy URLs in the search engine field. The mentors concluded that the students were ready to proceed to the next phase of the PBL project, the creation of the QR codes.

QR Code Generation in the elementary classroom

The young students were instructed to save the URL links which contained all the information they had gathered on their topic. The students submitted their long lists of URLs on pieces of paper to their mentors. Then the mentors asked the students if they were familiar with QR codes. Many students had observed the codes but were uncertain about how they functioned. One of the mentors solicited a question from one of the students, "*Look around the room and explain how something works in the classroom*." The students looked around the room and one student yelled, "How does a fire extinguisher operate?" The mentor entered the question into the Google search box. The students were promptly directed to a new website https://www.explainthatstuff.com/fireextinguisher.html where they learned about the hazards of fire, the fire triangle, the various kinds of fire extinguishers, and the functioning of fire extinguishers. The mentor clarified that a person could either keep typing the lengthy, frequently intricate code present in numerous URLs or generate a QR code that would instantly direct the user to the website just by scanning a square-shaped barcode. Each student received an iPad that had a QR code scanner app (TapMedia Ltd.) pre-installed, and they were given a short introduction on how to scan a QR code using the device.

The mentor pasted the URL: https://www.explainthatstuff.com/fireextinguisher.html into the QR stuff.com box, and immediately a QR code appeared. The mentor uploaded the QR code, which then appeared larger on the Smartboard located at the front of the classroom (see Figure 1). The students approached the Smartboard with their QR scanners, scanned the QR code, and were thrilled to witness how rapidly they connected to the website. Right away, they

wanted to upload their websites to the QR code generator (QRstuff.com). Each group waited patiently for their URL to be uploaded to the QR code generator. Once each QR code was created, the groups obtained a printed version of their QR code. Students started to walk around the room exchanging their QR codes and highlighting how the website they had been developing appeared so rapidly after scanning the QR code. Students seemed to recognize the distinctive features of the website, such as the photos of the invasive plants and their special physical traits. Students admired the stunning Brazilian Pepper tree adorned with its vibrant red berries, but they contrasted the trees distinct beauty against the harm it inflicted on the Everglades ecosystem.

Elementary students started offering some ideas on how to enhance the information found on the websites. After investing considerable time attempting to decipher certain scientific vocabulary found on the website, they proposed that some terms could be linked to a glossary, enabling students to grasp the meanings of phrases such as wetlands, ecology, and impenetrable thickets without spending unnecessary time searching for definitions on Google or in a classroom dictionary. They incorporated some of the new vocabulary into their classroom Word Wall, ensuring they would recall the vocabulary later. They also mentioned several questions they wished to follow up on, which were not addressed on the website: *Do the chemicals harm wildlife in the Everglades? Can toxins cause illness in humans? What actions can we take to assist the Everglades?*

To complete the lesson and the KWL chart, the mentors requested that the students briefly outline what they had discovered regarding their group's invasive plant or tree. The students chose one member from their group to compose a summary of the

findings. The mentors incorporated the summaries into the KWL chart, and the students additionally encouraged the mentors to add the QR codes in the KWL chart as evidence for their research project. As the project ended, the elementary students could be heard expressing their enjoyment while working on the project. Several students stated that they experienced a sense of inventiveness when they discovered the websites and URLs, which subsequently enabled them to create QR codes. As one student stated: "*It feels like magic… you go from having a strange code that you input into a field and voilà… you receive this neat, small box that can be scanned.* Another student stated*, "You are transported to a website…it's incredible!"* After students settled back in their designated seats, the mentors asked them to complete an Exit Slip detailing a new fact or idea they had acquired, a suggestion they wished to propose, or a question they still had regarding the project. Reactions varied from worries expressed by students regarding the fragile ecosystem in the Everglades to the potential adverse impacts of invasive species in their local neighborhoods. Numerous students resided on farms in rural Ohio and were accustomed to family discussions regarding the health and condition of their crops. Students acknowledged that invasive plants could significantly harm their own crops.

Other students offered various recommendations regarding the project and proposed ideas for expanding QR code use within the school. A student noted that his grandfather intended to deliver his lunch but became disoriented while searching for the main office. "*If he spotted a QR Code, he could simply scan it, and a school map might appear, helping him navigate!*" Some proposed installing QR codes around the school to inform visitors about the locations of the nurse's office, cafeteria, and gym. Students devised inventive concepts for utilizing QR codes, such as organizing a school scavenger

hunt in which fellow classmates would need to discover information hidden in the QR codes. As a reward for participating in these scavenger hunt games and had successfully deciphered all the messages, they would receive a reward. Students also mentioned that they were eager to demonstrate to their friends and families how to scan the QR codes for extra information in advertisements.

Discussion and Implications for using QR code technology in the future

The PBL science activity utilizing QR codes in societal applications demonstrates that these codes served as an effective educational resource to improve students' understanding of scientific issues. Feedback from the third graders indicated that they were enthusiastic about being involved in PBL communities that participated in practical activities, gathering important data on plants and subsequently creating QR codes to deepen their understanding and spark their interest in invasive plants found in the Everglades. Several students recommended installing QR codes throughout the school to direct parents and new students to key areas such as the nurse’s office, lunchroom, and gymnasium.

The significant impact of efficiently applying pedagogical strategies in PBL must not be overlooked in QR enhanced mentoring environments. The mentors thoughtfully employed techniques like KWL and various prediction methods to kickstart learning while consistently motivating elementary students to express their thoughts and cultivate insights through several reading strategies. Students were encouraged to draw upon their existing background knowledge, inquiry, and improve their comprehension to boost their education. These reading and writing strategies promoted an engaged learning atmosphere that has a social link central to PBL teaching.

Schools could use QR codes to promote problem-based learning in science for a variety of age groups and student populations, such as children for whom English is not their first language or students with learning disabilities. All students should be engaged in a range of content areas through meaningful technological applications and education. Even though PBL assisted by QR codes gave mentors and elementary students a tremendous sense of success and satisfaction, it is difficult to say whether this activity led to more widespread use of technology in the classroom. The activity was a part of a short visit by a group of high school mentors who were eager to impart their skills to younger primary students. Both groups of participants expressed enthusiasm and motivation, highlighting the value of offering younger students' opportunities to engage with complex content through interactive, technology-enhanced tools such as QR codes. It is crucial that mentors and educators receive regular, relevant in-service training that exposes them to academically enhancing QR code technologies so that they may modify tasks to meet the individual needs of their students.

Linking science, technology, and society is crucial for equipping students for the future, but no single instructional method should be considered a universal solution for teaching and learning. Enriching the contexts of learning are crucial for involving students in problem-based learning within STEM fields, and multimedia platforms are very effective for creating enriched environments that improve problem-based learning and informed decision making (Kumar, 2021; Kumar & Yurick, 2018). Instruction on QR code technology improves PBL, positioning it as one of the most effective instructional designs to provide students with the knowledge and cognitive abilities necessary to tackle 21st-century global challenges.

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Preventing Proximity Bias

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Abstract

In this article, hybrid meeting leaders' responsibilities that can facilitate more effective meetings in which all participants do not experience meeting inequity and proximity bias will be discussed. These strategies for meeting leaders include: ensuring participants are well-equipped with needed technology, choosing an efficient platform, providing training, ensuring a platform export is available, encouraging attendees to arrive early, setting up cameras and sound, assigning someone to follow the chat and virtual hand-raising, moderating who speaks, dispersing visuals, soliciting meeting feedback, reflecting on feedback, and implementing suggested improvements. The article concludes with a checklist that hybrid meeting leaders can access when preparing for meetings in Appendix A.

Key Words: hybrid videoconferencing, meeting equity, proximity bias

Introduction

Prior to the Covid pandemic, businesses and universities were already taking advantage of the benefits of offering video conferencing as an option for meetings. It can be convenient since members can join anywhere from their smart phone or laptop, as long as they have Internet access. Telecommuting can save a company the costs of attendees' transportation (Bednarski, 2020). Virtual meeting options can also be preferred because they allow for AI note summaries, transcription, and recording (Tolliver and Sass, 2024). Data that measures meeting participation and efficiency can be automatically collected through virtual meetings, which can provide companies with information on how to more efficiently operate during hybrid meetings (Tolliver and Sass, 2024). When the Covid pandemic occurred, videoconferencing became mandatory for companies who wished to continue business (Ali, 2020; Biswas et al. 2021; Jones, 2022; Schmitt et al., 2021). Many platform options became available during the Covid pandemic. Businesses had to determine which platform would best meet their needs (Jones, 2022).

Post-Covid, many businesses are choosing to continue to offer videoconferencing as an option for employees. In the global report, "Rebuilding Ourselves for the Hybrid Era" (2022), researchers originally predicted that as the workforce returned to their desks in their prior places of business, the number of videoconference meetings would decrease when compared to the Covid era. However, more meetings reflect hybrid meeting participation (in which employees have an option to telecommute to meetings) than even before Covid. When 2,800 employees in six countries were surveyed about their work preferences, results indicate that most (57%)

of the surveyed workers prefer a hybrid setting for work, approximately 23.5% prefer to work remotely, and approximately 19% prefer to complete all business in the traditional office location. Post-covid data from 40 million virtual meetings from 11 organizations further suggests that videoconferencing is here to stay (Tolliver and Sass, 2024). Furthermore, 86% of respondents foresaw that their ability to remotely work was important to their future job roles (Holstein, 2024).

Because many businesses have evolved into being dependent on hybrid meetings, meeting inequity and proximity bias must be discouraged (Meeting Equity Explained, 2022). Meeting leaders must work harder to ensure that all meeting members feel valued, respected, and listened to equally, whether they attend the meeting in person or through videoconferencing. In this article, hybrid meeting leaders' responsibilities that can facilitate more effective meetings in which all participants do not experience meeting inequity and proximity bias will be discussed. These strategies for meeting leaders include: ensuring participants are well-equipped with needed technology, choosing an efficient platform, providing training, ensuring a platform export is available, encouraging attendees to arrive early, setting up cameras and sound, assigning someone to follow the chat and virtual hand-raising, moderating who speaks, dispersing visuals, soliciting meeting feedback, reflecting on feedback, and implementing suggested improvements. The article concludes with a checklist that hybrid meeting leaders can access when preparing for meetings in Appendix A. First, it is necessary to discuss in greater detail the importance of leaders providing the same opportunities for all employees to efficiently participate in meetings, which is referred to as meeting equity (Meeting Equity Explained, 2022).

Meeting Equity

Meeting equity means that all members in a meeting feel equally seen and heard (Holstein, 2024; Meeting Equity Explained, 2022). In one study, only about 1/3 of people surveyed were even familiar with meeting equity terminology (Meeting Equity Explained, 2022). Meeting equity ignorance can result in hybrid video-conferencing behavior that causes participants to be less satisfied with feeling respected and heard. It is important bear in mind that meeting inequity issues can cause dissatisfied employees to leave their positions. There is a direct correlation between meeting equity and job retention (Tolliver and Sass, 2024). Job attrition can be a detriment to the growth or health of a company. Every meeting member should have an equal opportunity to participate without feeling the frustration of their attempts at communication being blocked due to poor hybrid meeting behavior, such as ignoring meeting participants who wish to speak (whether they attend in person or remotely). Proximity bias, which could be unintentional for how telecommuting attendees are treated, should also be discouraged.

Proximity Bias

Proximity bias is closely related to meeting inequity. Proximity bias can occur when outcomes for online employees are different than for in-person attendees (*Ensari, 2024;* Holstein, 2024). Those sitting next to their boss in a meeting can be favored over online attendees. A higher number of videoconference participants report being passed over for promotions (69% more frequently) than those who attend live (Meeting Equity Explained, 2022). Another study's results indicate that 90% of CEOs surveyed tend to advance in-office employees over forgotten online employees for prestigious projects that can lead to promotions and raises, 70% of managers report that online workers are

more easily replaceable than office workers, 62% believe that remote work that is full-time is detrimental to workers' career ambitions, and 72% share that they prefer for all staff to be at an office location (Holstein, 2024). Proximity bias can also result in online attendees being invited to fewer meetings, obtaining less desirable work projects, receiving less training and mentorship, and obtaining less feedback from bosses (*Ensari, 2024*, Holstein, 2024), especially women (Holstein, 2024).

Proximity bias's definition is closely linked to the propinquity effect. The propinquity effect is the natural phenomena that humans develop relationships with those who are close (in location) to them *(*Festinger,1950*).* Therefore, those in closer proximity to the boss may develop closer relationships with the boss and receive more preferential treatment. Proximity gives employees the opportunity to connect with each other more easily (Holstein, 2024; Newcomb, 1960) and form deeper friendships and trust, which are all necessary for employees to feel that they have an important role on the team *(Allport,1954; Ensari,2002).* Guaranteeing that online attendees have the tools they need to have a stronger presence regarding engagement opportunities can alleviate meeting inequity and proximity bias, which is a strategy for meeting leaders.

Ensure Participants are Well-Equipped with Needed Technology

Rebuilding Ourselves for the Hybrid Era (2022) shares that workers are not adequately prepared with needed technology for our virtual era, which directly impacts meeting equity, resulting in possible proximity bias. Guaranteeing that remote workers are equipped with the same technology as non-remote workers can facilitate a stronger teaming dynamic between all participants (Ensari, 2024). One study indicates that 80% of their meetings are virtual and that the type of technology that participants can access,

directly affects the ability to participate (Meeting Equity Explained, 2022). Interpersonal tools like headsets and professional-grade cameras that allow participants to more clearly identify facial expressions, for example, can boost the hybrid meeting experience for all participants (Holstein, 2024). Once convinced that all participants are set up with the equipment they need to attend a hybrid meeting, it is necessary to examine available platforms for videoconferencing.

Choose a Platform

The “Checklist for Evaluating a Video-Conferencing Platforms” developed by Jones (2022) offers many suggestions for choosing videoconferencing platforms. For example, Jones (2022) recommends that platform should be able to synchronize with a variety of computer systems, allow for virtual hand raising when videoconference participants wish to speak, and include a chat feature where videoconference participants can insert comments and questions throughout the meeting. These features can improve meeting collaboration. Jones also suggests reevaluating current available platforms from time to time to stay abreast with newer developments that enable greater meeting efficiency. Selecting a platform that meets the needs of a company can make a strong impact in bringing hybrid meeting participants together (Ensari, 2024*).* Some available platforms and their features may be challenging for participants to take advantage of unless they are offered some training, which is another duty of meeting leaders.

Provide Training

The most frequent obstacle to meeting productivity that Tolliver and Sass (2024) identify in their research on hybrid meetings is meeting inefficiency. Even though

meeting inefficiency was an issue prior to Covid, it seems as if videoconferencing has worsened inefficiency. Meeting leaders have key role in strengthening hybrid meeting productivity. Tolliver's and Sass's (2024) findings suggest that of those surveyed, only 10% of the employees host 54% of all meetings. However, only 15% of managers rate themselves as feeling very comfortable leading a hybrid meeting. Adept meeting leaders who are comfortable with running hybrid meetings are needed to efficiently promote best virtual meeting practices, establish a positive culture, and lay the foundation for meeting equity to avoid proximity bias. Furthermore, training needs to the be offered to leaders and participants of hybrid meetings to nurture technology and leadership skills and allow participants to internalize the concepts of meeting equity and proximity bias (Ensari, 2024). Offering training can better empower meeting leaders, as well as participants. Online participants, especially, need opportunities to showcase their talents through engagement in meetings (Holstein, 2024). However online participants may not fully engage in meetings if they experience pre-meeting anxiety due to feeling non-tech savvy and being unfamiliar with the chosen platform (Jones, 2022; Schmitt et al., 2021). Offering training can dissipate anxiety and make participants feel comfortable participating and using available features that can help them feel more included in a meeting.

Many virtual platform providers offer free training to subscribers who are even trying out the platform on a free-trial basis (Jones, 2022). Ahead of meetings, new videoconference attendees can also be tutored by someone (from inside the company) who is knowledgeable about the platform to better reassure the confidence of users. It is not surprising that platforms are constantly updating and making improvements (Jones,

2022). Nobody wants to attempt to join a meeting online only to find that their older version of a platform no longer coordinates with their work's new online system. If this does occur, ensuring a videoconferencing expert is available during meetings, can be extraordinarily beneficial.

Ensure a Platform Expert is Available

Attending meetings in which major time is wasted due to technical difficulties is extremely frustrating. Part of meeting efficiency is to determine roles and responsibilities of the leaders and participants and to support them in their roles (Tolliver and Sass, 2024). Having a platform expert on standby will enable meetings to run more seamlessly. When attendees were surveyed regarding their thoughts on videoconferencing efficiency, most share that they have "often" attended meetings in which nobody present really knew how to address technical difficulties (Meeting Equity Explained, 2022). Technical difficulties can block equitable participation if they are not quickly unraveled. The meeting leader can make sure an expert is available and encourage him/her to arrive early to set up cameras and sound.

Arrive Early and Set Up Cameras and Sound

Because some experimentation and testing may be necessary when setting up sound and cameras, attendees should be encouraged to arrive at least 5 minutes early to a hybrid meeting to ensure technology issues run smoothly and that meeting time isn't reduced. Input from videoconference attendees should be solicited regarding whether they can see and hear office participants clearly. To ensure all members feel included, the camera for live attendees should be set up so that all live members appear on camera. Virtual attendees, need to be encouraged to keep their cameras on for the

duration of virtual meetings since camera use strongly correlates with job satisfaction and retention. Camera use encourages engagement and those who participate frequently in virtual meetings report less burn-out than those who do not participate. Non-participation contributes to employees leaving their jobs within a year (Tolliver and Sass, 2024).

Microphones need to be set up in a spot where live attendees can best be heard. It can be tricky setting up the microphones since soft voices can be overwhelmed by louder voices, which can subtly result in proximity bias (Bibhudatta, 2023). Those sitting closest to the microphone can be heard more clearly than those sitting farther away, which is why having speaker technology that provides equal voice opportunity (regardless of placement or voice volume) is powerful (Meeting Equity Explained, 2022). To promote meeting participation equity, somebody also needs to be assigned to monitor virtual hand-raising and chat texts.

Assign Someone to Follow the Chat and Virtual Hand-Raising.

When attending live, meeting members can follow visual and auditory cues that assist in identifying when to contribute to meeting topics. Because there can be a small delay for online users, it can be quite difficult for videoconferences to know when to join into a conversation to make comments. Because of this factor, videoconference participants can often feel like spectators at a meeting as the in-person dialogue continues without a break (Rebuilding Ourselves for the Hybrid Era, 2022). The follower of the chat and hand-raising can cue the meeting moderator when a videoconference participant wishes to speak.

Moderate Who Speaks

Leaders of a meeting may take on more than one responsibility. For example, the meeting leader may also be the moderator or follower of the chat and hand-raising. It really doesn't matter if roles are combined, as long as their meeting roles are defined and attendees feel as if they have plenty of opportunity to speak (Tolliver and Sass, 2024). It is the moderator's job to ensure that all voices are heard. The moderator determines who speaks and in what order. Live attendees can make online participants feel more included in a meeting if they occasionally ask if they wish to contribute anything further to a conversation. Another strategy to promote equity and avoid proximity bias is to ensure that all meeting members have access to all meeting materials at the same time.

Disperse Visuals

It is disappointing for hybrid attendees when they find that they do not have access to the meeting materials (including handouts and visuals) that are being referred to in a meeting. Meeting time can be lost while attachments are sent to attendees. It is also pertinent for online participants to be able to see what is on a whiteboard if it is being used as a visual during a meeting. To improve hybrid meetings, it is useful to provide participants with the chance to evaluate the meetings.

Solicit Meeting Feedback, Reflect, and Implement Suggested Improvements

To improve meetings, it is beneficial for data to be collected to evaluate how the meeting went. Companies aware of attrition rates regarding hybrid meeting non-participation can use online meetings to measure the percentage of on-task behavior such as the percentage of participants who spoke during the meeting and left their cameras on. (Tolliver and Sass, 2024). Obtaining this rich data could inform better decision-making on how to run productive meetings. Participants can also be asked to identify which best practices for hybrid meetings were

followed (Tolliver and Sass, 2024). This feedback can then be reflected upon by leaders and participants. Suggestion for improvement can be implemented in future meetings. This data can be re-examined after trainings to see if positive changes result.

Conclusion

In this article, it was discussed that hybrid meetings are the most popular option for workers (when compared to working completely from home or in an office setting). In other words, hybrid meetings are here to stay. Since participants are both online and in person at the workplace, avoiding meeting inequity and proximity bias is crucial to build a more inclusive work environment. Meeting leaders set the tone for best practice and can facilitate better meetings by using techniques that encourage participation of all members. Leader strategies (which also appear in a check-box format in Appendix A) include: ensuring participants are well-equipped with needed technology, choosing an efficient platform, providing training, ensuring a platform export is available, encouraging attendees to arrive early, setting up cameras and sound, assigning someone to follow the chat and virtual hand-raising, moderating who speaks, dispersing visuals, soliciting meeting feedback, reflecting on feedback, and implementing suggested improvements. Suggested future research regarding this topic can include determining how best hybrid meetings can be evaluated and online meeting protocol for attendees.

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Appendix A

Checklist for Meeting Leader

- **Ensure participants are well-equipped with the needed technology**.
- **Choose a platform** that will synchronize with a variety of computer systems, allow for virtual hand-raising when videoconference attendees wish to speak, and includes a chat feature where videoconference participants can insert comments and questions during the meeting.
- **Provide training** regarding the chosen platform for video conference attendees.
- **Ensure that a platform expert is available** to tweak the chosen platform.
- **Encourage attendees to arrive at meetings at least 5 minutes early** to provide time to correctly set up technology.
- **Ensure that the camera's placement allows all meeting members to be seen**.
- **Ensure that the microphone system is set up** so that all attendees are heard.
- **Assign someone to be in charge** of following the chat comments and virtual hand-raising.
- **Moderate who speaks**. Occasionally ask videoconference participants if they have anything to contribute to a conversation.
- **Ensure that visuals are dispersed** to all meeting attendees.
- **Disperse videoconference evaluations** to participants.
- **Solicit evaluation feedback.**
- **Reflect upon evaluation feedback**.
- **Implement suggested improvements** at next meeting.

AI and the Future of Educational Leadership and Teaching: Bridging Creativity and Technology

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Abstract

The integration of artificial intelligence (AI) into education is rapidly transforming instructional design, student engagement, and professional development. This descriptive qualitative study examines the perspectives of teacher leadership candidates on the use of AI in lesson planning, differentiation, and instructional innovation. Through an analysis of responses from graduate students enrolled in a Master of Teacher Leadership program, the study identifies key themes including time efficiency, enhanced creativity, personalized learning, and concerns about over-reliance on AI. Findings reveal that while AI facilitates lesson development and instructional scaffolding, educators emphasize the importance of balancing AI-generated content with professional expertise to maintain authenticity and pedagogical integrity. The study contributes to ongoing discussions on AI adoption in teacher leadership, underscoring its potential to support educational practices while highlighting the need for ethical and strategic implementation.

Keywords: Artificial intelligence, Education, Lesson planning, Instructional creativity, Student-centered.

Introduction and Background

Artificial intelligence (AI) is no longer a distant concept; it is here, reshaping education in ways we could only imagine a decade ago. From automating routine tasks to generating personalized learning experiences, AI is transforming how educators plan lessons, engage students, and support diverse learners. However, with these advancements come critical questions: How much should teachers rely on AI? Does it enhance creativity or diminish the authenticity of instructional design? Can AI truly support meaningful teacher leadership and educational reform?

As teacher leadership candidates navigate this evolving landscape, they must determine how AI fits within their pedagogical philosophy and professional identity. The adoption of AI tools presents both exciting opportunities and real challenges, streamlining workflows and fostering innovation while raising concerns about over-reliance and the role of human expertise in the classroom.

This study explores the perspectives of teacher leadership candidates in a Master of Teacher Leadership program, analyzing how AI influences their instructional decisions, leadership development, and commitment to student-centered learning. By synthesizing participant reflections and recent educational research, this paper sheds light on AI's impact on lesson planning, differentiation, and leadership identity, offering a balanced discussion on how educators can harness AI's potential while maintaining the relational and creative core of teaching.

Review of Literature

The purpose of this descriptive qualitative study was to gain insight into teacher leadership candidates' use of technology tools to help enhance teacher lesson plans and differentiate instruction to meet student educational needs. The use of AI in instructional planning can bring new activities, enhance instruction, and provide scaffolding ideas to help meet the needs of students. It can also save time researching best practices, allowing teachers to concentrate on their pedagogical practices.

Time-Saving Tool

As artificial intelligence continues to reshape educational practices, its role in lesson planning has emerged as a powerful tool for reducing teacher workload and enhancing instructional quality. A growing body of research underscores how AI-powered platforms streamline repetitive tasks, such as content generation, grading, and resource organization allowing educators to redirect their time toward pedagogical strategies that deepen student comprehension (Li et al., 2023; Kim & Reeves, 2022).

Building on this foundation, Nurmanova et al. (2024) highlight AI's capacity to support differentiated instruction tailored to diverse learner needs. Their findings suggest that when lesson planning is guided by intelligent systems, teachers gain more time for individualized support and student engagement intelligent systems guide lesson planning key drivers of effective teaching.

Kehoe (2023) explores the integration of generative AI tools like ChatGPT and Google Bard in initial teacher education, noting that these platforms alleviate time constraints while enhancing the structure and quality of instructional design. Rather than replacing teacher input, AI-generated lesson plans offer adaptable frameworks that educators can refine to meet curriculum goals and student outcomes. Main (2025) takes this further, framing AI as a "thinking partner" in the planning process. From generating engaging lesson hooks to crafting resources for varied learning styles, AI applications support instructional creativity while automating routine tasks. Crucially, the main emphasis is that teacher expertise remains central. AI enhances efficiency, but the human touch ensures relevance, responsiveness, and ethical application.

Together, these studies affirm that AI's integration into lesson planning holds immense promise not as a substitute for educators, but as a strategic ally. To fully realize this potential, professional development must accompany implementation, equipping teachers to harness AI tools with confidence, discernment, and care.

Creativity and Innovation

Artificial intelligence is rapidly transforming the creative landscape of education, offering new tools that empower teachers to design more engaging, student-centered learning experiences. By automating routine tasks and generating differentiated content, AI

enables educators to focus on pedagogical innovation and personalized instruction (Jones & Smith, 2021; Wang & Nelson, 2022). Platforms such as ChatGPT and Canva AI have introduced fresh perspectives and flexible lesson structures, contributing to increased instructional creativity across diverse learning environments (Brown & Patel, 2020).

Recent studies have deepened our understanding of AI's role in fostering creativity. Noroozi et al. (2024) emphasize AI's capacity to deliver personalized feedback and support innovative teaching methodologies, suggesting that AI-driven tools help educators refine their strategies while enhancing student engagement. Similarly, Lin and Chen (2024) explore the impact of AI-integrated educational applications on student creativity and emotional engagement. Their findings reveal that AI can strengthen problem-solving skills and introduce novel learning techniques though they caution against overly rigid implementations that may limit authentic creative expression.

Walter (2024) adds a critical dimension to this conversation by highlighting the importance of AI literacy and prompt engineering. His study underscores the need for professional development that equips educators to use AI tools thoughtfully, ensuring that technology enhances rather than replaces pedagogical creativity.

These findings suggest that AI has the potential to be a powerful ally in instructional design, one that expands creative possibilities while preserving the essential role of teacher expertise. As AI continues to evolve, its integration into classrooms must be guided by intentional training and ethical considerations, ensuring that creativity remains at the heart of teaching and learning.

Student Engagement

Recent advancements in artificial intelligence have opened new pathways for enhancing student engagement through personalized instruction. A growing body of research highlights the transformative impact of AI-driven adaptive learning systems on motivation, participation, and academic performance. Rodriguez et al. (2023) found that incorporating AI-generated activities into classroom instruction led to a 20–23% increase in student engagement, underscoring the power of personalization in learning

environments. Expanding on this, Gligorea et al. (2023) conducted a systematic review of adaptive learning platforms, identifying key algorithms that optimize learning paths and foster deeper student involvement. Their findings emphasize the role of tailored AI recommendations in boosting motivation and retention.

Contrino et al. (2024) explored the effectiveness of adaptive learning tools across both online and face-to-face modalities. Their study concluded that AI-personalized instruction significantly improves student achievement and satisfaction, reinforcing the importance of individualized learning approaches. Similarly, Olaoye et al. (2024) highlighted the value of real-time feedback, gamification, and interactive content as essential components of AI systems that drive classroom participation and enthusiasm.

Together, these studies illustrate a compelling narrative: when thoughtfully implemented, AI-enhanced instruction can serve as a powerful catalyst for student engagement, offering educators new tools to meet diverse learning needs with precision and empathy.

Differentiation and Accessibility

Artificial intelligence is increasingly recognized as a catalyst for personalized and inclusive education. Through gamification, interactive quizzes, and adaptive learning pathways, AI-powered tools have been shown to improve cognitive retention and boost student enthusiasm (Park et al., 2021). These technologies also play a pivotal role in modifying instructional materials to meet the needs of diverse learners, including English language learners (ELLs) and students with varying proficiency levels (Garcia & Thompson, 2020).

Recent research has expanded, discussing AI's potential to support differentiated instruction. Abbes et al. (2024) explore the integration of generative AI and gamification in personalized learning environments, demonstrating how adaptive systems tailor content to individual student profiles while maintaining high levels of engagement. Naseer et al. (2025) propose a framework that combines game mechanics with AI-driven personalization, resulting in measurable gains in student motivation and learning outcomes.

For struggling students, AI offers dynamic scaffolding by adjusting text complexity, generating sentence stems, and suggesting alternative instructional strategies (Lee & Martinez, 2021). Laak and Aru (2024) emphasize AI's role in bridging linguistic gaps, particularly in multilingual classrooms, where tailored support fosters more equitable learning experiences. Spencer (2023) further highlights how AI-generated recommendations empower students to progress at their own pace, reinforcing the importance of individualized learning trajectories.

Beyond differentiation, AI is also advancing accessibility. Hernandez and Evans (2022) underscore AI's ability to deliver tailored support that meets diverse learning needs, while Gibson (2024) explores its impact on digital accessibility, noting its potential to create more equitable environments for students with disabilities. Fitas (2025) adds to this conversation by examining how AI-powered assistive technologies can support learners with special needs, reinforcing the role of AI in inclusive education.

Together, these studies affirm that AI is not merely a tool for efficiency, it is a transformative force for equity, personalization, and access. As educators continue to integrate AI into their practice, thoughtful implementation and ongoing professional development will be essential to ensure that every student benefits from the promise of intelligent, responsive learning.

Skepticisms and Concerns

While artificial intelligence offers promising advancements in instructional design, many educators remain cautious about its impact on authenticity and professional autonomy. Concerns center around the potential over-reliance on AI-generated lesson plans, the erosion of teacher creativity, and the risk of diminishing the human element in education (Taylor & White, 2019).

This skepticism is often linked to limited exposure and training. Miller and Green (2021) found that teachers with minimal AI literacy were significantly more hesitant to integrate AI tools into their practice. Expanding on this, McGehee (2024) identified key barriers to educator acceptance including technological complexity, ethical concerns, and resistance to shifting pedagogical norms. Aljemely (2024) further emphasized the need

for customized professional development, arguing that targeted AI training programs are essential to build trust and foster meaningful adoption.

To address these concerns, researchers advocate for a balanced approach that preserves teacher expertise. Stevenson et al. (2023) stress the importance of blending AI-generated content with educator insight to maintain instructional authenticity. Culley (2025) echoes this sentiment, framing AI as a tool that should enhance not replace,the human connection central to effective teaching. Roberts (2025) adds a nuanced perspective on originality in the age of AI, promoting collaborative and peer-reviewed lesson planning as a safeguard against homogenized or impersonal instruction.

Together, these studies underscore a critical truth: the successful integration of AI in education depends not only on technological capability, but on empowering educators to remain at the heart of instructional design. By investing in thoughtful training and fostering collaborative practices, schools can ensure that AI serves as a supportive partner, one that amplifies creativity, preserves authenticity, and respects the professional judgment of teachers.

Adoption & Future Considerations

As artificial intelligence becomes more embedded in educational practice, teacher perceptions have gradually shifted from skepticism to cautious optimism. Studies show that educators are increasingly comfortable incorporating AI tools into their workflow, recognizing their potential to streamline tasks and enhance instructional design (Williams et al., 2022). However, this growing acceptance is shaped by a complex interplay of psychological and pedagogical factors. Filiz et al. (2025) found that while teachers acknowledge AI's efficiency and adaptability, concerns around ethics, curriculum alignment, and pedagogical control continue to influence adoption.

AI is poised to play a transformative role in professional development, teacher training, and instructional intervention. Chen and Adams (2023) highlight its expanding presence in educator preparation, while Tammets and Ley (2023) demonstrate that sustained AI training improves teachers' ability to refine strategies and foster student problem-solving. Poth (2023) emphasizes the value of structured professional development,

noting that guided exploration and personalized learning experiences help educators integrate AI meaningfully into their practice.

Looking ahead, researchers call for deeper inquiry into the long-term effects of AI-driven lesson planning on student achievement. Liu and Scott (2024) advocate for ethical implementation that preserves pedagogical creativity and teacher agency. Swargiary (2024) reports notable gains in engagement and academic performance through AI-personalized learning but also raises critical concerns about data privacy and equitable access. Malone (2024) echoes these concerns, urging transparency and professional development to address algorithmic bias and ensure responsible use.

Together, these studies suggest that the future of AI in education depends not only on technological advancement but on thoughtful integration guided by ethics, equity, and educator expertise. As schools embrace AI's potential, sustained support and intentional design will be essential to ensure that innovation enhances, not compromises, the human heart of teaching.

Methodology

This study employs a descriptive qualitative research design to explore teacher leadership candidates' perspectives on the use of artificial intelligence (AI) in lesson planning and instructional development. This study was guided by one research question. The study aims to analyze how educators integrate AI into their practices, assess the perceived benefits and challenges, and identify emerging trends in AI adoption within teacher leadership.

Content of the Course

This course focuses on curriculum and assessment for ESL education. Course readings, assignments, and class discussions will serve as guides for exploring the relationships among standards, lesson planning, and assessment. A key component of the course is to discuss issues and concepts of assessment and think about how English language teachers' oral, reading, and writing development is assessed, using as guidelines the Texas English Language Proficiency Standards (ELPS) or similar

standards from another state. The course also provides a general background in teaching and assessing ESL-Special Education students.

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Participants

The participants in this study were graduate students enrolled in the Master of Teacher Leadership program at a regional institution in southeast Texas. The sample was drawn from the Spring 3 2025 cohort of ENSL5302, a five-week online course designed to synthesize learning and application of leadership principles in education. A random sample of 20 participants was selected from a total enrollment of 23 students, ensuring representation across diverse backgrounds and instructional experiences. The demographics of the participants mirrored the general demographics of the university’s online graduate student body.

Procedures

This study employed a descriptive, qualitative research design, utilizing textual analysis to examine the use of AI to develop engaging lessons, develop intervention plans for struggling teachers, and analyzing data by teacher leadership candidates within the Master of Teacher Leadership program at a regional institution in southwest Texas. Data were collected from a required assignment in Module 5 of the ENSL 5302 course, where 20 randomly selected participants provided answers to open-ended research questions on lesson planning, plans to develop struggling teachers, and the AI platforms that were used during the process. To ensure a systematic approach, comparative analysis principles were applied, with coded textual responses categorized into emergent

themes. The study reviewed archived student responses to the four research questions. This article examines the responses to Research Question 1. These responses were then analyzed for patterns in leadership development, instructional efficacy, and future refinement strategies. The methodological approach provided an in-depth understanding of how coursework and AI are being used to develop lesson plans and differentiation strategies to meet student needs.

Data Collection and Analysis

Data was collected from archived textual responses from a course-embedded assignment in Module 5, which required candidates to answer open-ended questions in this study. For this article, we will be focusing on research question one. The candidate answered an open-ended question. These questions were designed to assess each candidate's evolving use of AI to help craft lessons to engage students and use data to determine a personalized instructional plan to help meet the needs of struggling students.

The following question was answered:

1. Have you used AI to help you develop engaging lessons? Describe the lesson and its impact on students.

Research Question

The research question that this paper will discuss is research question one.

RQ 1. Have you used AI to help develop engaging lessons? Describe the lesson and its impact on students.

Findings and Emergent Themes

Analysis of participant responses provided rich insights into how teacher leadership candidates currently utilize or could leverage AI platforms to enhance lesson planning and create personalized intervention plans using data to inform instruction. The study identified several key themes, including saving time, personalization to meet individual needs, creativity, and the overall value of this technology tool. However, they also recognize the importance of balancing AI use with professional expertise to maintain

authenticity and relational aspects of teaching. These emergent themes highlight both the opportunities and challenges of integrating AI into educational leadership.

Table 1

Emergent Themes for RQ1 (N = 20)

Theme	Frequency	Percentage (%)
AI as a Time-Saving Tool	17	85
Enhanced Creativity & Innovation	16	80
Improved Student Engagement	16	80
AI for Differentiation & Accessibility	15	75
Skepticism & Concerns About AI Use	9	45
Growing AI Adoption & Future Considerations	12	60

Analysis of the Research Question.

RQ1: Have you used AI to help develop engaging lessons? Describe the lesson and its impact on students' performance.

Thematic analysis of responses from 20 teacher leadership candidates revealed several key findings. The majority (85%) reported that AI served as a significant time-saving tool, allowing them to streamline lesson planning and focus more on instructional quality. Eighty percent of participants noted that AI enhanced creativity and innovation, enabling them to design more interactive and differentiated lessons. Improved student engagement was also reported by eighty percent of candidates, who observed increased participation and motivation when AI-generated activities were incorporated. Seventy-five percent used AI for differentiation and accessibility, particularly for English language learners and students needing additional scaffolding. However, forty-five percent expressed skepticism and concerns about over-reliance on AI, emphasizing the need to balance technology with professional judgment. Sixty percent indicated a growing willingness to explore AI's potential in instructional practice further.

Representative comments included, "AI-generated activities helped me make my lesson feel fresh. The prompts were dynamic, and students responded well to the interactive approach," and "I am learning how to refine AI prompts to get better results. The more precise I am with my requests, the more useful AI becomes in tailoring lessons to my students."

AI as a Time-Saving Tool. Eighty-five percent of participants (n = 17) reported that AI tools significantly reduced lesson planning time, allowing them to focus more on instructional strategies and student engagement. One participant stated, “AI-generated activities helped me make my lesson feel fresh. The prompts were dynamic, and students responded well to the interactive approach.”

This perception aligns with growing evidence that AI streamlines repetitive tasks such as generating instructional materials, organizing resources, and scaffolding content (Kim & Reeves, 2022; Jones & Smith, 2021). By reducing the burden of lesson preparation, teachers in our study echoed findings from Nurmanova et al. (2024), who emphasize that intelligent planning systems free educators to dedicate more time to individualized student support and meaningful engagement. Similarly, Kehoe (2023) noted that generative AI platforms like ChatGPT provide adaptable frameworks that ease planning pressures while maintaining opportunities for teacher creativity and contextual adaptation. Participants’ descriptions of AI as a tool that “made lessons feel fresh” also resonate with Stevenson et al.’s (2023) observation that AI can generate innovative lesson hooks and materials that enhance instructional design while preserving the teacher’s central role in ensuring quality and relevance. Furthermore, Brown and Patel (2020) argue that AI’s time-saving potential lies not only in efficiency but also in enabling educators to invest more energy in designing engaging and student-centered learning experiences.

The participant responses support broader scholarly claims that AI functions less as a replacement for teacher expertise and more as a strategic partner in improving efficiency, creativity, and instructional focus (Nurmanova et al., 2024; Kehoe, 2023; Stevenson et al., 2023). Importantly, while time savings were consistently emphasized, several participants also noted that the flexibility and novelty of AI-generated resources

sparked new instructional ideas and approaches. This suggests that beyond efficiency, AI may serve as a catalyst for enhanced creativity and innovation in lesson design, a theme explored in the following section.

Enhanced Creativity and Innovation. Eighty percent of participants (n=16) indicated that AI fostered creativity in lesson design. They described AI as an "idea generator," enabling them to try new instructional activities. A participant remarked, "AI-generated lessons have inspired me to try new activities I would not have thought of on my own. It is like having an idea generator at my fingertips." This sentiment reflects a broader pattern in which educators saw AI not merely as a time-saving device, but as a catalyst for exploring innovative approaches to teaching and learning. Rather than constraining professional judgment, participants reported that AI suggestions often sparked new lesson structures, differentiated activities, and engaging instructional strategies that aligned with student needs. These findings echo Jones and Smith's (2021) assertion that AI integration can foster teacher creativity by introducing novel approaches to content delivery, as well as Brown and Patel's (2020) argument that AI enhances instructional strategies through its capacity to generate flexible, adaptable learning resources.

The link between creativity and innovation identified by participants also aligns with emerging scholarship that situates AI as a partner in pedagogical experimentation. Lin and Chen (2024) found that AI-integrated applications stimulate both student creativity and teacher innovation by supporting the design of emotionally engaging problem-solving–oriented lessons. Similarly, Noroozi et al. (2024) highlight how AI-driven tools can provide personalized feedback loops that allow teachers to refine their methodologies, thereby enhancing both instructional quality and creativity. Several participants in our study confirmed this potential, explaining that AI tools encouraged them to attempt "riskier" or less traditional strategies they might have otherwise overlooked. Walter (2024) extends this conversation by underscoring the importance of AI literacy and prompt engineering, noting that educators who are trained to use AI thoughtfully are better positioned to harness its full creative potential without diminishing their pedagogical agency. Taken together, these findings suggest that when

implemented with discernment and professional expertise, AI can operate as a dynamic creative partner—one that inspires teachers to expand their instructional horizons while maintaining student-centered learning at the core of their practice. Notably, several participants emphasized that the creative activities inspired by AI were not only innovative for teachers but also energizing for students. The infusion of fresh lesson ideas and interactive strategies frequently translated into higher levels of classroom participation, curiosity, and enthusiasm. This connection points directly to our next theme: the role of AI in fostering improved student engagement.

Improved Student Engagement. Eighty percent of participants (n = 16) observed increased student participation and motivation when using AI-enhanced lessons. Teachers frequently attributed this improvement to the personalization afforded by AI-driven adaptive learning platforms, which adjusted activities and resources to align with student readiness levels and interests. One participant explained that when AI-generated tasks were integrated, “students leaned in more they were excited to see what was next, and more willing to take risks in discussion.” Such accounts affirm that AI integration was not simply about efficiency or creativity for teachers, but also about cultivating higher levels of enthusiasm and involvement among learners.

These findings mirror a growing body of scholarship demonstrating the impact of AI on student engagement. Rodriguez et al. (2023) found that embedding AI-generated activities into instruction increased classroom engagement by over twenty percent, highlighting the power of personalization to drive motivation. Similarly, Gligorea et al. (2023) identified how adaptive algorithms optimize learning pathways, making instruction more responsive to individual student needs and fostering deeper involvement. Participants in our study echoed these dynamics, noting that AI-driven adaptability helped reluctant learners re-engage with content while giving advanced students new challenges.

Further evidence underscores the versatility of AI in boosting engagement across modalities. Contrino et al. (2024) showed that adaptive platforms enhanced both student satisfaction and achievement in online and face-to-face settings, while Olaoye et al. (2024) emphasized that gamification features, real-time feedback, and interactive

tasks built into AI systems can heighten classroom participation and sustained interest. Taken together, these findings suggest that AI functions as a powerful catalyst for engagement, helping educators foster more dynamic and inclusive learning environments. When implemented thoughtfully, AI not only personalizes instruction but also promotes student agency, motivation, and a sense of belonging in the classroom. Yet, participants emphasized that the real power of AI extended beyond general engagement to its capacity for meeting diverse learning needs. Teachers reported that AI-supported platforms were particularly effective in tailoring instruction for struggling learners, English language learners, and students requiring additional accommodations. This shift from engagement to equity underscores our next theme: the role of AI in differentiation and accessibility.

AI for Differentiation and Accessibility. Seventy-five percent of participants (n = 15) reported using AI to tailor lessons for diverse learners, including English language learners (ELLs) and students with varying proficiency levels. One participant explained, *“AI helped me modify materials for my ELL students. It suggested alternative explanations and scaffolded activities, making the lesson much more accessible.”* Teachers consistently described AI as an adaptive partner that could reframe content to meet students “where they are,” whether by simplifying complex texts, generating multiple representations of content, or offering alternative practice activities. These accounts illustrate how AI tools extended teachers’ capacity to differentiate instruction in ways that felt responsive and inclusive.

These findings resonate with research positioning AI as a catalyst for personalized learning and equity. Abbes et al. (2024) highlight how generative AI, when integrated with gamification, can personalize learning environments and sustain student engagement. Similarly, Park et al. (2021) and Garcia and Thompson (2020) identify AI’s potential to modify instructional materials to meet the needs of learners with different linguistic and academic profiles. Participants’ experiences align with these claims: by automating scaffolds such as sentence stems, alternative explanations, and leveled activities, AI helped teachers support both struggling learners and advanced students in the same classroom context.

Beyond differentiation, participants also noted how AI expanded accessibility for students requiring accommodations. Hernandez and Evans (2022) point to AI's ability to create individualized support for learners with disabilities, while Gibson (2024) underscores the broader potential of AI-driven accessibility tools to foster more equitable digital learning environments. Several participants shared similar reflections, observing that features like text-to-speech, adaptive quizzes, and resource modifications made lessons more accessible to students who previously struggled to engage with standard materials. Together with emerging research (Fitas, 2025; Lee & Martinez, 2021), these findings underscore AI's promise as both a differentiation engine and an inclusion mechanism, extending the reach of instructional practices to meet diverse student needs.

While these benefits are noteworthy, participants also acknowledged that the use of AI for differentiation and accessibility raises important questions about reliability, teacher dependence, and ethical implementation. Several expressed concerns about whether AI-generated accommodations always aligned with curriculum standards or cultural contexts. This growing awareness of potential risks provides a natural bridge to the next theme: Skepticism & Concerns about AI Use.

Skepticism and Concerns About AI Use. Nearly half of participants (n = 9, 45%) expressed reservations about relying too heavily on AI in their instructional practice. Concerns centered on issues of creativity, authenticity, and professional identity. One participant reflected, *"I am still unsure how much I should rely on AI. It is great for generating ideas, but I do not want my lessons to lose their originality."* Such reflections reveal a persistent tension: while teachers recognized AI's efficiency and creative potential, they also feared that over-reliance might dilute the distinctly human elements of teaching such as relational understanding, contextual nuance, and the personal voice that gives lessons meaning.

These findings parallel broader research documenting educators' cautious stance toward AI integration. Taylor and White (2019) cautioned against the erosion of professional autonomy when lesson planning becomes overly dependent on algorithmic suggestions, while Stevenson et al. (2023) emphasized that authenticity requires a

careful blending of AI-generated content with teacher expertise. Participants in this study echoed these concerns, often positioning AI as a helpful supplement rather than a replacement. Several linked their hesitancy to limited training or uncertainty about ethical use, reflecting Miller and Green's (2021) finding that AI hesitancy often stems from low AI literacy and lack of practical exposure.

Other studies point to systemic barriers underlying this skepticism. McGehee (2024) identified technological complexity, ethical risks, and resistance to pedagogical change as major obstacles to teacher confidence in AI use. Likewise, Aljemely (2024) underscored the importance of targeted professional development, arguing that when educators are supported with customized training, they are more likely to integrate AI thoughtfully and confidently. More recently, Culley (2025) and Roberts (2025) have stressed the importance of positioning AI as an enhancement rather than a replacement, calling for collaborative lesson design and peer review processes to safeguard originality and maintain the human dimension of teaching.

Taken together, both our participants' experiences and the literature suggest that skepticism toward AI is not rooted in outright rejection but in a desire for balance. Teachers want to preserve creativity, authenticity, and autonomy, while cautiously experimenting with new technologies. This recognition sets the stage for our final theme: Growing AI Adoption and Future Considerations, a theme that highlights not only how teachers are beginning to embrace AI more fully, but also what supports and safeguards are needed to guide its sustainable, ethical integration into education.

Growing AI Adoption and Future Considerations. Sixty percent of participants (n = 12) reported a growing willingness to explore AI's potential beyond lesson planning, extending its use to areas such as teacher coaching, professional development, and instructional intervention. Participants consistently emphasized that AI should complement, not replace, human expertise, with one teacher noting that "AI is a helpful tool, but it works best when paired with professional judgment and classroom experience." This perspective reflects an important shift from cautious experimentation toward more intentional adoption, suggesting that teachers are beginning to envision AI as a long-term partner in their professional growth.

These findings resonate with studies documenting the gradual normalization of AI in educational practice. Williams et al. (2022) observed that teacher perceptions evolved from skepticism to cautious optimism as AI tools became more familiar and accessible. Still, as Filiz et al. (2025) reminds us, adoption remains shaped by complex psychological and pedagogical factors, including lingering concerns about ethics, curricular alignment, and teacher control. Several participants voiced similar hesitations, noting the importance of preserving creativity and ensuring AI integration aligned with student needs and institutional goals.

At the same time, participants pointed toward future opportunities for AI in supporting professional learning. Chen and Adams (2023) highlight AI's emerging role in teacher preparation programs, while Tammets and Ley (2023) demonstrate that sustained AI training can strengthen teachers' problem-solving strategies and instructional design. Echoing these findings, Poth (2023) emphasizes the value of structured professional development, where guided exploration and individualized training help educators build both technical confidence and pedagogical discernment. Such insights align with participant feedback suggesting that professional learning will be critical in determining whether AI adoption enhances teacher expertise or simply adds another layer of complexity.

Looking ahead, both participants and researchers caution that adoption must be tempered by ethical reflection and equity considerations. Liu and Scott (2024) stress the importance of protecting pedagogical creativity and agency, while Swargiary (2024) and Malone (2024) raise concerns about data privacy, algorithmic bias, and unequal access to AI-enabled resources. These concerns were echoed by participants who worried about over-dependence on automated suggestions or inequities between schools with varying levels of technological infrastructure. Taken together, these findings suggest that the trajectory of adoption of AI will depend not solely on technological innovation, but on intentional, ethical integration guided by equity, transparency, and teacher expertise.

Discussion

This study was guided by the research question: *Have you used AI to help develop engaging lessons? Describe the lesson and its impact on students' performance.* The

findings suggest that teacher leadership candidates are actively experimenting with artificial intelligence (AI) in their instructional design, viewing it as both a time-saving tool and a catalyst for creativity, engagement, and accessibility. The participants' reflections align with a growing body of research highlighting the transformative potential of AI in lesson planning and instructional practice (Kim & Reeves, 2022; Nurmanova et al., 2024; Kehoe, 2023). At the same time, their voices reveal important cautions, emphasizing the need to preserve creativity, authenticity, and professional autonomy in an AI-driven educational landscape (Taylor & White, 2019; Stevenson et al., 2023).

A central theme emerging from the data was the dual role of AI in enhancing efficiency while fostering innovation. For many participants, AI reduced the burden of repetitive planning tasks, enabling them to dedicate more time to pedagogy and student support. These accounts echo prior research underscoring AI's value in streamlining instructional design and promoting differentiated learning (Jones & Smith, 2021; Garcia & Thompson, 2020). Beyond efficiency, participants consistently described AI as an "idea generator," sparking new lesson designs and activities that enhanced both teacher creativity and student engagement. This finding is significant, as it reframes AI not merely as a productivity tool but as a creative partner, an observation supported by Brown and Patel (2020) and Lin and Chen (2024), who document AI's role in expanding instructional imagination.

Yet, despite these benefits, participants' concerns highlight the complexity of AI integration. Nearly half expressed skepticism about over-reliance, questioning whether AI-generated content could compromise originality, diminish teacher voice, or create dependence on automated systems. Such concerns mirror broader scholarly debates about the tension between technological innovation and pedagogical authenticity (Miller & Green, 2021; McGehee, 2024). Importantly, this skepticism was not characterized by rejection, but by a call for balance AI should complement, not replace, the human expertise and relational knowledge that define effective teaching.

Another critical finding relates to equity and accessibility. Participants highlighted AI's potential to support English language learners, struggling students, and those requiring

accommodations, aligning with Hernandez and Evans (2022) and Fitas (2025), who emphasize AI's role in inclusive education. However, participants also raised questions about equitable access to AI-enabled tools across diverse school contexts, echoing Swargiary's (2024) and Malone's (2024) concerns about the digital divide and algorithmic bias. These findings underscore that the promise of AI is contingent upon ethical and equitable implementation, paired with professional development that equips educators to use AI responsibly (Aljemely, 2024; Walter, 2024).

Finally, the theme of growing adoption and future considerations situates teacher leadership candidates at a pivotal juncture. With many participants expressing openness to AI's role in professional development and coaching, this study suggests that AI may play an increasingly influential role in shaping both classroom practice and educator preparation programs. This finding aligns with Chen and Adams (2023) and Tammets and Ley (2023), who emphasize the importance of sustained AI training in developing pedagogical adaptability. However, as Liu and Scott (2024) remind us, the long-term impact of AI on student achievement and teacher expertise remains an open question—one that requires ongoing inquiry and reflection.

In sum, this study contributes to the growing literature on AI in education by amplifying the voices of teacher leadership candidates as they navigate opportunities and challenges. The findings affirm that AI holds great promise for efficiency, creativity, engagement, and accessibility, but its successful integration depends on maintaining a balance between technological innovation and human expertise. For schools and preparation programs, the challenge moving forward lies not in whether to adopt AI, but in how to do so thoughtfully, ensuring that AI enhances, rather than erodes, the heart of teaching and learning.

Conclusions and Implications

The integration of artificial intelligence (AI) into educational leadership and teaching is transforming how educators plan lessons, engage students, and support diverse learners. This study highlights both the opportunities and challenges associated with AI adoption, reinforcing its role as a time-saving tool, creativity enhancer, and

differentiation mechanism while also addressing educator concerns regarding authenticity, autonomy, and ethical considerations.

Findings from teacher leadership candidates indicate that AI significantly improves lesson planning efficiency, fosters instructional innovation, and enhances accessibility for diverse student populations. However, skepticism remains regarding the over-reliance on AI, the potential dilution of teacher creativity, and the need for structured professional development to ensure meaningful implementation.

To maximize AI's potential while preserving pedagogical integrity, institutions must prioritize ongoing professional development, ethical implementation strategies, and policies that balance AI-generated content with educator expertise. Future research should explore longitudinal impacts on student outcomes, teacher effectiveness, and systemic educational reforms to ensure AI remains a collaborative tool rather than a replacement for human insight and leadership.

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Integrating Flow Theory into Digital Lifelong Learning: Engagement, Challenges, and Strategies

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Abstract

In the era of rapid technological advancement, digital education has emerged as a critical component of lifelong learning. This study explores how digital learning environments can support sustained learner engagement and reduce educational inequalities, particularly when designed through the lens of Csikszentmihalyi's Flow Theory. Drawing on recent empirical studies and international case analyses. This research examines the conditions necessary to foster deep learner immersion, self-directed motivation, and long-term participation in digital education. It emphasizes that effective digital learning should be designed to help learners reach a state of *flow,* where they are fully immersed and engaged in the learning process. These conditions enable learners to concentrate fully, maintain intrinsic motivation, and actively persist in their digital learning journey.

Furthermore, the study highlights key structural and pedagogical factors influencing the sustainability of digital lifelong learning, such as equitable access to ICT infrastructure, teacher professional development, and well-structured learning management systems. While digital platforms offer immense opportunities for flexible and scalable learning, they also pose risks of cognitive overload, low learner participation, persistent digital divides and more. Addressing these challenges requires policy strategies and learner-centered design practices. By integrating Flow Theory into digital pedagogy and platform development, this study proposes a comprehensive framework to enhance digital learning effectiveness and equity. The findings contribute to ongoing discussions on how to optimize digital education for diverse learners in an increasingly digital world.

Key words: digital lifelong learning, flow theory, digital divide, learner engagement, instructional design, self-regulated learning

Introduction

As digital technology advances, education is rapidly shifting toward more flexible and accessible formats. In the post-COVID-19 era, the need for lifelong learning beyond the limits of time and place has become more important than ever. Digital learning platforms such as MOOCs and online learning systems are now widely used across all age groups, supporting continuous learning in diverse ways. However, providing technology alone is not enough to ensure effective learning. Government support, teacher training, and well-designed digital content are all essential. According to Bo (2024), strong internet connections and access to digital devices are key to reducing educational inequality, especially in rural and low-income areas. In addition, teachers must have skills not only in instructional design and digital tools but also in guiding learner engagement and assessment (Baran et al., 2011; Bawane & Spector, 2009).

In this context, Flow Theory by Csikszentmihalyi (1990) offers a helpful framework. It explains that learners are most engaged when tasks match their abilities and provide clear goals and feedback. Digital environments can support these conditions well. Nevertheless, several challenges persist. For example, a lack of human interaction in online classes can increase transactional distance, lowering motivation and participation (Banna et al., 2015). Information overload is also a concern that can reduce focus and satisfaction (Chen et al., 2011). Recent efforts like Spain’s UniDigital project show how real-time feedback and personalized learning systems can improve engagement and reduce dropout rates (Zabala et al., 2025). These examples highlight that effective

digital lifelong learning requires both strong systems and thoughtful design that consider learners' needs.

This study explores how digital learning environments, when guided by flow theory and supported by strong policy and pedagogy, can enhance lifelong learning and learner engagement.

2. Fundamental theory

2.1 Lifelong Learning in the Digital Era

Lifelong learning is often associated with acquiring new skills or maintaining competencies for work. However, Billett (2017) argues that it extends beyond formal education, being a self-directed practice shaped by learners' interpretation and meaning-making. He emphasizes that learning emerges from intrinsic motivation rather than from policy-driven initiatives alone. The advancement of digital technology has drastically transformed lifelong education, making digital platforms an essential element. Head et al. (2015) further note that global shifts such as increased mobility, longer lifespans, and income inequality have triggered new learning patterns, including digital learning, and call for research on factors like managerial support, cultural identity, and self-efficacy that influence adult participation. Ivenicki (2021) also highlights that in lifelong learning, digital education should not focus solely on access but also on pedagogy, advocating for inclusive policies that consider cultural diversity and reduce inequalities (p. 370). Importantly, Tang & Chaw (2016) define digital literacy not just as technical skill but as the ability to interpret multi-modal information and construct new meaning. Prior et al. (2016) show that digital literacy and a positive attitude enhance

self-efficacy, promoting peer interaction, LMS usage, and instructor engagement. Therefore, effective digital learning design must account for learners' digital literacy, foster self-directed learning, and support positive learning attitudes. In lifelong education, policy backing is essential. According to Komur, Sahin, & Okur (2023), learners evolve into active participants through interaction with systems, teachers, and peers. Structured guidance on tool usage, feedback-rich interaction, and collaborative environments that foster confidence and a sense of achievement are key to sustaining long-term learning engagement.

2.2 Flow Theory and Immersive Learning in Digital Environments

The educational integration of digital technologies plays a pivotal role in creating immersive, learner-centered environments. Haleem et al. (2022) suggest that technology-enhanced instruction improves student engagement by increasing attention and interest in the subject (p. 276). This digital educational ecosystem encompasses blended learning, adaptive learning systems, and mobile learning and more. Each offerings flexibility and personalized pathways. Komur, Sahin & Okur (2023) describe blended learning as a “dynamic learning structure” that fosters continuous interaction among learners, instructors, and technology, thus significantly enhancing learner immersion (p. 20). Simon, Zeng & Fryer further argue that learner engagement in adaptive platforms depends on system quality, content quality, learner characteristics, and social interaction; addressing both technical infrastructure and emotional-social factors can enhance outcomes. These insights align closely with Csikszentmihalyi’s flow theory, which defines flow as an optimal psychological state arising when one’s skills perfectly meet the challenge at hand. Such a state induces deep concentration,

creativity, learning, and pleasure (Csikszentmihalyi, 1990). Flow also motivates individuals to choose challenging activities to develop their capabilities. Integrating flow principles into digital learning by balancing difficulty, supporting feedback, and providing interaction can significantly elevate lifelong learning quality. Billett (2018) also notes that while policy sets learning goals, real learning outcome depends on how learners interpret and integrate their experiences. This idea reinforces the importance of designing digital learning environments that facilitate intrinsic motivation, not just content dissemination.

2.3 Engagement and Interaction in Online Learning

Recent studies indicate that online learning enhances engagement, discussion quality, and interaction, while mobile technologies boost accessibility and efficiency (Yu, 2021). Collaborative learning and virtual communities further strengthen learning outcomes, providing more flexible and sustainable learning environments than traditional classrooms. These digital environments also support deeper immersion and foster lifelong learning attitudes. However, maximizing these benefits requires more than just deploying digital tools. Rather, it demands strategies that amplify learner motivation and strengthen teacher–learner interaction. Higgs & McCarthy (2008) argue that to promote integrative learning, educators must deeply understand not only the complex connections students need but also how to help them bridge the gap between ability and motivation (p. 71). This underscores the need for a psychosocially-aware, integrated approach in digital learning design.

2.4 Challenges in Digital Learning: Information Overload and Cognitive Burden

Digital learning offers flexible, boundary-crossing educational opportunities and diverse content formats. Yet, Yu (2021) cautions that it may also lead to reduced engagement, lower academic performance, and increased time consumption. This is particularly evident in online classes conducted without clearly defined goals or well-structured content, where learners find it difficult to maintain focus in a distracting environment. As a result, their motivation may decline, and the quality of task performance can suffer. Poorly structured design and rigid scheduling can undermine learning effectiveness, while anxiety and stress may hinder academic outcomes. (Zepke & Leach, 2010) Furthermore, online platforms can foster addictive behaviors, distract from core subjects, and encourage exploratory behavior toward visually stimulating but cognitively burdensome contents which creating a risk of cognitive overload. Bayne & Inan (2022) report that in online courses, information overload and excessive learning environments increase cognitive fatigue and reduce both immersion and persistence. Kim & Kim (2021) add that while VR-based learning improves satisfaction, it does not significantly enhance self-efficacy or immersion, emphasizing the need for well-designed instructional frameworks to build confidence and effective learning experience

3. Case Analysis in digital lifelong learning

3.1 Successful case of digital lifelong learning platforms.

In recent years, a number of digital platforms have emerged as successful models in facilitating lifelong learning opportunities through technological integration. According to Abdelmagid & Jabli, Massive Open Online Courses (MOOCs) have developed alongside the advancement of digital learning platforms, supporting learners in generating and modifying knowledge throughout the learning process. They also

noted that these platforms are used in various ways in educational settings, such as tracking student behavior, and emphasized that interaction-centered instructional design is essential for effective learner engagement. For example, Korea's K-MOOC program, operated under the Ministry of Education, provides equitable and open access to high-quality university-level courses. The government actively supports the platform by funding course development and promoting partnerships with universities (Lee, 2015). According to Lee & Chung (2019), key success factors of K-MOOC include authentic learning, teaching presence, and reputation, which positively influence learner satisfaction, engagement, and continued use intention. Learner engagement is also enhanced by features such as real-time feedback, discussion boards, and periodic assessments. Another example is Spain's UniDigital project, a nationally coordinated initiative that invested 400 million euros to promote community engagement through digital content and platform development, pedagogical innovation, enhancement of digital competencies, and inter-university collaboration. According to Zabala et al. (2025), this project is recognized for going beyond traditional MOOCs by building a digital learning management system suitable for both face-to-face and online learning. It incorporates features such as real-time analytics, feedback systems, enhanced assessment tools, and early warning systems to predict learning risks.

These systemic improvements have established an infrastructure that is more conducive to learner-centered, personalized education. Moreover, by comprehensively analyzing learners' participation rates and interaction records, the project has demonstrated effectiveness in managing dropouts and low engagement, thereby enabling continuous learning as a representative case of success. These elements

closely align with Csikszentmihalyi's flow theory, which posits that deep engagement occurs when there is a balance between the challenge of a task and the learner's skill level. When digital learning environments are well-designed to provide clear goals, immediate feedback, and appropriately challenging tasks, learners are more likely to experience a state of "flow," characterized by full concentration, intrinsic motivation, and the loss of self-consciousness and time awareness. In this context, features such as interactive content, structured pacing, and real-time communication help sustain learner motivation and foster this optimal learning state. Kuo, Tsai, and Wang (2021) further support this by showing that higher levels of online learning self-efficacy significantly enhance behavioral, emotional, and cognitive engagement among MOOC learners. This effect is mediated by learners' online academic hardiness, which reflects their persistence and adaptability, both essential for maintaining the flow experience.

These findings highlight that digital education platforms such as K-MOOCs and UniDigital project are most effective when designed with interactive and personalized features that not only stimulate learners' intrinsic motivation but also cultivate the self-efficacy, resilience, and focused engagement necessary for sustaining long-term participation in digital lifelong learning environments.

3.2 Challenges of Digital Learning platforms

Despite various research findings demonstrating that the use of digital tools significantly enhances student engagement and academic performance, numerous limitations and barriers still persist. One of the major concerns is the unequal access to digital tools**.** Van Dijk (2020) explains the digital divide as a multi-layered structure that goes beyond mere physical access, dividing it into three stages: physical access

(devices and internet), digital skills, and usage outcomes. Each stage reinforces the next, ultimately exacerbating social inequality. This suggests that the digital divide is not simply an issue of accessibility, but also encompasses the ability to effectively use technology and derive meaningful benefits from it. From a Flow Theory perspective, the absence of foundational access and skills makes it nearly impossible for learners to enter a state of flow, as they are unable to interact meaningfully with digital content or meet its challenges.

Another significant barrier is the lack of digital literacy among students and teachers. In order to promote the sustainability of lifelong learning, the active use of digital tools is essential, yet many learners lack the necessary skills and capabilities to navigate complex online learning systems or manage their own learning progress. Teachers, too, often face difficulties in designing and delivering effective lessons using digital tools. This gap in competencies can lead to frustration, loss of motivation, and ultimately lower academic achievement (Song et al., 2004).

According to Rafiq, Iqbal, and Afzal (2024), many teachers still lack the capacity to effectively integrate digital tools into their instructional practices, and this is further intensified by limited opportunities for professional training and development. These issues are especially pronounced in developing countries or regions with poor digital infrastructure. Without the necessary support to build digital competencies, learners and teachers are unlikely to reach deep immersion or intrinsic engagement, thus failing to realize the potential of flow-based digital learning.

Meanwhile, Abdelmagid & Jabli (2024) point out that student participation in online classes remains low, with higher dropout rates compared to face-to-face

instruction. Most learners remain passive users, and concerns over data privacy reduce trust in digital platforms, making active participation even more difficult. In fact, Song et al. (2004) report that many learners tend to remain “lurkers” who merely consume content rather than engage actively, attributing this to a lack of interaction and a sense of psychological distance. This lack of participation can lead to reduced motivation and decreased persistence in learning. To counteract this, it is necessary to implement design strategies that promote emotional and social engagement.

In addition, Chen, Pederson, & Murphy (2011) emphasize that perceived information overload in online learning environments can cause cognitive burden, resulting in reduced concentration, loss of interest, and poor learning outcomes. They particularly highlight that multitasking, unstructured content, and constant digital stimuli can overwhelm learners’ information-processing capacity, disrupting key conditions required to achieve a flow state, such as clear goal setting and balanced task difficulty. These information overload issues suggest that digital learning can become a source of stress, hindering not only the effectiveness of learning but also its continuity.

In conclusion, these various limitations demonstrate that digital lifelong learning is not merely a matter of introducing new technologies. Van Dijk (2020) emphasizes that addressing this divide requires not just providing technology but also enhancing skills and structured usage opportunities through policies targeting infrastructure, training, and equitable resource distribution. To build an effective digital learning environment, it is essential to adopt a multifaceted and layered policy and educational approach that expands access, develops user competencies, builds trust, and designs content that takes into account learners’ cognitive load.

4. Recommendations

Effective and sustainable digital education requires a holistic approach that addresses technological access, teacher professional development, and learner-centered instructional design.

1. Enhancing Technological Access and political and financial support.

Government-level support must go beyond merely providing devices; it plays a crucial role in reducing inequalities in learning opportunities. In particular, students from low-income households or rural areas with limited access to Wi-Fi are at a relative disadvantage in terms of digital infrastructure. According to Bo (2024), strong connectivity and sufficient distribution of digital devices are essential components of ICT infrastructure. For example, Korea allows students to access public Wi-Fi for free, and Brazil and Japan have improved access to digital learning through regular surveys of ICT infrastructure. These kinds of national investments also enhance the sustainability of lifelong education. By expanding learning opportunities regardless of time and place, they ultimately strengthen learners' self-directed learning and capacity development in a positive direction. As the OECD (2020) notes, targeted investments in digital infrastructure, especially in underserved areas, significantly reduce educational disparities and improve equitable access to learning. These investments not only improve access to digital learning tools for students in rural and underserved communities, but also foster equity, self-regulated learning, and broader participation in lifelong learning.

2. Teacher Professional Development

Professional development for teachers in digital learning environments is emerging as a key challenge. As new educational projects continue to emerge, not only students but also teachers must adapt quickly to the changing digital landscape and acquire the necessary technical and pedagogical skills. Recent research suggests that in order to improve the effectiveness of online instruction, teachers need instructional design skills for developing digital content and learning activities, as well as platform navigation abilities to operate Learning Management Systems (LMS) smoothly. In addition, engagement strategies to foster learner participation in online settings and assessment competencies for applying appropriate tools and feedback are also considered essential components of teacher expertise (Baran et al., 2011; Bawane & Spector, 2009). Indeed, without proper training and continuous support, even experienced educators may struggle to deliver effective online instruction, resulting in reduced student engagement and learning outcomes (Rafiq et al, 2024). This highlights the need for institutional investments in targeted training programs and professional learning communities that equip teachers with the evolving digital pedagogical competencies.

3. Fostering social and emotional presence in digital learning environments

In digital settings, where physical presence is limited, emotional support and real-time communication with teachers and peers can be more important. The lack of interaction can lead to feelings of isolation, making it difficult for learners to stay motivated and engaged. A study by Banna et al. suggests that in technology-driven online classrooms, a lack of human interaction between teachers and students can increase ‘transactional distance,’ thereby diminishing learners’ sense of belonging and

engagement. Bo (2024) also noted that excessive reliance on technology can reduce social presence and human connectedness, negatively affecting learning outcomes and teacher-student relationships (p.288). Learning environments that go beyond simple technology adoption and consider emotional bonds and social presence play a critical role in ensuring the sustainability of digital learning and enhancing learner engagement and achievement.

4. Designing immersive digital learning with flow theory

Csikszentmihalyi (1990) explains that optimal learning occurs when tasks match the learner's skill level and provide clear goals and feedback. In fact, digital learning environments are well suited to implement such conditions, as they make it easier to adjust task difficulty and provide immediate feedback, enabling learners to become immersed and focused. However, the existing Open edX system has been criticized for its limitations. It can analyze individual course data but lacks the capacity for cross-course analytics or detailed real-time tracking and comparison of individual learner performance (Zabala et al., 2025). To foster true immersion and engagement, future digital learning platforms must be equipped with sophisticated features that can present level-appropriate tasks and offer personalized feedback in order to foster learner immersion.

This study emphasizes that implementing effective and sustainable digital education requires a comprehensive and strategic approach that goes beyond the mere adoption of technology. To fully realize the potential of digital education, it is essential to adopt a multifaceted strategy that includes robust technological infrastructure, teacher capacity

development, learner-centered instructional design, and the integration of emotional and social interaction.

While the expansion of ICT infrastructure and national-level investment such as Spain's UniDigital project has laid the groundwork for improved access and engagement, true educational transformation depends on a comprehensive strategy. Specifically, teacher professional development in instructional design, platform navigation, online engagement strategies, and assessment is essential to maximizing learning outcomes in virtual environments (Baran et al., 2011; Bo, 2024). Moreover, the findings underscore the importance of maintaining human interaction in online learning spaces. The lack of social presence and increasing transactional distance may hinder learners' sense of belonging and participation (Banna et al., 2015; Bo, 2024). Therefore, digital learning environments should be designed to not only deliver content efficiently, but also to foster emotional connection and real-time feedback, which in turn enhance learner motivation and engagement (Csikszentmihalyi, 1990; Zabala et al., 2024).

As digital education continues to evolve, future initiatives must focus on building learner-centered, adaptive systems that support lifelong learning across diverse populations. Policies that bridge the digital divide and promote inclusive access, alongside scalable pedagogical innovations, will be critical to ensuring educational equity and quality in the digital age. Regardless of its form, education has now moved beyond traditional face-to-face instruction, evolving into an era where digital tools are integrated into various learning environments. Rather than focusing solely on the potential limitations of this shift, it is imperative to direct our attention toward maximizing the effectiveness of digital-based learning. By acknowledging the challenges while

proactively seeking strategies to enhance engagement, personalization, and accessibility, we can fully harness the potential of digital education for diverse learners in the 21st century.

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The Global AI Race: Advancing AI Literacy

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Abstract

This paper examines global approaches to Artificial Intelligence (AI) literacy, with a focus on China, India, the United States, and Russia. Each country has launched explicit plans to integrate AI education across K–12, higher education, workforce development, and public awareness. China and Russia pursue highly centralized strategies with strong state-led implementation, while India and the U.S. combine national direction with local or state-level execution. India stands out for embedding AI in the CBSE curriculum and public campaigns, while the U.S. emphasizes federal guidance, university fluency programs, and workforce readiness. This session proposes a U.S. course correction: setting measurable literacy goals, expanding teacher training, and launching nationwide public micro-learning opportunities. The presentation highlights comparative strengths, gaps, and pathways to establish U.S. leadership in AI literacy

Keywords: Artificial Intelligence (AI), AI Literacy, China, Russia, India, United States

Introduction

Artificial intelligence (AI) has evolved from a specialized research field into a pervasive, general-purpose technology that now drives innovation across various sectors, including education, healthcare, finance, logistics, the creative industries, and national defense. As models grow more capable and accessible, citizens encounter AI as users, workers, voters, patients, creators, and regulators. This ubiquity elevates a new public good: AI literacy. Similar to the role that statistical literacy plays in a data-rich society, AI literacy equips individuals and organizations to understand, critique, and responsibly leverage AI systems. Without it, communities risk widening digital divides, uncritical adoption, security exposure, and policy decisions that lag technical reality (NIST, 2023; U.S. Department of Education, 2023).

Despite AI's rapid integration into daily life, AI literacy remains uneven across nations and demographics. Without deliberate, inclusive strategies, this gap risks widening economic, civic, and educational inequalities.

AI literacy matters now because capability frontiers continue to advance while guardrails - standards, policy, and social norms - develop at uneven speeds across jurisdictions. The result is a moving target: the benefits of productivity and discovery sit alongside risks, including bias, erosion of privacy, disinformation, labor dislocation, and over-reliance on opaque systems. Countries that systematically invest in AI literacy gain not only economic advantages but also institutional resilience and democratic capacity for oversight. This paper defines AI literacy, explains its importance, situates it within the global AI landscape, surveys trends in China, India, the United States, and Russia, and proposes a multi-sector, lifespan strategy spanning K–12, higher education, workforce

development, and public awareness. It closes with a call to action and an agenda for future research.

AI Literacy Definition

For this paper, *AI literacy* refers to the knowledge, skills, and dispositions that enable individuals to understand, evaluate, and responsibly engage with AI systems across educational, professional, and civic contexts (NIST, 2023; OECD, 2019/2024). It includes four interrelated dimensions:

- Technical – understanding how AI systems function.
- Evaluative – critically assessing AI tools and their outputs.
- Practical – applying and managing AI responsibly in teaching, research, and operations; and
- Ethical – recognizing and mitigating bias, ensuring transparency, and upholding accountability (Kassorla et al., 2024).

These dimensions, adapted from Kassorla's *AI Literacy in Teaching and Learning (ALTL)* framework, form the foundation for the broader societal model advanced in this paper.

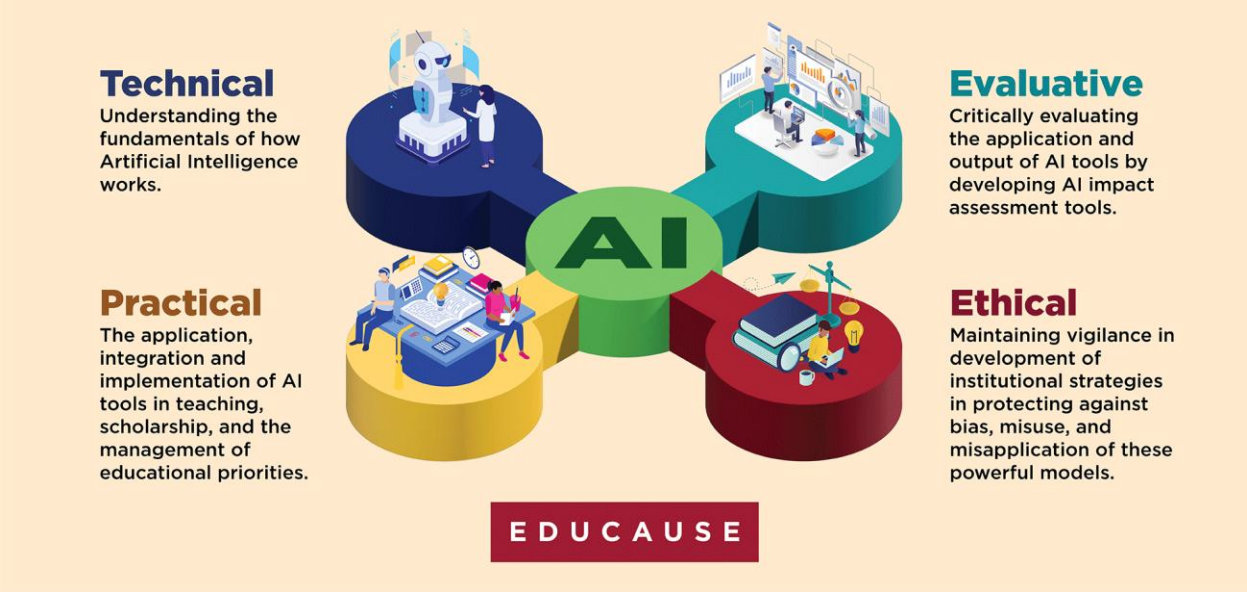

Figure 1. AI Literacy in Teaching and Learning Framework (Kassorla, 2024).

Building upon this educational framework, the present study extends AI literacy beyond the classroom to include civic and professional competencies such as risk assessment, data stewardship, human-in-the-loop design, and policy evaluation - anchoring literacy in national frameworks like National Institute of Standards and Technology (NIST) AI Risk Management Framework (RMF) 1.0 and the Organization for Economic Co-operation and Development (OECD) AI Principles. Operationally, organizations can anchor AI literacy with established governance and ethical frameworks. The NIST AI RMF 1.0 articulates governance, mapping, measurement, and management functions, providing vocabulary for risk identification, evaluation, and mitigation, and encouraging context-appropriate controls (NIST, 2023). The OECD AI Principles frame trustworthy AI around inclusive growth, human-centered values, transparency, robustness, and accountability (OECD, 2019/2024). Education-specific guidance from the U.S. Department of Education (2023) and UNESCO (2021) extends

these standards to classrooms, focusing on age-appropriate competencies, teacher support, and integration across subjects.

Collectively, these frameworks provide the **institutional scaffolding** for developing AI literacy at scale, linking the conceptual definition (Figure 1) to practical governance and educational policy.

Importance of AI Literacy

AI literacy enhances productivity and responsible innovation at every level personal, organizational, and societal by enabling people to automate repetitive tasks, critique AI outputs, and collaborate safely with intelligent systems. It strengthens digital judgment, recognizing synthetic media, questioning sources, and validating claims, thereby countering misinformation. Surveys suggest that a sizable share of teachers feel underprepared to integrate AI responsibly into instruction—for instance, 69% of U.S. teachers report having received minimal formal AI training (Fitzpatrick, 2025). It also supports privacy-preserving habits, secure data handling, and awareness of model limitations (e.g., hallucination, non-determinism).

At the organizational level, it accelerates responsible adoption by clarifying roles (e.g., product owners vs. risk owners), simplifying procurement due diligence, and embedding evaluation and monitoring into the development lifecycle (NIST, 2023).

At the societal level, AI literacy is foundational to democratic governance of powerful technologies. Publics that understand trade-offs can deliberate about surveillance, biometric systems, content moderation, and the automation of critical infrastructure. Policymakers can then calibrate incentives and accountability regimes more effectively. Finally, AI literacy enhances institutional resilience: during crises—such

as natural disasters, pandemics, or cyber incidents—literate institutions can both deploy AI tools and anticipate cascading risks, thereby minimizing harm while preserving human agency (OECD, 2019/2024; U.S. Department of Education, 2023).

The global race for AI literacy is underway among the United States, China, India, and Russia, driven by essential economic factors that fuel competitiveness and dominance.

Global AI Race

Discussion of an AI “race” typically centers on computing capacity, model performance, and capital investment. Yet the decisive variable may prove to be human capability diffusion—how quickly and equitably a society builds AI literacy across its population and institutions. Below, six domains illustrate why literacy is a strategic lever alongside hardware, data, and algorithms: economic competitiveness, industry dominance, national security, innovation ecosystems, geopolitical influence, and environmental impact (Geenens, 2025).

Economic Competitiveness

AI-enabled productivity growth will depend on complementary human capital. Firms that pair process redesign and skills upgrading with AI tools achieve outsized gains, while those that merely “bolt on” AI see limited returns. McKinsey estimates that generative AI could add trillions of dollars in value globally, but capture depends on workforce re-skilling and re-bundling of tasks (McKinsey, 2023). AI literacy accelerates diffusion by reducing experimentation costs, enhancing prompt engineering quality, and enabling frontline workers to assess outputs against domain-specific constraints.

Industry Dominance

Industry leadership emerges where sectors convert research breakthroughs into robust, regulated products. AI-literate professionals in healthcare, finance, manufacturing, and media can identify feasible use cases, navigate regulatory boundaries, and design appropriate controls (e.g., human review for high-risk decisions). Nations that scale sector-specific literacy—such as clinical AI competency for clinicians, responsible ML operations for fintech, or safety-first autonomy for mobility—gain defensible advantages that are hard to replicate quickly.

National Security

AI reshapes intelligence, cyber operations, logistics, and defense industrial bases. Literacy enables both adoption (e.g., rapid decision support) and defense (e.g., counter-disinformation, model security, supply-chain risk management). Military and civil-defense organizations need cadres who can evaluate model reliability, adversarial robustness, and mission suitability, while ensuring compliance with law of armed conflict and democratic oversight. As states rush to deploy AI, the security externalities of low literacy—such as accidental escalation, brittle autonomy, or mis-calibrated trust—grow (OECD, 2019/2024).

Innovation Ecosystems

Innovation ecosystems flourish when entrepreneurs, researchers, regulators, and customers share mental models. Literacy lowers transaction costs among these actors; it fosters shared taxonomies (e.g., data lineage, evaluation metrics), making collaborations faster and safer. Universities that blend AI fluency with entrepreneurship

and translational research help local clusters move from prototypes to production. Public funding tied to training and open evaluation resources (datasets, benchmarks) can catalyze inclusive innovation while avoiding lock-in.

Geopolitical Influence

Countries shape global norms when their domestic institutions exemplify trustworthy AI and when their diplomats can negotiate technical standards, safety evaluations, and export controls. AI-literate civil servants and regulators are essential to participate credibly in standard-setting bodies and plurilateral initiatives. Literacy also supports digital diplomacy—countering influence operations and communicating complex policy choices to international audiences (OECD, 2019/2024).

Environmental Impact

Training and running large models can be energy-intensive, and AI can also enable significant efficiency gains in buildings, grids, agriculture, and logistics. Literacy is required to measure lifecycle impacts, select architectures and deployment patterns responsibly, and weigh trade-offs between capability and footprint. Without literacy, organizations may over-provision compute or overlook opportunities for edge-AI efficiency and carbon-aware scheduling (OECD, 2019/2024).

Global Trends in AI Literacy

This section surveys AI-literacy trends across China, India, the United States, and Russia. It emphasizes education initiatives, workforce programs, policy signals, and institutional capacities, recognizing that each country is internally diverse and dynamic.

China

China's central and provincial governments have invested heavily in AI education and talent pipelines aligned with industrial policy. Curricula emphasizing coding, robotics, and data science are being introduced in primary and secondary schools in major cities, complemented by "smart education" platforms (The Take, 2025) (Reuters, 2025). University programs are expanding machine-learning and applied AI tracks, and national plans are highlighting AI instructors and digital resources. Workforce upskilling is tied to manufacturing modernization and platform-economy services. Governance emphasizes state oversight, content controls, and security compliance, shaping how literacy is taught and applied in practice. These efforts support the rapid diffusion of AI in e-commerce, fintech, logistics, and public services, although the ongoing trade-offs of open scientific collaboration and academic freedom constraints remain (OECD, 2019/2024).

India

India pursues an inclusion-first strategy to leverage its large and youthful population. National initiatives encourage AI-for-All awareness modules, foundational data and coding skills in schools, and public digital infrastructure that lowers participation costs. Universities expand AI and data-science seats, while skilling programs target SMEs and government services. India's IT services sector acts as a capability multiplier by training global workforces on applied AI. A strong emphasis on multilingual access, mobile-first microlearning, and public–private partnerships reducing literacy gaps across regions (OECD, 2019/2024).

United States

The United States combines world-leading research universities and companies with a decentralized education system. Federal guidance is increasingly addressing AI in teaching and learning, safety, and civil rights. The U.S. Department of Education's 2023 report recommends educator-centered design, evaluation literacy, and professional development (U.S. Department of Education, 2023). NIST's AI RMF provides a cross-sector risk vocabulary (NIST, 2023). States and districts pilot K–12 AI modules; universities launch AI fluency programs for non-majors (e.g., journalism, law, and health) (EdWeek Market Brief, 2025) (Statehouse News Bureau, 2025). Workforce programs range from apprenticeships to rapid upskilling boot camps, while civil-society organizations and libraries expand public awareness. Challenges include uneven access, fragmented funding, and varied capacity across institutions.

Russia

Russia prioritizes strategic autonomy in digital infrastructure and advanced research in mathematics, physics, and security domains. University programs in applied mathematics and informatics remain strong, and defense-linked research institutions are exploring autonomy, cyber operations, and AI-enabled intelligence, surveillance, and reconnaissance (ISR). However, international sanctions and reduced scientific exchange limit access to computing, specialized hardware, and global research ecosystems, creating headwinds for the diffusion of broad-based literacy and commercialization outside state-linked sectors. Public literacy initiatives exist but are less visible internationally (OECD, 2019/2024).

The following table summarizes the comparison of each country.

Area of Analysis	China	India	United States	Russia
Education Initiatives	Coding, robotics, data science in K-12; smart education; expanding AI university programs	AI-for-All modules; foundational coding; multilingual, mobile-first micro-learning	Decentralized K-12 AI pilots; AI fluency university programs; federal guidance	Strong math/informatics in universities; public literacy less visible
Workforce Programs	Upskilling tied to manufacturing modernization and platform services	Skilling for SMEs and government; IT sector trains global workforce	Apprenticeships, boot camps; civil-society and libraries expand awareness	Defense-linked research; exploration of autonomy and AI-enabled ISR
Policy & Governance	State oversight, content controls, security compliance; national AI plans	Inclusive national initiatives; public digital infrastructure; public-private partnerships	U.S. Dept of Ed 2023 report; NIST AI RMF; varied state initiatives	Strategic autonomy focus; sanctions impact access to global ecosystems
Institutional Capacity / Challenges	Rapid AI diffusion; trade-offs with academic freedom and open collaboration	Large youth population; literacy gap reduction focus	World-leading research; challenges with uneven access and fragmented funding	Limited diffusion beyond state sectors; reduced collaboration and hardware access
National strategy mentions AI education/literacy	Yes – 2017 AI Development Plan	Yes – NITI Aayog Strategy + AI for All	Yes – White House actions + Dept of Ed guidance	Yes – 2019 AI Strategy, federal AI projects
K-12 integration	AI content in schools, university pilots	CBSE AI subject (Class 9+), inspire modules	Guidance emerging, varies by state	Digital AI lessons in schools, youth academies
Teacher training	Policy support, local rollouts	CBSE, Intel, IBM programs	Federal/state PD efforts, uneven	State-linked training programs

Public/at-scale awareness	State media, open courses	AI for All micro-course	Federal communication, university mandates	National 'Digital Lessons' campaigns
Higher-ed & workforce	Courses tied to domestic AI models	University & skills partnerships	NSF AI Institutes, AI fluency initiatives	Workforce upskilling targets, BRICS links
Ethics/safety framing	'Safe & controllable', sovereignty focus	'Responsible AI', constitutional values	Safe, equitable, transparent use	National interest emphasis

Table 1. Comparative Analysis of AI Literacy Across China, India, the United States, and Russia.

Comparative Snapshot

Across all four nations, AI literacy is now embedded within national strategies. China and Russia emphasize centralized planning and state delivery systems, while India and the United State**s** pursue national direction with regional implementation. India distinguishes itself through early K–12 integration and inclusive, multilingual access; China accelerates higher education expansion; the U.S. advances through decentralized innovation and federal guidance; and Russia links literacy to state interests and digital lesson campaigns. Ethical framing varies—from control and sovereignty to equity and responsibility.

Building AI Literacy Across the Lifespan

The global comparisons above demonstrate that lasting progress in AI literacy depends on policies that reach learners of all ages and professions. A comprehensive strategy links schools, universities, employers, and community institutions in a continuous ecosystem of capability building. Together, these levels cultivate technical

fluency, ethical awareness, and civic responsibility—the human foundations of a trustworthy AI society.

K–12 Education

Early education should foster curiosity about patterns, logic, and data. In the primary grades, students can explore cause-and-effect reasoning through games and story-based problem solving. By middle school, students can work with examples of how algorithms “learn,” experiment with fairness simulations, and discuss the concept of bias. High school students should progress to designing, documenting, and evaluating models while considering privacy, intellectual property, and environmental impact. Programs such as India’s *AI for All* demonstrate how short, modular lessons and mobile delivery can scale to millions of learners. Integrating these activities across civics, language arts, mathematics, and science connects technical understanding with ethical and societal reflection.

Higher Education

Universities should embed AI fluency across all disciplines, rather than confining it to computer science departments. Nursing students can study AI-assisted diagnostics; biology majors can use discovery tools for research; and law students can analyze AI in evidence and contracts. Institutions can also offer **micro-credentials** in responsible and transparent AI use, ensuring that graduates understand both the capabilities and limitations of these models. Assessment should combine practical artifacts—such as datasets, prompts, and evaluation plans—with a reflective analysis of bias, validity, and reliability. These practices cultivate graduates who can interpret, audit, and co-create AI systems in a responsible manner.

Workforce Development

In the workplace, AI literacy enables automation to become augmented. Employers can identify tasks that benefit from human-in-the-loop collaboration and train managers to recognize and mitigate algorithmic risks. Sector-specific credentials—such as *AI for Educators*, *AI for Compliance*, or *AI for Manufacturing*—help align skills with measurable outcomes like shorter cycle times or higher quality. Public–private partnerships can subsidize training for small enterprises and expand rural access. According to McKinsey (2023), firms that combine AI adoption with workforce reskilling achieve productivity gains two to three times greater than those that rely solely on technology investments. Continuous upskilling ensures that workers remain adaptable as AI reshapes every profession.

Public Awareness

Beyond formal education and employment, public literacy is a key anchor of democratic resilience. Libraries, museums, and community colleges can host brief workshops and demonstrations that demystify AI and teach people how to evaluate sources, detect synthetic media, and safeguard personal data. Media campaigns should highlight individual rights and avenues of recourse—how to contest algorithmic decisions, demand transparency, and recognize misinformation. **Community partnerships** between civic groups, local governments, and broadcasters can reach diverse populations through accessible, multilingual content. Informed citizens become critical consumers and constructive participants in shaping AI policy and practice.

Integrating the Four Domains

Together, these domains form a lifespan continuum of AI literacy, encompassing curiosity and ethical reasoning in youth, critical evaluation and transparency in higher education, responsible application and innovation in the workforce, and civic participation across society. This continuum ensures that nations do not merely deploy advanced technologies but cultivate the human judgment required to govern them wisely. Building such an ecosystem transforms AI literacy from a technical skill set into a shared civic competency—one that sustains innovation, equity, and accountability in the global AI era.

Approaches and Implementation

Effective approaches share four traits: (a) alignment to recognized frameworks (NIST AI RMF, OECD Principles), (b) explicit attention to equity and access, (c) embedded evaluation and measurement, and (d) continuous updating.

- Curriculum integration: Rather than stand-alone electives, embed AI concepts across subjects; use project-based learning with real datasets and community problems.
- Practice and reflection: Require students and workers to keep “AI lab notebooks” documenting prompts, data lineage, model settings, and evaluation—supporting reproducibility and transfer learning.
- Governance-by-design: Institutions should maintain model inventories, data protection impact assessments, and incident response playbooks; literacy programs should train stakeholders on these artifacts.

- Open evaluation culture: Encourage participation in public benchmarks, red-teaming exercises, and shared evaluation hubs; teach error analysis and calibration as core competencies (NIST, 2023).

Federal Guidance, University Fluency Programs, and Workforce Readiness

Federal guidance is coalescing around safety, civil rights, and innovation. The U.S. Department of Education (2023) advocates for educator-centered, assistive uses of AI and cautions against the use of automated surveillance and high-stakes decisions without human oversight. NIST's AI Risk Management Framework (RMF) (2023) provides a foundation for procurement and governance. Universities are responding with campus-wide "AI fluency" programs for students, faculty, and staff—often pairing short modules with discipline-specific labs. Employers report that "AI-capable" job descriptions increasingly emphasize evaluation literacy, privacy and security basics, and collaboration workflows over narrow tool familiarity. Readiness improves when policy, curricula, and employer demand are synchronized through regional talent alliances and shared credential frameworks (OECD, 2019/2024; NIST, 2023).

Call to Action

The next two years are decisive for translating aspiration into capacity. Two levers—teacher training and public micro-learning—can rapidly expand reach while institutions build longer-term programs. The decisive variable in the global AI race will not be computational power but human understanding. Building AI-literate citizens ensures that AI serves society, rather than the other way around.

Teacher Training

Educators are the multiplier. National and state systems should fund stackable micro credentials for pre-service and in-service teachers, anchored in classroom practice and student outcomes. Programs should include: (a) AI-assisted lesson planning with disclosure and documentation; (b) formative assessment with human-review safeguards; (c) student data protection and IP literacy; (d) critical media literacy (detecting synthetic media and evaluating sources); and (e) project-based modules aligned to local community needs. Teacher communities of practice can propagate exemplars, and districts can adopt model policies that protect teacher professional judgment while allowing innovation (U.S. Department of Education, 2023).

Launching Nationwide Public Micro-Learning

At the same time, a nationwide “AI for Everyone” initiative can raise public understanding within months rather than years. Delivered through mobile, broadcast, and community channels, short interactive modules—co-developed by universities, public broadcasters, and consumer-protection agencies—can teach citizens how to recognize synthetic media, evaluate claims, and use AI responsibly. Each module should be multilingual, accessible, and privacy-protective by design, with optional micro-badges to track learning progress.

Together, teacher professionalization and public micro-learning form complementary levers for democratizing AI literacy. Educators shape the next generation of informed users, while accessible public modules elevate the baseline understanding of all citizens. This dual strategy ensures that AI literacy expands not

only through institutions but across the everyday lives of people, creating a culture of competence, accountability, and shared stewardship of intelligent technologies.

Future Research Areas

Several research threads warrant priority to launch the U.S. to the forefront of this critical race. The following are the areas that require future research.:

1. Measurement science for AI literacy. Develop validated instruments to assess competencies across ages and professions; align with psychometrics for reliability and fairness.
2. Efficacy of instructional designs. Compare project-based, simulation-based, apprenticeship, and microlearning approaches across various contexts; identify cost-effective models for rural and under-resourced communities.
3. Evaluation and oversight literacy. Study how non-technical professionals (judges, clinicians, teachers, auditors) learn to evaluate AI systems; design artifacts and workflows that enable rigorous human-in-the-loop oversight.
4. Labor market dynamics. Track how task composition changes across occupations, identify reskilling pathways and support for displaced workers, and quantify productivity complements versus substitution effects.
5. Environmental accounting. Standardize lifecycle energy and water metrics for AI systems; test interventions (model compression, retrieval-augmented generation, and carbon-aware scheduling) to assess their real-world impact.
6. Civic resilience. Examine interventions that strengthen resistance to AI-driven manipulation—media-literacy curricula, platform design choices, and community fact-checking ecosystems.

7. International comparisons. Build comparable datasets on literacy policies, curricula, participation rates, and outcomes across countries to illuminate what works and under what conditions.

Sustained investment in these areas will enable evidence-based policy and program design, improving equity, safety, and opportunity.

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