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Charting the Future: A Research Agenda for AI in Education

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AI applications are currently proliferating in the educational landscape, but research regarding effects on teaching and learning is proceeding at a much slower pace. In this paper, a call for a broadscale AI in education research agenda is proposed, one that incorporates the best of lessons learned regarding waves of new information technologies introduced into education over the past 50 years, but also with a particular eye toward the systematic study of the tremendous benefits as well as possible dangers to our society that could result with the unchecked explosion of this new emerging technology. The authors propose to 'fast track' research by simultaneously looking through the lens of qualitative, quantitative, and mixed methods research paradigms in a coordinated fashion, while also recognizing that systems being studied will be rapidly evolving in a design-based research evolutionary cycle. The authors contend that the highest priority for research on AI in education should be focused on effectiveness for improving human learning.

INTRODUCTION

Historical Context

Almost 70 years have passed since the term Artificial Intelligence (AI) was officially coined at a Dartmouth College conference in 1956 (Moor, 2006). Since then, AI has had many definitions that have evolved over time. Most definitions in the 20th Century centered around computer algorithm accomplishments that were previously thought to be possible only by humans (speech recognition, etc.). However, in the 1990s, when feats such as IBM's Big Blue computer defeat of the world chess champion (Kasparov) began to take place (Greenemeier, 2017), our society was faced with the prospect of finding a new definition that allowed for AI to exceed the capacity of humans in selected areas. This paper will focus on the type of AI most commonly used in education, which is generative AI. This type of AI can create novel output in text, images or other media based on user prompts, using a Large Language Model (LLM) algorithm to find patterns in the data set upon which the particular system (ChatGPT, Claude, etc.) was trained (Bommasani et al., 2021; National Library of Medicine, 2024).

Within the realm of education, a conceptually simple definition for AI is proposed as being sufficient for charting a research agenda: "AI is the process of computers learning and making decisions" (Ottenbreit-Leftwich, 2025). Based on this definition, we can consider AI to be a new educational technology tool that is a) capable of learning and b) able to make decisions. This definition closely aligns AI with topics at the core of education, specifically learning (a desirable outcome for students) and making appropriate decisions (a desirable pedagogical behavior for teachers).

In the early 21st Century, educational researchers advocated for a US national research agenda for educational technology (Roblyer & Knezek, 2003). This initiative proposed three categories of research studies that could produce credible evidence of "returns on learning" of educational technology investments at the federal, state, and local levels. The types of proposed research studies were:

- Research to establish relative advantage
- Research to improve technology implementation methods
- Studies that monitor and report on current technology uses to help us shape desired directions (Roblyer & Knezek, 2003)

The overarching focus advocated by Roblyer and Knezek (2003) was to conduct research to provide a sound rationale for technology use.

One issue regarding rationale was whether the efforts required to implement educational technologies in teaching/learning environments produced returns (learning enhancements) that were worth the tremendous investment. Another issue was whether implementing educational technologies in teaching/learning environments made possible new forms and new heights of learning that would not be possible without the emerging technologies. These guiding principles can be applied to focusing research on AI in education during the second quarter of the 21st Century.

As in 2003, the integration and implementation of technology in education during the 2nd quarter of the 21st Century continues to include multiple stakeholders such as classroom teachers, learning leaders (e.g., instructional coaches, curriculum directors), teacher educators and educational researchers – as well as policymakers, school administrators, and industry leaders. New research that focuses on AI in education needs to include views from multiple levels of education and society.

For the purposes of developing a robust research agenda, we can expand the initial categories of relative advantage, improvement of implementation methods and monitoring and reporting to shape desired directions, to focus on additional principles for research on AI in education, due to the growing ubiquitous nature of access and constantly changing landscape of AI as well as an evolving society. The additional principles might include:

- Empowering teacher agency,
- Creating a focus on equity,
- Exploring adaptability of tools, and
- Requiring accountability

Research should center on the teacher and learner voices (agency) as the goal of a research agenda for AI in education. Equity is a critical principle to ensure all voices are heard and the research design is created with inclusion in mind. Because AI is a dynamic technology environment, research designs must include the ability to be adaptable, embracing the change and uncertainty that will continue to exist. Finally, accountability is often not included in a research design, although it is critical for holding stakeholders/systems responsible for ethical use and reporting.

Proactively Focusing on Effectiveness of AI

In the past, a new technology was often held out of use in education until credible research studies resulted in guidelines and recommendations for

use, including audiences, prospective benefits, and concerns. However, the rapid expansion of smartphones is a recent example where adoption was expanded into education without rigorous study. We are now realizing it could be much more harmful for children than anticipated, and we are now trying to "put the toothpaste back in the tube". With the rapid advancement of AI technologies and their availability to the masses, there is an urgency to determine how and in what ways AI might be used to promote positive benefits in and out of the classroom. Creating a research agenda that includes the ethical, pedagogical, and policy implications is essential.

Previous research on AI in education may not be focused in the right direction. Research findings to date appear to have an overemphasis on administrative and technical effectiveness and an underrepresentation of pedagogical and humanistic pros and cons (Zawacki-Richter et al., 2019). For example, in a systematic review of 146 AI in education articles published between 2007 and 2018, Zawacki-Richter et al. (2019) found that more than half focused on institutional goals and administration, while only a few focused on student collaborative learning, and very few focused on the teacher's perspective. The authors concluded that "We should not strive for what is technically possible, but always ask ourselves what makes pedagogical sense" (p. 21).

However, some findings (pro and con) based on humanistic and/or pedagogical perspectives are beginning to emerge. For example, a four-week study from MIT Media Lab examining interactions with Chatbots designed to provide social experiences, such as being your friend, found that loneliness was actually higher among users who developed a greater dependence on the AI systems (Fang et al., 2025). On the other hand, a randomized subject assignment, true experiment conducted at Dartmouth Medical School using a Chatbot constructed in-house, found that AI-based psychotherapy produced mental health improvements comparable to traditional face-to-face therapy sessions with a human counselor and was well-received by the study participants (Heinz et al., 2025). It seems clear that the prospective affordances as well as the potential dangers of generative AI need to be thoroughly researched. In the words of Jon Dron:

> *Interacting with AI changes us—it's inevitable. If you spend a lot of time with generative AI, it shapes your ways of thinking and being, just like any learning experience. It's human-like but not truly human, and that's where the risk lies*. (Jon Dron, in Panke, 2024, np)

The Rapidly Changing Landscape of AI in Education

A continually increasing number of AI tools are also expanding the environment of AI in education. Personalized learning systems, generative AI chatbots, AI tutors, data dashboards, and grading assistants are just a few of the tools being touted for their use in education (Holmes et al., 2019; Zawacki-Richter et al., 2019). What is unknown is the extent to which they support or improve the learning landscape. Furthermore, and especially relevant to the focus of this paper, the type of AI system being evaluated may dictate the type of methodology needed, as AI systems and their purposes and uses can vary to a great extent. Additional issues to be considered in the expanding realm of "black box" AI technology for education include equity, bias, ethics, transparency, and teacher preparedness.

CREATING A RESEARCH AGENDA

The main goal in charting a research agenda for AI in education is to assess the effectiveness of AI-powered tools and interventions in support of student learning. Another important goal is assessment of the impact on critical thinking skills and creative expression when students use AI tools. Both goals are little studied to date, but important as AI applications will likely be a top educational technology issue for the next 20 years (Zawacki-Richter et al., 2019). The following sections will address areas in which AI in education research agendas could readily be focused. These areas include professional development/teacher preparation, pedagogical opportunities, ethical considerations, human-AI collaboration, and school leadership.

Professional Development and Teacher Preparation

Preparing teachers for the continuous changes in education is an ongoing endeavor. From preservice teachers to seasoned educators, when considering what pedagogical, technological, and content expertise is needed, the goal is the same – preparing students to thrive in the world in which they will live in the future. Generative AI is a newer and invasive "tool" that requires proactive actions to support student learning in a safe and equitable environment.

Teachers adopt educational technology tools when the tools support a vision for high-quality learning, including equity for their students. We can learn from past research on teacher adoption and integration of technology

when designing research on how to best prepare teachers for AI implementation (Ertmer & Ottenbreit-Leftwich, 2010). Oftentimes, the sequence in adopting these tools begins with teachers initially using AI tools for their own use, either personally or to support their teaching (Hughes, 2005). Conceivably, there are ways to use AI to support the personalized professional development needed to use AI tools for teachers at different levels of implementation. Rather than focusing on efficiency metrics alone, it is most important to support teachers who are at the heart of educational transformation (Mishra et al., 2025). Rather than concentrating on AI literacy as a technical skill, it is important to focus more on fostering "a critical and cautious understanding of the pedagogical, ethical, and societal implications of these technologies" (Mishra et al., 2025).

What are the broader competencies that will be needed to model for students and teach using AI systems and tools? Noteworthy areas of focus could include examining teacher attitudes toward AI, perceived benefits, concerns, and AI's impact on teacher roles and autonomy. Research studies are needed to capture how teachers integrate AI into their pedagogical practices and how AI influences teachers' professional identity.

New Pedagogical Opportunities

An ultimate goal should be to guide the integration of generative AI in education through a clear focus on authentic pedagogical needs and a deep commitment to supporting the growth of all learners—rather than allowing it to be shaped by unchecked technological enthusiasm or commercial agendas (Mishra et al., 2025). Studies should be aimed at how AI tools can support critical thinking, creativity, and student motivation—not just test scores. Research studies should analyze whether AI enhances personalized learning or narrows pedagogical approaches. Some areas to consider are whether AI supports inquiry-based, constructivist, and culturally responsive pedagogies as opposed to traditional teaching methods. Another important consideration is the role the teacher plays in shaping the environment that considers whether AI is used as only a tool or also as a co-collaborator in designing and implementing instruction.

Ethical Considerations

Research is needed to investigate how AI impacts various student populations, including students with disabilities, multilingual learners, and those

from underrepresented backgrounds. Research should attend to the ethical deployment of AI in diverse classrooms and the impact on different populations (Zawacki-Richter et al., 2019). Other considerations should include assessment of the risk of exacerbating digital divides that exist in using technology in education. AI systems and tools must be inspectable, explainable, and provide human alternatives to AI-based suggestions; educators will need support to exercise professional judgment and override AI models when incorrect information or recommendations are being conveyed.

Human-AI Collaboration

In *Co-Intelligence* (Mollick, 2024), users are encouraged to engage with AI as a co-worker, co-teacher, and coach using AI's enormous power without losing our identity. As AI develops into a more interactive technology, there will likely be research methods that utilize this dynamic nature of AI as a partner in research as well as in designing instruction (Baker, 2016; Luckin et al., 2022). It will be valuable for research to determine the impact of having AI as a research partner, as well as researching the pros and cons of having educators co-construct knowledge and pedagogical practices with AI tools. This could lead to a deeper understanding of the importance of maintaining the human input along with AI information. Research can help to determine the boundaries of teacher autonomy in AI-augmented decision-making.

School Leadership

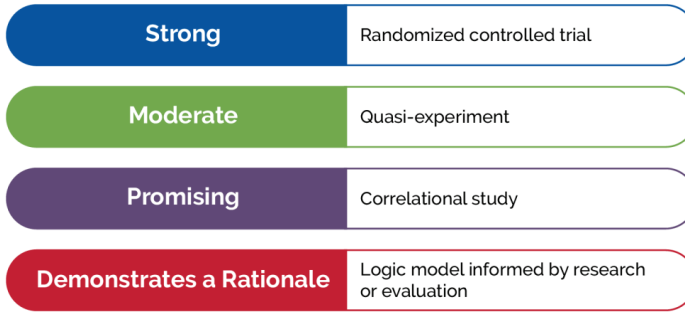
It is critical to understand what institutional supports (e.g., training, resources, governance) are needed for effective AI use. Studies to evaluate whether AI investments yield meaningful educational returns compared to alternative innovations already in place in the schools are needed (Zawacki-Richter et al., 2019). How should learning leaders assess and select AI tools? Scholars agree it is important to include multiple stakeholders, including teachers, parents, and even students, if age-appropriate, in determining the guidelines and safeguards for AI use in education (Luckin et al., 2022).

RESEARCH METHODOLOGIES AND DESIGNS

What types of research studies are needed to determine the impact of AI in education? In the US Department of Education's recent policy regarding AI in education, there is a call for evidence of effectiveness (US Dept. of Ed, 2023). The policy recommends that AI-enhanced technology should meet the previously established Elementary and Secondary Education Act (ESEA)'s four levels of research-based evidence, ranging from a logic model to strong evidence obtained through randomized controlled trials (Fig. 1).

Figure 1

The Elementary and Secondary Education Act (ESEA) defines four levels of evidence. (Source: US Dept. of Ed., 2023)



Note that randomized controlled trials (resulting in strong evidence) are often difficult to implement in K-12 education. While a range of study types are important, the most common type of study available for the classroom level is typically correlational or quasi-experimental. However, with a broader coordinated effort that may be supported by federal or private funding, collaboratives can seek to create randomized controlled trials that require a much larger and diverse sample size than is available for typical school systems. Large, rigorous studies may soon be feasible due to recent indications that future US federal funding will likely be focused on AI in education (Vesco, 2025). Research conducted in the Moderate and Strong Evidence categories of Figure 1 will certainly be needed to verify effectiveness and ensure the lack of severe negative side effects.

Synergies Among Traditional Research Designs

Which research designs best capture the sociotechnical realities of AI in education? Many approaches are promising in these early days of research on AI in education. The traditional categories of Qualitative, Quantitative, Mixed Methods (Creswell & Creswell, 2018) are proposed as a good starting point (Table 1). Note that each of these types of designs could be used to provide evidence of effectiveness at any of the four levels listed in Figure 1. However, it is most common for qualitative methods to be involved with rich explanations and theory building, while quantitative methods are typically employed to answer a specific research question (to what extent does the use of technology implementation X bring about a positive outcome in Y) with a randomized controlled trial. This type of true experiment seeks to eliminate the possibility that influences other than the targeted activity could have caused the desired outcome, and hence qualifies for the category of "Strong" evidence according to the US Dept. of Education (2023).

Table 1

Traditional Research Designs: A Starting Point for AI in Education

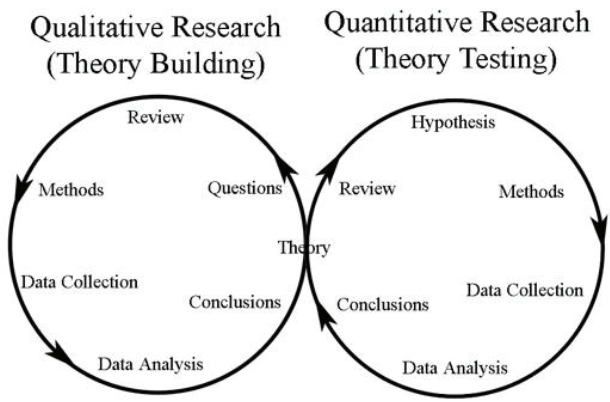
Type	Examples	Description
Quantitative	Experimental designs Non-experimental designs, such as surveys Longitudinal designs	Quantitative research is an approach for testing objective theories by examining the relationship among variables.
Qualitative	Narrative Research Phenomenology Grounded theory Ethnographic Case Study	Qualitative research is an approach that involves emerging questions and procedures in which data analysis is used to inductively build from particulars to general themes, with the researcher making interpretations of the meaning of the data.
Mixed Methods	Convergent Explanatory sequential Exploratory sequential Complex designs with embedded core designs	Mixed methods research is an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data using designs that may involve theoretical frameworks. The integration of qualitative and quantitative data yields additional insight beyond the information provided by either the quantitative or qualitative data alone.

Note. Adapted from Creswell & Creswell (2018), p. 60.

The guidance by Creswell & Creswell (2018) toward thinking about quantitative, qualitative, and mixed methods research is especially useful if the concept of theory building through qualitative methods, followed by theory testing through quantitative methods, is planned in advance to be implemented in a cyclic fashion (Colquitt & Zapata-Phelan, 2007). As shown in Figure 2, a researcher might begin on the qualitative side of the diagram by asking a question such as "Does AI as a time saver for teachers actually improve student learning?" and then conduct a literature review, choose a formal qualitative research method, collect some data (perhaps through interviews), analyze the findings and then develop a theory such as "Collaborative synergy: Assign to computers things that they are good at (things that require speed and/or repetition) and reserve for humans how to best convey to the next generation how to become a mature, productive human." Then the researcher would shift to the quantitative side of the Figure 2 diagram and review related quantitative research literature, develop and test a hypothesis, and draw some conclusions based on the results of data analysis. Typically, the results of any experiment will raise some unanswered questions, so the researcher might then return to the qualitative side of Figure 2, ask teachers more refined questions about time-saving aspects and how they envision their use of AI would improve student learning, and the cycle could repeat.

Figure 2

Synergistic prospects for theory building and theory testing using combinations of qualitative and quantitative research



Source: R.E. Schumacker, personal communication, August 29, 2025.

In some fields, the theory-building <> theory-testing cycle has historically been combined with grounded theory research (Wieland, 2012), the latter of which has the general goal of discovering or uncovering patterns or trends in data and developing or identifying (and testing) a theory that explains the observed phenomenon. Grounded theory research is an approach that may be especially appropriate for the rapidly expanding field of AI in education. An overview of grounded theory research and related research techniques is provided in the following paragraphs.

Prospects for the Future with Mixed Methods Research Designs

Grounded theory research is listed in Table 1 as a qualitative research methodology designed to develop theory that is grounded in systematically gathered and analyzed data (Birks & Mills, 2015). Rather than starting with a hypothesis, grounded theory begins with open-ended inquiry and builds theory inductively based on what emerges from the data. This approach is inductive, beginning without a preconceived theory or framework but instead identifying patterns, categories, and concepts directly from the data. The goal of grounded theory research is to build a more context-specific or generalized theory that explains how a social process or phenomenon works.

While researchers have historically classified grounded theory as a qualitative research design (Birks & Mills, 2015; Charmaz, 2012; Glaser & Strauss, 1967), some have recently pointed out that "Qualitative and quantitative data generation techniques can be used in a grounded theory study" (Chun Tie et al., 2019, p.1). Glaser (1998) himself pointed out that reflecting back to the late 1950s, "… grounded theory in large measure had its roots in quantitative methodology […] due to Glaser "… being trained in quantitative research, methodology, and theory generation at Columbia University" (p. 22), prior to collaborating with Strauss for the early seminal work on the topic (Glaser & Strauss, 1967). As we look forward to future research agendas, it is possible that grounded theory research could evolve to be considered as a mixed-methods research design, incorporating aspects of traditional qualitative and quantitative research techniques. Related methods, such as Data Mining (the practice of analyzing large databases to discover patterns and/or new knowledge from data) (Han et al., 2011), can also be couched within a mixed-methods framework centered around grounded theory. We contend that understanding the inductive-deductive process of grounded theory research, with the goal of finding out what Glaser (1998) called "what is actually going on" (p 21), is more important for guiding research on AI in education than attempting a precise classification of the technique.

Since grounded theory does not begin with a fixed hypothesis, it could be a good method for revealing unanticipated shifts in the impact of AI in education, such as subtle changes in teacher-student relationships. The ultimate goal is to generate a theory grounded in the actual words and actions of participants that explains how AI is reshaping teaching and learning practices in a specific context or across multiple settings. Example research questions for grounded theory research might include:

- How do teachers interpret their evolving role in classrooms using AI?
- In what ways do students perceive AI tools as influencing their learning motivation, privacy, or engagement?
- How does AI influence classroom power dynamics, collaboration, or differentiation?

Data sources for beginning the cycle of grounded theory research might include:

- In-depth interviews
- Classroom observations
- Survey data acquisitions
- Teacher and student journals
- AI tool use logs triangulated with participant narratives.

Grounded theory is often considered to be a good approach for research in a new domain, when little is known about a topic, existing theories do not adequately explain a phenomenon (Charmaz, 2006), or there is a need to focus on how people interact and are affected by things such as the integration of AI in education (Birks & Mills, 2015). Grounded theory research would appear to be particularly well-suited to exploring how AI impacts the learning environment because it allows researchers to generate theory from the ground up, based on rich, contextual data gathered directly from participants. For example, it could be used to develop a theory about how AI integration reshapes classroom dynamics, teacher practices, student learning experiences, and overall educational culture—rather than testing pre-existing assumptions.

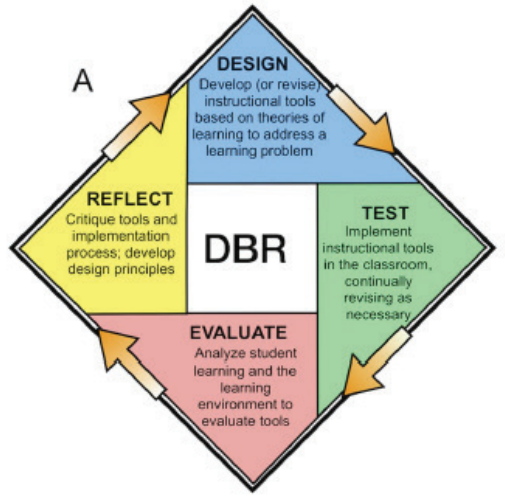
Grounded theory research also supports the identification of emerging patterns. By systematically coding and categorizing data (e.g., interviews, survey responses, classroom observations, reflection journals), researchers could identify recurring themes around agency, equity, trust, and pedagogical change. These organic findings could be used for hypothesis creation within the conceptual mixed methods cycle of theory building and theory testing, in the manner graphically displayed in Figure 2.

Conducting Research Within a Design-Based Research Technology Implementation Paradigm.

Since research on AI in education will typically be conducted in a teaching and learning environment, one can expect that research will often take place with learning-enhancement systems that are themselves in various stages of development and refinement (alpha, beta, ChatGPT v1, v2, v3, etc.). In this situation, an approach to be considered in conjunction with grounded theory research could be design-based research (DBR), more commonly implemented in educational technology arenas as educational design research (EDR) (McKenny & Reeves, 2013; 2018). In educational design research, the goal is multiple inputs and continual improvement using a cyclical process to refine the product and produce the desired learning outcome. The principles of design-based research from an educational psychology perspective (Sandoval & Bell, 2004) are graphically illustrated (Fig. 3) by Scott et al. (2020), based on specifications provided by Sandoval (2014). These widely-respected curriculum implementation steps are: 1) Design, 2) Test, 3) Evaluate, and 4) Reflect and repeat as needed.

Figure 3

Design-Based Research in a Curriculum Implementation Cycle



Source: Scott et al. (2020).

Advocacy for a combination of traditional research methods and analysis techniques when addressing AI in education (AIEd) is consistent with the recommendations of scholars in the field. For example, Zhang and Aslan (2021) concluded after their systematic review of 40 empirical studies in AIEd that:

> "… emerging methods like educational data mining, text mining, learning analytics, data visualizations are also imperative to advance AIEd research. In particular, emerging educational research methods, such as educational design research (EDR) (McKenney & Reeves, 2018), is highly recommended for research on innovative technologies like AIEd, because it empowers educators to incorporate their research inquiries as part of the technology development and implementation cycle in authentic settings. EDR can be particularly powerful when educators participate during the stages of AI technology creation, development or evaluations for educational purposes. (p. 8)

As AI in education implementations advance, so must the research on their effects on teaching and learning.

Formative assessments often guide continual improvements in a design-based research paradigm. As the name implies, the goal of formative assessment is to have users and/or outside observers provide constructive feedback for improving the educational intervention (CMU Eberly Center, 2025). Formative assessment has traditionally been used in educational technology implementations in the past, due to the feedback loops known to be critical to improving teaching and learning (Nu-Man & Porter, 2018). Zawacki-Richter et al. (2019) observed that AI-based systems used in a formative manner at the university level have been successful in informing personalized learning pathways for students, and that "[…] AI applications can perform assessment and evaluation tasks at very high accuracy and efficiency levels." (p. 17)

The formative assessment feedback loop can be contrasted with summative evaluation or assessment, which provides a final judgment regarding "does it work"? Summative evaluation is the type referred to in the first level of the US Department of Education evidence of effectiveness (Demonstrates a Rationale) in Figure 1.

For the foreseeable future, research on AI in education will likely be conducted on 'moving target' AI systems that are subject to frequent up-

grades and improvements. Failure to confirm positive learning outcomes during a specific research study could easily be the result of: a) a poorly designed AI system, or b) the assignment of a good system to a learning task for which the system is a poor match. Design-based research principles could go hand-in-hand with sound research-on-impact practices, in pursuit of the goal of demonstrating the effectiveness of a specific AI use in the education system. Note that here it is important to keep in mind that greater effectiveness is being defined as improved human learning.

Based on the perspectives conveyed in this section, both design-based research and formative evaluation techniques might also be viewed as fitting under the umbrella of a mixed-methods research design, in the situation where a project is focusing on the implementation of a new technology (AI) in education and assessment of its impact or outcomes.

ACHIEVING RESEARCH OUTCOMES AIMED AT IMPLEMENTATION

The Importance of Co-Design

The types of research designs and methodologies to consider for AI should be interdisciplinary and participatory. Involving educators and students in the co-design of research allows important voices to be included in the research design, which likely means it will be meaningful and useful for the participants as well as the researchers (Lin & Van Brummelen, 2021). The purpose of co-design would be to facilitate effective research that is relevant and accessible, while also resulting in the desired student outcomes, by having researchers work in partnership with teachers and schools.

Authentic research that is relevant to schools requires close collaboration between schools and universities. Some of the research that is most useful to teachers is best conducted in the classroom. It is important to ensure that research questions are relevant to the needs of schools, but are designed with clear safeguards for data privacy, not only in researcher data that are collected, but in data provided to AI systems. Creating a co-collaborative team in the initial stages of research that includes teachers, administrators, and researchers can help ensure that the research is carefully designed and safely implemented while providing useful information to the classroom teacher, enabling her/her to enhance learning with the studied technology implementations.

The principles that have been followed for human-computer interface design for decades (user interface of person communicating with a machine)

(Norman, 1983; 1988) can still apply to the new field of AI for enhanced learning, but careful attention needs to be paid to the human-computer interactions that occur with the AI engine of systems that are currently going online. Specifically, the typical "black box" nature of everything that a user does not directly interact with would appear to encourage distrust for AI in education environments. Outcomes from human-AI interactions can be studied through Rationale Demonstrating, Promising, Moderate, and Strong research designs as listed in Figure 1, while keeping a focus on the criterion for greater effectiveness, which is improved human learning.

Practical Realities: A Multi-dimensional Perspective

A report from the US National Technology Leadership Summit in 2005 began with *Identifying Key Research Issues* and reiterated that technology should not be the main point in educational technology research:

> The generic question, "Does technology improve learning?" is too broad to be answered in a meaningful way. The use of technology in each subject area needs to address the learning issues specific to that subject area. Therefore, the important research questions will be different for each subject area. *Learning with technology should not be about the technology itself but about the learning that can be facilitated through it.* Technology should provide an instructional method or learning environment that would not be possible through a non-technology method. We believe that technology can best be studied as an integrated part of the content area curriculum. We also believe that technology has a particular capacity to foster higher cognitive functions. (Knezek et al., 2006, p. 19)

The designer of a research study, and importantly the reader(s) of findings from the study, need to be able to identify the context within which a study was conducted, and acknowledge limitations that findings cannot automatically be expected to be relevant outside the confines of a single research study. Otherwise, inappropriate generalizations of findings may emerge, and the focus will likely be shifted to the technology rather than the specific conditions where the technology was found to produce the desirable outcome of enhanced learning.

Prospective Advantages

Twenty-first-century scholars (Dede, 2008; Kanaya et al., 2005) have pointed out that the key issue is not whether technology can work, but rather under what precise conditions and for which educational goals it works. For example, Dede (2008) has pointed out that the desired specificity to be reported for technology interventions that have been found to work should include frequency, intensity, and duration, similar to the way instructions on prescription medications are specified by medical doctors to assure a high probability of effectiveness.

The International Society for Technology in Education (ISTE) Center for Applied Research in Educational Technology (CARET) formulated some relevant answers to precise conditions toward the end of the 20th Century (Cradler, 2003). According to CARET, technology improves student learning when it:

- directly supports the curriculum objectives being assessed
- provides opportunities for student collaboration
- adjusts for student ability and prior experience, and provides feedback to the student and teacher about student performance or progress with the application
- is integrated into the typical instructional day
- provides opportunities for students to design and implement projects that extend the curriculum content being assessed by a particular standardized test
- is used in environments where teachers, the school community, and school and district administrators support the use of technology (Cradler, 2003).

Researchers have carefully made the case that we must demonstrate that technology's benefits outweigh potential negative aspects such as distractions from learning objectives, constraints on classroom interactions, as well as cost, including time and money.

While designing research to study AI in education, a top priority to consider is keeping humans in the loop and in control (Mollick, 2024; Zawacki-Richter et al., 2019), which includes focusing on the people engaged with assessments: students, teachers, school leaders, families/caregivers, and others who support learners. This concept is consistent with the criterion for effectiveness which is improved human learning.

Stakeholder-Specific Priorities

Clearly, not everyone has the same priority for assessing the use of AI in education. The main focus of this research agenda will include teachers, teacher educators, learning leaders, as well as educational researchers. Opportunities for research on AI in education exist across a wide range of stakeholders. How might each of these stakeholders benefit from a research agenda designed to provide feedback on their critical role in education?

- For classroom teachers, it is important to get feedback that improves learning for their students. This often involves classroom-level experimentation and action research.
- For teacher educators, there may be a need to redesign curriculum to include AI ethics, tools, and pedagogy. Teacher educators maintain a critical role in facilitating conversations about AI's impact on education and ensure they are prepared to provide these important guidelines.
- Learning leaders such as principals and curriculum designers may need to understand the impact of AI in education for strategic planning for both infrastructure as well as professional development of teachers. Learning leaders also have a spotlighted opportunity to guide conversations about equity and privacy related to the adoption of AI tools and the use of the data that may be shared.
- Educational researchers may be able to structure longitudinal studies of AI's impact on teaching and learning that also provide ongoing feedback to participants. Researchers have a unique opportunity to work across university programs such as computer science, education, and learning sciences.
- Policymakers are important stakeholders who often create the ability to create and enact guidelines and best practices across large segments of the education system.

HOW TO BEGIN RESEARCH ON AI IN EDUCATION? ASK GOOD QUESTIONS

Scholars over the decades have suggested that good research begins by asking good questions (Mertens, 2014; Wierszewski et al., 2022). Several important issues have emerged for key stakeholders, including teachers.

Simply focusing on AI and educators raises numerous questions, such as: 1) Can AI support teacher tasks to reduce the burden, or does it create new burdens that negate the potential benefits? 2) Can AI provide feedback to teachers regarding student strengths, allowing for more focused individual instruction? 3) Are teachers allowed agency and voice to choose what AI systems and tools they will use with their students, or yielding to decisions made for them? Many sources contend that transparency and responsible use must involve humans in the loop (Mollick, 2024) to ensure that educational values are prioritized. Table 2 contains a list of selected questions regarding AI in education that span the research goals (purposes) recommended in this paper.

Table 2

Sample Questions Worth Asking About AI in Education

Category	Question
Establishing relative advantage	Are teachers experiencing less burden and more ability to focus and effectively teach their students? How does AI impact learning outcomes and engagement in real classrooms?
Improving implementation methods	Should all teachers be expected to become comfortable with AI, or should we respect existing levels of discomfort and fears? Which existing AI tools have demonstrably improved student learning, and what can we learn from their implementation?
Shaping desired direction using data	Does AI impact motivation, creativity, and critical thinking? What unintended consequences have emerged from current AI deployments in education settings?
Empowering agency	Do teachers have a voice in determining how AI is used with their learners? How does AI influence teacher autonomy, identity, and practice?
Creating a focus on equity	Are the protections against surveillance adequate? Are diverse learners and in varied educational settings included? Does AI use reinforce or remediate existing inequities and biases?
Exploring adaptability of the tools	Does AI provide teachers with detailed insights into their students and their strengths? To what extent can educators customize AI tools to suit specific classroom goals or student needs?
Requiring accountability	As AI reduces one type of teaching burden, are additional workloads being assigned to teachers that negate the potential benefits of AI? What infrastructure and policies support effective AI integration?

Early Findings are Emerging

Like Rogers' (1995) Diffusion of Innovations Stages from Laggards to Early Adopters, we now see emerging categories of levels of acceptance for educators and adult students, ranging from Skeptics to Advocates based on perceptions-of-AI measures such as perceived benefits and ethical concerns (Kelly et al., 2023). Yet to be determined is whether these perceptions are permanent for educators (traits) or can be altered through professional development (states). Results from exploratory computational psychometric studies that derive these attributes, where the attributes can then be used to describe groups of educators, seem to have much in common with the principles described for grounded theory research in a previous segment of this paper. One detailed example is described in the following paragraphs to illustrate this point.

Categories of AI adopters were derived by Lacey (2025) based on the following four factors (or constructs):

1. Perceived Pedagogical Utility (e.g., "AI helps me tailor feedback"),
2. Operational Efficiency (e.g., "AI reduces time on routine tasks"),
3. Ethical & Reliability Concerns (e.g., "I worry about bias in AI output"), and
4. Professional Development Needs (e.g., "I need training to use AI effectively").

These four constructs were derived through exploratory factor analysis of a 57-item survey administered to 124 respondents, comprising 64 faculty members and 60 PhD students aged 18 to 65+.

Next, the scale scores for the participants on each of these four constructs were analyzed through a clustering technique to classify the participants into typologically common groups, based on participant ratings of low, medium, or high on each of the four constructs. The resulting clusters of respondents were:

Cluster 1: Skeptics. Consistently negative scores across almost all items. They register the highest levels of Ethical & Reliability Concerns.
Cluster 2: Cautious Adopters. Moderately negative on utility and efficiency items, yet far less extreme than Skeptics. They share many skeptics' concerns but at a subdued intensity, hinting at potential openness if reliability and bias issues are resolved.

Cluster 3: Pragmatists. Members neither reject nor champion AI; instead, they view it as useful in some contexts but not transformative.
Cluster 4: Enthusiasts. Mirror-opposite of Cluster 1, strongly agree that AI improves teaching effectiveness and workflow efficiency. Their expressed training needs are moderate rather than high, suggesting they already feel competent with AI tools.
(Adapted from Lacey, 2025, p. 6)

This derived continuum, which began with an analysis of 124 responses to 57 Likert-type items on a survey, appears to comply with the general goal of grounded theory research. That is, the process complies with the general goal of discovering or uncovering patterns or trends in data and developing or identifying (and testing) a theory that explains the observed phenomenon (Wieland, 2012).

Formulation of the theory testing stage in this example began when the current authors observed that the progression discovered by Lacey (2025) appears to be similar to the *Stages of Adoption of Technology* introduced by Christensen (2002), which was itself based on the earlier work of Russell (1995). In the 21st Century Stages of Adoption of Technology has also been confirmed as being aligned with the Concerns-Based Adoption Model Levels of Use (CBAM-LoU) (Hall, et al., 1975) and the Apple Classrooms of Tomorrow Teacher Stages (ACOT) (Dwyer, 1994) (Hancock, et al., 2007). The recognizable theoretical underpinning that could be said to encompass all of these technology proficiency development models is Diffusion of Innovations (Rogers, 1995). Diffusion of Innovations is proposed as being still relevant to the most current innovation of technology in education: AI.

Practical research on AI in education, based on the theoretical approach of Diffusion of Innovations, could begin by simply substituting "AI" for every occurrence of "technology" and "computer" in the late 20th Century Stages of Adoption of Technology instrument. This approach would appear to produce a rapid (< 3 minutes) self-classification tool for educators that would enable universities and/or K-12 schools to tailor AI in education professional development toward the specific needs of each educator group in a particular stage of development. The core of the derived instrument is shown in Table 3, and is offered as one possible place for those responsible for educator professional development in school systems to start.

Table 3

Stages of Adoption of AI in Education

Stage	Stage Description
Stage 1: Awareness	I am aware that AI exists, but have not used it - perhaps I'm even avoiding it. I am anxious about the prospect of using AI.
Stage 2: Learning the process.	I am currently trying to learn the basics. I am sometimes frustrated using AI. I lack confidence when using AI.
Stage 3: Understanding and application of the process	I am beginning to understand the process of using AI and can think of specific tasks in which it might be useful.
Stage 4: Familiarity and confidence	I am gaining a sense of confidence in using AI for specific tasks. I am starting to feel comfortable using AI.
Stage 5: Adaptation to other contexts	I think about AI as a tool to help me, and am no longer concerned about it. I can use AI in many applications and as an instructional aid.
Stage 6: Creative application to new contexts	I can apply what I know about AI in the classroom. I am able to use it as an instructional tool and integrate it into the curriculum.

Note. Adapted from Christensen (2002) Stages of Adoption of Technology.

CONCLUSIONS

AI is advancing exponentially, with powerful new AI features for generating images and text becoming available to the public, and leading to changes in how people create text and images, how humans communicate, and how students learn (US Dept. of Ed, 2023, p. 8). As AI advances, more users are finding ways to take advantage of its powerful features. To ensure it is implemented in an appropriate and ethical way, it is critical to build a shared vision for how research can support the use of AI in education in a way that addresses the recommended categories discussed in this paper. Including cross-role partnerships (e.g., design-based research teams) allows for more voices to be included in the decisions that are made regarding use in education. Those who provide institutional support should prioritize funding that addresses these concerns/issues. Researchers should embrace the opportunities for global collaboration and knowledge exchange.

One specific area that is important to study includes whether AI supports instruction in a way that improves quality without overburdening the teachers. Research needs to support the educators who have previously been and will always be central to meaningful educational change. Specifically,

research could immediately focus on whether AI can support educators in their day-to-day tasks (scheduling, attendance, etc.) that take effort and time but do not directly contribute to improved instruction, thereby allowing educators to use their human expertise to focus on teaching their students more effectively.

The prospective affordances as well as the potential dangers of generative AI in education need to be thoroughly researched. We should proceed quickly and carefully with good research, especially for the sake of our future generations. Focusing on the impact of use of AI rather than the technical details of AI is recommended, because whatever we are currently using becomes obsolete as we are using it, due to rapid changes. While AI is human-like, it is not truly human, and interacting with it will change many parts of our lives. AI presents great risks to be carefully considered. AI also has great potential for improving education.

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