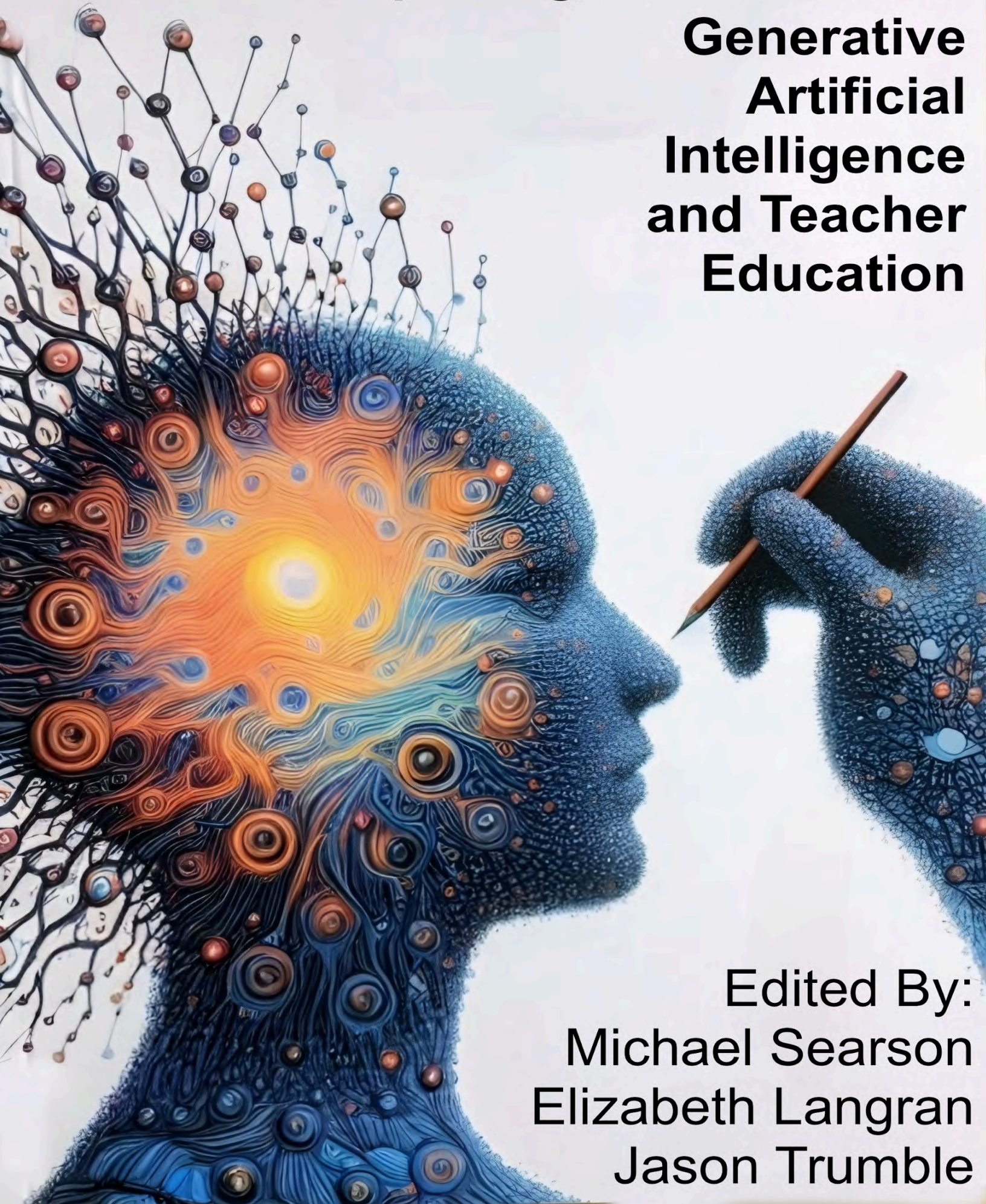


Exploring New Horizons: Generative Artificial Intelligence and Teacher Education



Edited By:
Michael Searson
Elizabeth Langran
Jason Trumble

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**Published by
AAACE - Association for the Advancement of Computing in Education**

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Please cite as:

Searson, M. Langran, E., Trumble J. (Eds). (2024). *Exploring new horizons: Generative artificial intelligence and teacher education*. Association for the Advancement of Computing in Education (AACE).

<https://www.learntechlib.org/p/223928/>

ISBN: 978-1-939797-75-9

Cover art created through a combination of Microsoft Designer AI (Microsoft. (2024). *Microsoft Designer* (Feb 12, 2024 version) [Artificial Intelligence System] <https://designer.microsoft.com/>) and Picsart.

ACKNOWLEDGMENTS

This book is the outcome of the efforts of many people. First and foremost, we thank our authors, who were responsive and patient as we worked through rounds of edits.

We wish to thank the SITE community, our academic home where this idea was hatched, and AACE, especially Gary Marks, for green-lighting the project: Rick Ferdig, who assumed new editorial responsibilities for AACE at about the time we launched this project and, Kathryn Mosby for her support on the publishing end.

We also want to thank Whitley Cochran for her meticulous work.

We would like to thank our life partners and families who were patient and understanding of our time dedicated to getting this completed within a one-year timeframe.

We are thankful for the time we have had together weekly to dedicate to expanding our own understanding of generative AI. We had international travel, COVID, pneumonia, lightning-fried electronics, and, of course, day jobs (at least some of us did). Through all of this, we kept working in an area that often felt like drinking from a firehose with the rapid pace of development and adoption. Even though there is always something new to include, it is time to stop writing and put this volume in your hands. We hope this book informs and inspires you.

DEDICATION

This book is dedicated to teachers and teacher educators everywhere who are bravely venturing into new horizons and inspiring the next generations of learners.

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Setting the Stage

Transforming Teacher Education in the Age of Generative AI

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Artificial Intelligence is not new. Not only has it been a formal academic discipline since the 1950s, but it has also been surrounding and impacting our lives through smart speakers and devices, personalized content on social media and e-commerce sites, and cognitive assistants in healthcare, education, and more. The issues associated with AI—privacy, biased algorithms, inadequate regulation of areas such as facial recognition—have also been raised for several years; in 2019, educational events such as the UNESCO Mobile Learning Week and the US National Technology Leadership Summit featured strands and presentations on AI’s potential impact on education.

So what is different about this moment? Of course, technology has improved, including significant progress in deep learning techniques, particularly in Generative Pre-trained Transformer (GPT) architecture, a type of transformer model used for various natural language processing tasks. Most importantly, tools such as DALL-E, MuseNET, and ChatGPT allow users to generate realistic images, music, and text – having this technology in our hands now has been exciting for many of us. 2023 was AI’s breakout year, with the explosion of scale of Generative AI and Large Language Models.

It also creates much uncertainty, especially in our field of education. We know that this requires a new skill set for prompt generation, evaluating the output of generative AI, and knowing when it is appropriate or inappropriate to use (e.g., Is it ok to use for grading? What about writing a letter to parents about a serious matter?). If ChatGPT can synthesize multiple texts easily, how do we reshape our student assessments to focus on more critical thinking? In an era when so many of us turn to YouTube for “tutoring” or how-to’s on nearly any subject, now we can have a conversation with a technology that remembers what we have discussed. Exposure will happen early, as AI chatbot toys are being developed for young children (Lorenz, 2023). From task assistance to content creation, this will inevitably be part of professional and daily life in many areas. And, of course, being cognizant every step of the way that this is a nascent technology whose full powers and capabilities are still to come to the fore.

Even those of us who have spent our careers examining, researching, and teaching about technology in education recognized that there was something fundamentally different about this generative AI technology. There was great interest in figuring out not only how this can and should be included in education but also what needs to be addressed in educator preparation programs. Following an AI panel at the Society for Information Technology & Teacher Education (SITE) conference in March 2023, the three editors of this book hatched a plan to tap into the expertise of the SITE network and beyond and publish an edited volume on GenAI and teacher education. And we were off!

Of course, we went there. Like many writers, including academics, we incorporated generative AI tools into our writing activities for this book, using them to generate ideas and perform other tasks. For example, we posed a prompt to Claude, “Why write an academic book on generative AI in teacher education?” Claude responded:

Here are a few reasons why writing an academic book on generative AI in teacher education could be valuable:

- Generative AI is an emerging and rapidly evolving technology that has significant implications for education. A book would allow for an in-depth examination of how technologies like large language

models can be applied in teacher training and professional development.

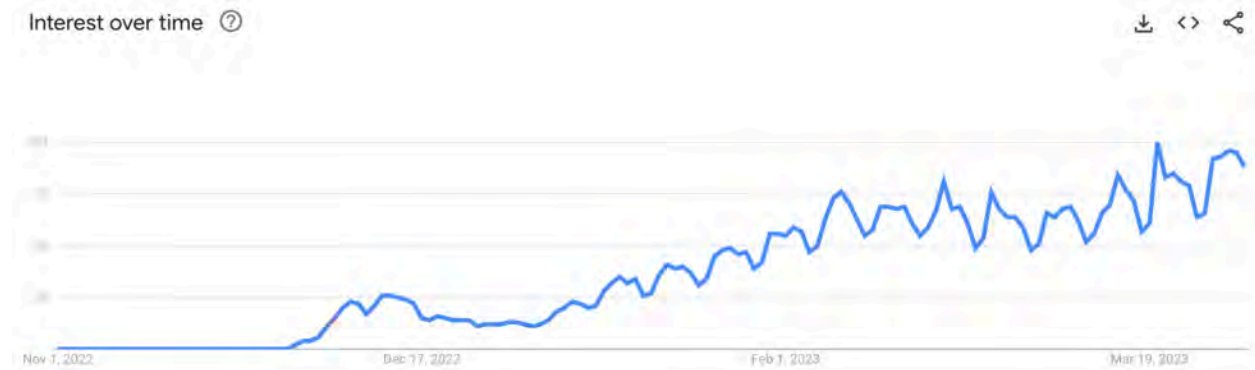
- There is not much research or literature currently available on this specific topic. An academic book could help synthesize existing knowledge, identify open questions, and set an agenda for future research.
- Generative AI technologies will likely impact the teaching profession. A book could help prepare educators and teacher training programs for this future by exploring key opportunities, challenges, and ethical considerations.
- Generative AI has the potential to transform teaching practices, classroom dynamics, assessment, and more. An academic book could analyze how best to integrate generative AI into teacher education to enhance, rather than replace, human teaching.
- As a new technology, generative AI carries risks and limitations that an academic book could investigate, such as the potential for bias, misinformation, and deception. Responsible implementation in teacher education will require critical examination.
- Overall, an academic book on this topic could serve as a valuable resource for researchers, teacher educators, education policymakers, and teachers exploring the intersection of AI and teaching. The book could synthesize current knowledge, analyze implications, and provide recommendations to shape the future of AI in education. (Anthropic, 2023).

As with many who had prior expertise before turning to generative AI tools at the initial writing stage, the prompt response was not particularly illuminating. Mostly, these were ideas that had already gone into our initial conceptions about this book. However, since Claude’s response is generated from a large language model, it was refreshing to find that data collected across the internet meshed with our thinking.

Another preliminary discussion among the editors focused on the book's primary subject—Artificial Intelligence (AI) vs. generative AI. In fact, it’s all too common for people to alternately use the terms “AI” and “generative AI” as though there is no difference between them. Marr (2023) provides a succinct distinction between AI and GenAI; a more comprehensive discussion on the history of generative AI can be found in Cao et al. (2023). Our book was conceived in late Winter 2023 as generative AI was attracting tremendous attention across society, including education and teacher education. Most notably, the release of Open AI’s Chat GPT in late November 2022 (Open AI, 2022) galvanized worldwide attention. In the wake of the announcement of the OpenAI blog post, worldwide interest in the generative AI tool exploded (Figure 1).

Figure 1

Worldwide “interest” in ChatGPT, Nov 1, 2022-Mar 31, 2023



Note. From Google Trends, (2023). Interest over time [ChatGPT Nov.1, 2022 - Mar. 31 2023]

<https://trends.google.com/trends/explore?date=2022-11-01%202023-03-31&q=chatgpt>

Soon, the press heralded the launch of this generative tool and its potential impact on society (Marr, 2023; Roose, 2023a, 2023b; Saetra, 2023). And Bill Gates chose this moment to announce that “The age of AI has begun” (Gates, 2023, p. 1). In his blog post, Gates notes that while AI has been around for decades, “with the arrival of machine learning and large amounts of computing power, sophisticated AIs are a reality, and they will get better

very fast” (Gates, 2023, p. 3).

The conversations around the AI of today and tomorrow include perspectives that AI is hype; will save/destroy humanity; will free us up to do more “human” and creative things; will make us unable to determine what is “real;” and holds both promise and danger. We do not doubt that it is a powerful tool. As we write this, there is debate as to where the responsibility for “responsible AI” rests. These large language models, trained on vast and uncurated datasets, “encode hegemonic views that are harmful to marginalized populations” and amplify biases (Bender et al., 2023, p. 613). The industry’s “move fast and break things” philosophy has morphed into an Effective Accelerationism viewpoint that AI should be allowed to “move as fast as possible, with no guardrails or gatekeepers standing in the way of innovation” (Roose, 2023b, np). Their message is that any irresponsible use is a result of edge cases and that governments do not understand the technology sufficiently to regulate it (NBC, 2023). AI companies have yet to demonstrate the ability to regulate themselves, perhaps due to a “capitalism problem” (Farid, as cited in Fowler, 2023). “Profiting from the latest craze while blaming bad people for misusing your tech is just a way of shirking responsibility” (Fowler, 2023, np).

TEACHER EDUCATION AS PART OF THE GENERATIVE AI CONVERSATION

This only increases the urgency for the development of AI literacy, where people understand what AI is, how it works, what are the limits and affordances, and how it can be harmful—and who it harms. They understand that it attempts to imitate humans (from human-sourced data), but that also includes racial and gender bias. They understand the increasing energy and water costs to our environment to run AI data centers and the labor exploitation of digital sweatshops that may have gone into training AI systems (Bartholomew, 2023). They understand how to evaluate fake versus real (Neil Postman (1969) refers to this as “crap detection”)—and they also care whether it is real. Teachers are at the center of much of any literacy work, and AI literacy is no exception. For teachers to be able to teach with and about AI, teacher educators must develop the needed competencies, model its use, and lead critical conversations. In addition to AI literacy, teaching AI as a content area helps students understand how AI works rather than experiencing AI as a black box whose algorithm must be obeyed.

Technology developers, policymakers, administrators, teachers, students, and, yes, teacher educators all have a role to play in the effective, ethical, and equitable uses of AI, and there is an urgency to do it now and do it right. Teacher educators—and particularly those of us in the field of educational technology—are at the forefront of the conversations happening at many universities, being asked to take the lead in educating our colleagues about the technology, informing policies, and hopefully taking advantage of this moment to rethink how we assess students to focus more on the process of learning or performance assessments than the product of a completed essay. “Why are we emphasizing tasks that can be effectively completed by AI? We are ‘preparing people to lose to AI instead of focusing on what people can do differently and better’ (Dede, as cited in Warr et al., 2023, p. 5). We have heard some comments comparing GenAI to other educational technology tools; where years ago, the handheld calculator was banned from classrooms as it was seen as a “crutch” that would mean students did not develop computation abilities, and now it is an accepted technology, common to many classrooms. While this is an example of a machine that can take over some tasks to enable humans to do more, in other ways, GenAI is fundamentally different from other classroom technologies (first of all, a calculator will not “hallucinate” an answer). The answer a tool such as ChatGPT provides may look polished but is not necessarily trustworthy. Encouraging critical thinking and helping students connect back to intrinsic motivation can be supported by offering students an opportunity to find their voice. Culturally Responsive Teaching honors the lived experiences of our students and offers opportunities to bring that into their learning. This is something that GenAI cannot do. While some may argue that we are entering a post-plagiarism world where hybrid writing (co-created by humans and AI) will become the norm (Eaton, 2023), and others posit that writing cannot be learned by editing someone else’s thoughts (Dede & Cao, 2023), teaching students how to write (and do other tasks) alongside AI will likely be an important workplace skill.

Ultimately, teacher education programs must decide how much they will integrate AI and generative AI into their curriculum—both in terms of breadth and depth. Will AI be fully integrated across student experiences, e.g., classroom fieldwork, which could require preservice teachers to construct and teach an AI-infused lesson? Will preservice teachers be trained to use AI tools when writing lesson plans? Will key courses be revised to integrate AI into their syllabi? Will there be a wholesale revision of programs—or even the creation of new programs featuring AI integration? Imagine, for example, a program entitled “The AI-Empowered Educator” (perhaps offered at the graduate level). All of the above? Some of the above? None of the above?

Navigating Program Revision and Development

Integrating AI into teacher education programs presents a daunting challenge for faculty and administrators, requiring navigation through multiple layers of approval, including curriculum committees, college-level governing bodies, and external agencies. This process is time-consuming, potentially taking 2-5 years to approve new or significantly revised programs (Higher Learning Commission, 2023). As a professional discipline, teacher education may be governed by a complex array of state, federal, and professional association regulations and guidelines, making any curricular modifications subject to approvals at various levels and reviews by accreditation agencies. Any curricula modification, including course revisions, is often subject to approvals at various levels. These activities all take time. In other words, while many educators view AI and, specifically, generative AI as a possible game changer, their teacher preparation students will likely see little evidence of systematic AI integration at the programmatic level soon.

However, many faculty feel they cannot wait until formal curriculum and program revision activities occur. Spring 2023 was the first full semester where college faculty could leverage (or restrict) generative AI tools. Initial responses were wide-ranging; some faculty formally integrated AI into their teaching and even included AI-based assignments in their syllabi. Other faculty restricted students' use of AI. Often, this created conflicting experiences for students. In some classes, AI was directly addressed; in others, it was ignored; and, in still other classes, it was prohibited. Often, the issue of using AI came from students themselves. For example, there were cases where students asked, "Professor, am I allowed to use ChatGPT to complete this assignment?" or, "My professor in another class told us we were not allowed to use ChatGPT; what about you?" Confronted with a dynamic with which most faculty struggled to come to terms, faculty responses were wide-ranging. Some faculty quickly adjusted their syllabi, finding a way to integrate chatbots into their courses. Others simply banned the use of ChatGPT, invoking fear of cheating. Still, others put the matter off, "Let's wait until next semester so we can figure all this out." They added, "Besides, I'm waiting for the administration to provide guidelines on how to use ChatGPT."

While program revision or development of new programs in colleges and universities varies from institution to institution and state to state, several commonalities exist. We will consider these steps and their implications for those struggling with integrating AI into teacher preparation activities.

Organic Discourse

Often, the upper administration initiates the mandate for new programs or substantive program revision, e.g., deans, provosts, and sometimes the college president. On the other hand, program revision may be sparked by informal discussions among faculty, who sense the need for a new or revised program to better prepare their students to enter their chosen profession successfully. Likewise, discussions about AI spontaneously emerged among faculty as we approached the Winter/Spring 2023 semester. Thousands of faculty on college campuses engaged in vigorous discourse about the values and horrors of ChatGPT. Teacher education faculty should engage in such discussions both within their program and with cross-disciplinary colleagues. After all, most classes taken by undergraduate teacher preparation students will be outside the college of education.

Build Momentum

Along the way toward program revision, department or school faculty must begin formal discussions about the "next steps" to take in a program revision. At this point, they will consider the formal process, e.g., precisely what steps must be taken to revise or build new programs. These include forms to fill out, courses to be revised or created, committees to be formed and informed, etc. Likewise, with AI at the program level, will interested faculty transition from inserting AI into courses here and there to formal adaptation and revisions? Specifically, will faculty formally revise or create new courses integrating AI into teacher ed? Or will they just tinker with existing courses?

University Parameters

At some point, university-level policies and procedures must be considered in any program revision process. Program revision will only succeed with approval at the institutional level, likewise with AI integration. Even if faculty plan to do no more than play around with AI in their courses, they should be aware of activities at the university level. Is their institution instituting policies on AI? What type of support are they providing for students? Are they sponsoring faculty dialogues to sort out emerging AI issues? Is professional development being offered?

Accreditation Agencies

Ultimately, accreditation agencies will review new or substantively revised programs. For example, the Council for the Accreditation of Educator Preparation (CAEP) requires that teacher preparation “providers ensure that candidates model and apply national or state approved technology standards to engage and improve learning for all students” (CAEP, 2022a). Faculty in accredited programs are expected to remain current in specific accreditation policies and practices that impact their professional expertise. Likewise, teacher education faculty should be vigilant regarding positions relevant accreditation may take regarding AI and teacher education.

Local School Partnerships

Many teacher education programs are intricately involved with local school systems. For example, programs with pre-service teacher fieldwork assignments almost always arrange these experiences through partner schools. As part of its accreditation process, CAEP’s Standard 2 (CAEP, 2022b) addresses “Clinical Partnerships and Practice.” Beyond potential accreditation issues, teacher educators should be aware of emerging K-12 policies on LLMs across the state where they are located. Sometimes, teacher educators could be asked to serve as consultants as local partners develop policies and practices.

Professional Associations

A common component of the accreditation process is the professional associations’ role in the steps leading to approval. For example, CAEP includes a Specialized Professional Association review, which invokes standards articulated by the appropriate professional association that governs the program under review. Currently, most professional associations address technology integration at some level. For example, in a position statement, the National Council for the Teaching of Mathematics (2015) states:

It is essential that teachers and students have regular access to technologies that support and advanced mathematical sense making, reasoning, problem solving, and communication. Effective teachers optimize the potential of technology to develop students' understanding, stimulate their interest, and increase their proficiency in mathematics. When teachers use technology strategically, they can provide greater access to mathematics for all students.

Will such professional associations revise their standards to address AI and LLMs specifically? Stay tuned! Moreover, many teacher educators are likely already familiar with the professional associations connected to their field. Many professional associations are now in the process of addressing the emerging AI-infused world. Awareness of developing policies and practices of relevant professional associations is essential for teacher educators.

Professional Expertise

Virtually all new programs or substantive program revision processes require that participating faculty submit their vita for review. This activity documents that program faculty are current and can make relevant professional contributions to the program under review. While updating one's vita to reflect relevant AI activities is often impractical, teacher education faculty should engage in professional and personal practices where they can interact with these new tools. They could also consider participating in relevant professional development

opportunities. Such activities will better position faculty to address new AI tools with their students.

Issues of Equity and Diversity

Almost from the beginning of technology integration into education (and across society), the *digital divide* has been a factor limiting educational opportunities for many (Resta et al., 2018). While discussions over the issue of the digital divide have transpired for decades, the COVID pandemic brought matters to a head where there was clear evidence that the factors related to technology access impacted student academic performance (Bronzino et al., 2021; Ramsetty & Adams, 2020). There are signs that digital divide factors will impact access to generative AI, specifically related to income and access to up-to-date tools (Mannuru et al., 2023). For example, newly released smartphones powered by AI tools may require additional data charges, “for pay” services, or both. Moreover, AI-equipped devices will likely require increased processing power and memory to support new AI features—resulting in increased costs for users. Very shortly, many smart device users will have to bypass AI-equipped units simply because they cannot afford the increased cost of the devices and related services (Velazco, 2024).

Issues related to diversity and equity present a dilemma for teacher educators, who will likely be education preservice teachers and, indirectly, the school children they will teach, who themselves could have inconsistent access to these tools. How do we educate future teachers about the potential of a powerful tool to which they may have limited access?

On the one hand, teacher education programs (and higher education, in general) cannot solve all societal inequities related to access to technology. On the other hand, universities often played a key role in supporting 1-1 laptop initiatives in school-college partnerships that addressed digital divide issues a generation ago, from leveraging grant awards to directly supply devices to local schools (Searson et al., 2006), conducting research to assess 1-1 programs (Muir et al., 2004), and serving on advisory committees that helped to address the digital divide. In 2017, the US Department of Education issued a draft report entitled *Reimagining the Role of Technology in Higher Education* that delineated activities that higher education could do to help “ensure greater equity and accessibility to learning opportunities over the course of a learner’s lifetime” (King & South, 2017, p. 1). A similar call could be issued to have higher education address comparable issues related to artificial intelligence. As we struggle with creating an equitable environment to address digital equity and diversity issues as related to generative AI (and AI, in general), teacher education faculty can play a similar role: seek related grants, engage in critical research, and leverage opportunities to serve on relevant advisory committees that could shape key policies.

As ChatGPT (and generative AI) burst upon the scene, many were quick to note that large language models upon which generative AI tools are based are biased toward Western, English-speaking perspectives (Kudless, 2023; Messner et al, 2023). The architecture of generative AI is directly related to large language models that reflect the evolution of the Internet and the World Wide Web, with a historic Western and English-speaking orientation (Kudless, 2023). While there is little teacher education programs can do to shape large language models, they should consider the importance of teaching AI literacy to their students. Further, they could convey AI literacies that could be taught by teacher education graduates to the school children they will teach. Recognizing key work in the area of AI literacy (Hillier, 2023; Kong et al., 2021; Ng et al, 2021), Farrelly and Baker (2023) address “the need for AI literacy in higher education” (p. 7). While AI literacies encompass a wide range of topics, teacher education programs should advocate that they include issues related to equity, diversity, cultural pluralism, and gender pluralism. Furthermore, teacher educators should advocate that these elements of AI literacy be embraced by future classroom teachers.

Most teacher educators will find their professional lives—from teaching to scholarship—impacted by AI for the remainder of their careers. Those facing this new challenge can follow the roadmap outlined above as they seek to address the burgeoning AI phenomenon. Of course, some faculty will actually engage in a program revision that vigorously incorporates AI into the teacher education curricula. That will be very exciting to watch!

AN OVERVIEW OF THIS BOOK

Given the fast-paced evolution of GenAI tools and our intention that what is here does not immediately become outdated, this book represents some frameworks and guidance for teacher education when considering how to approach GenAI in our programs. In this volume, you will find chapters that explore GenAI in teacher education

research, ethical frameworks, literacy, and more, with contributions from authors in Japan, Malawi, China, the Netherlands, and other parts of the world. We were fortunate to have a wide array of international authors to showcase the variety of work being done within teacher education as we grapple with the ever-changing landscape of GenAI. Our chapters are broken into five thematic categories:

Setting the Stage

Both this chapter and the next attempt to situate the conversation about teacher education and generative AI in the broader landscape of what is happening now and within the historical context of educational technology.

The (Neil) Postman Always Rings Twice: 5 Questions on AI and Education

Punya Mishra and Marie Heath explore the profound implications of GenAI in education, moving beyond discussions of plagiarism and teacher efficiency to examine its broader societal impacts. Drawing upon Neil Postman's five key ideas about technological change, the chapter examines inherent biases, who benefits, who is harmed, and ecological transformations brought about by the human-made GenAI. Mishra and Heath advocate for a critical awareness of AI's influences among educators and students, emphasizing the importance of ethical and responsible use in education.

Applying Frameworks to Impact Teaching Practice

In this section, our authors leverage the TPACK and Teacher Educator Technology Competencies (TETCs) frameworks to understand the complex interplay between GenAI and educational practices. Across these three chapters, there is an emphasis on preparing educators to critically engage with AI tools through understanding their pedagogical applications, ethical considerations, supportive scaffolding, and broader societal impacts while advocating for a thoughtful approach to incorporating AI into educational practices.

Integrating AI in Teacher Education Using the Teacher Educator Technology Competencies

Torrey Trust, Robert Maloy, and Nanak Hikmatullah discuss the application of the Teacher Educator Technology Competencies (TETCs) framework to equip educators with the skills and knowledge for using GenAI effectively. This chapter details how teacher educators can enhance AI literacy, adapt instructional methods for various learning environments, support diversity, and foster ethical and responsible use of AI among new teacher candidates, emphasizing the comprehensive development of skills, knowledge, and attitudes necessary for leveraging AI in education effectively.

Pedagogical Models and Generative AI Fluency: A Three-Tiered Empirical Framework Approach

Rebecca Blankenship introduces a three-tiered empirical framework approach, incorporating TPACK, the Johari Window, and Levels of Use, advocating for a scaffolded approach to support educators and learners in navigating the complexities of GenAI modalities and spaces. This exploration underscores the importance of awareness of the digital self and instructional spaces harmonized with empirical frameworks to navigate the intricacies of these new learning environments effectively.

Generative AI and TPACK in Teacher Education: Pre-service Teachers' Perspectives

Aijuan Cun and Ting Huang share their research on preservice teachers' perspectives in GenAI, using TPACK to understand their experiences and proposing a model for its application in teacher education. They present findings from interviews with preservice teachers revealing varied experiences and viewpoints on the application of ChatGPT for teaching and learning. Based on these insights and the TPACK framework, they propose a four-pathway model to guide the integration of generative AI in teacher education, with a discussion on the model's implications for the field.

Creating Guidelines and Examining Ethical Issues

While ethical issues are addressed in every chapter in this book, there are two chapters that have a particular focus on the need to develop solutions for transparency, equity, and community-centered design to enhance teaching and learning outcomes. These chapters propose guidelines and frameworks to address issues of bias, transparency, privacy, and accountability.

Locked In Generative AI: The Impact of Large Language Models on Educational Freedom and Teacher Education

Roland Klemke and Halszka Jarodzka acknowledge that in the field of education, LLMs present opportunities and benefits but also raise questions about consistency, factuality, and lack of transparency when using these commercially owned platforms. They argue that education must remain free, open, and teacher-led, outlining requirements for the safe use of LLMs in educational settings. The chapter provides guidelines for educators and students, emphasizing the importance of understanding what LLMs can and cannot do, and highlighting the responsibilities that teachers should continue to undertake to ensure effective learning outcomes.

Toward a Conceptual Generative AI Ethical Framework in Teacher Education

Asmaa Radwan and Jacqueline McGinty draw upon existing AI frameworks to create one that is more inclusive of teacher education. Their GENAIEF-TE framework emphasizes principles like Transparent Accountability and Culturally Sensitive and Inclusive Fairness, aiming to address these ethical issues. Advocating for an interdisciplinary approach, the chapter outlines a path for ethically integrating GenAI in teacher education, calling for a collective effort from educators, policymakers, and developers to ensure an ethical, inclusive, and equitable educational environment.

Toward Meaningful Practice

These chapters collectively explore the transformative potential of generative AI on educational practice, focusing on its application in specific contexts such as mathematics and special teacher education, the role of school librarians, and lesson planning. They highlight how GenAI can be used to design more engaging and conceptually rich assessments in mathematics, enhance data-driven decision-making skills among preservice teachers, and provide personalized learning experiences.

Embracing ChatGPT in the Evolving Landscape of Mathematics Teacher Education and Assessment

Angie Hodge-Zickerman and Cindy York address the education community's concerns regarding ChatGPT's impact on preservice teachers' learning and assessment, highlighting fears that students might bypass critical thinking with ChatGPT's help. They offer practical tools and strategies as they propose a reimagined approach to assessment, demonstrating how ChatGPT can be used to design assessments that require understanding, application, and articulation of concepts and promote deeper student engagement with mathematics.

Assessment and Instructional Decision Making: How AI Can Support Data Literacy Development for Preservice Teachers

Mary Jean Tecce DeCarlo, William Lynch, Vera Lee, Daniel Moix, and Valerie Klein emphasize generative AI's role in augmenting preservice teachers' data-driven decision-making skills, which is crucial for enhancing student outcomes in today's assessment-centric educational environment. They provide specific examples of how generative AI can assist in modeling learning analytics and crafting both simulated and authentic assessment tasks.

School Librarians as Collaborators in the Successful Use of GenAI

Elizabeth Gross and Holly Weimar give us the perspective of school librarians, who play a crucial role in fostering collaborative and supportive relationships with other educators, especially novice teachers. With their expertise in educational technology, they are well-positioned to integrate and demonstrate the use of GenAI as an instructional tool by guiding teachers in creating effective prompts for GenAI and exploring its potential for innovative and personalized learning.

Generative AI to Improve Special Education Teacher Preparation for Inclusive Classrooms

Rashmi Khazanchi and Pankaj Khazanchi share how generative AI tools offer significant opportunities to enhance the training of special education teachers for inclusive classrooms. These tools can help overcome common challenges faced by special education teachers, such as limited resources and training, by providing tailored learning materials and enabling the development of adaptive teaching strategies through data analysis.

Social, Cultural, and Political Perspectives of Generative AI in Teacher Education: Lesson Planning in Japanese Teacher Education

Masanobu Sakamoto, Shirley Tan, and Stephane Clivaz investigate how generative AI can be used in lesson planning. Their examination of an AI-generated second-grade math lesson was evaluated by teachers in Japan and Canada, revealing cultural differences in the acceptance and satisfaction with these plans. Despite the potential of generative AI to reduce teachers' burdens, challenges such as the depth of content and the specificity of teaching knowledge in generative AI lesson planning highlight the varied acceptance across different educational cultures.

GenAI and the Teacher Education Researcher

While the authors of these three chapters in this section examine the bigger picture of implications for the field of teacher education, they also address research with and about generative AI. These explorations include a call for researchers to leverage AI judiciously, highlighting the balance between leveraging GenAI's capabilities for productivity and maintaining the critical thinking essential for quality scholarship.

Examining Generative AI and Teacher Educators Research Practice: A Duoethnographic Dialogue

Donna Wake and Matthew White share experiences and reflections on using ChatGPT to support research in teacher education, employing a duoethnography approach to exchange stories, challenge perspectives, and explore ethical concerns. They discuss the potential of GenAI to enhance the research process through improved efficiency in tasks such as brainstorming and drafting while also cautioning against its pitfalls, including plagiarism and bias, emphasizing AI as a tool that supplements but cannot replace human expertise.

Developing Frames for Change: How Generative AI Impacts the Broad Practices of Teacher Educators

Chen-Chen Liu and Xiaoqing Gu investigate the broad impacts of generative AI on teacher education, highlighting both the benefits and challenges it brings to educators' teaching practices, as well as particular concerns about research in teacher education. They share their own study conducted with English teacher education majors from a public university in China to complete an informational instructional design proposal using ChatGPT under the instructor's guidance.

Envisioning Generative AI in Teacher Education in Malawi: The Role of Teacher Educators as Researchers and Curriculum Developers

Foster Gondwe and Frank Mtemang’ombe investigate the impact and future prospects of generative Artificial Intelligence in teacher education in Malawi, emphasizing the crucial role of teacher educators in preparing for its integration. It highlights the mixed responses to AI in education globally, noting the potential for personalized learning and creativity enhancement alongside risks like bias and reduced human interaction, with a particular focus on the under-researched context of Africa. The authors argue for the importance of equipping teacher educators in Malawi with the skills to utilize AI effectively, considering the unique challenges and opportunities presented by generative AI in enhancing teaching and learning while also addressing ethical considerations and the need for a tailored approach in diverse educational environments.

Setting Sail Toward New Horizons

In our final chapter, we use the imagery of new horizons to offer closing thoughts and reflections on our experiences engaging in these critical conversations about GenAI and teacher education. Recognizing that the publication of this work marks one moment at the beginning of our human journey with this new technology that is predicted to change how we live, work, and learn, we conclude by looking toward new horizons.

We are grateful for our authors' collaboration, time, and attention throughout this process, and we hope you enjoy exploring this book.

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The (Neil) Postman Always Rings Twice: 5 Questions on AI and Education

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In 2014, The Atlantic ran a story with the title *Why tech hasn't solved education's problems*, which focused on the failed promise of Massive Open Online Courses, aka MOOCs (Meyer, 2014). Specifically, it raised the question, “Why has the promised boom in educational technology failed to appear—and why was the technology that *did* appear not very good?”

Stories such as these and similar questions have been raised about many different technologies. The history of educational technology is littered with examples of technological hype, hope, and disappointment. For instance, a new technology, like the chalkboard, television, or computer (and its potential for learning), leads to a significant level of hype about how it would transform education (Cuban, 1986, 2001, 2013). When these extravagant promises are not met, educators often conclude the uselessness of technology in education.

Often, the argument for including technology in teaching is grounded in language that equates technological advancement to progress and presumes a world of technological immersion is the default world children will inherit (Heath et al., 2022). This insistence on responding tends towards reaction instead of agency and underscores the manner in which the world has been changed by technology, as well as the need for educational systems to respond to these changes. For instance, consider the following quote:

The modern school is forced to meet the demands of a rapidly changing civilization. Today, the world of the learner is almost unbounded. He must acquire facts relating to a bewildering variety of places and things; he must acquire appreciations of far-reaching interrelationships. The curriculum and methods of teaching must undergo a continuous appraisal. New subject matter and new devices for instruction are being scrutinized for their potential contributions to the learning process.

What is surprising is that this quote is not about generative AI or the Internet of MOOCs, but rather about educational film and was written over 90 years ago (Devereux, 1933). Not only that, it was claimed that

The introduction of the use of the talking picture into education may prove to be an event as epochal as the application of the principle of the wheel to transportation or the application of steam power to the industrial age. No development in education since the coming of the textbook has held such tremendous possibilities for increasing the effectiveness of teaching as the educational talking picture (Devereux, 1933).

It can be argued that this prophecy did not come true. While educational films have been and still are used in education, there is little evidence to suggest that they have transformed teaching and learning. Yet, similar stories are heard about every new technology. For instance, Gilder (2000) breathlessly declared that networking technologies, such as the Internet, would make us “into bandwidth angels” that would allow us to fly “beyond the fuzzy electrons and frozen pathways of the microcosm to boundless realm.” Similar rhetoric could be seen when describing MOOCs, social media, and now Generative AI.

Though technologies have changed almost all aspects of our lives, critics argue they have not had much discernable impact on education and educational systems. The reason typically given for this seeming inertia is usually to pejoratively characterize educational systems as being fossilized, inertial systems, unable to change to meet the needs of a changing world and to take advantage of the powers of new technologies (Cuban, 2013).

We take a somewhat more nuanced view in that we see the role of technology in education as being complicated by broader factors such as the nature of the technology and larger social, economic, and institutional constraints. Rather than solely emphasizing teaching *with* technologies in order to prepare children for lives in the 21st century, we contend that schools should also be teaching *about* technologies and their impacts on students' individual and collective lives (Krutka et al., 2022). For a range of reasons, from the attributes of the technology itself to the purposes of schooling, not all technologies are necessarily amenable to integration within classroom practice. Moreover, as Cuban (2001) has argued, technology, even when used, is rarely transformative since teachers “domesticate” innovative technologies by fitting them into their existing teacher-driven pedagogical practices. For instance, consider television. It has had limited impact on the classroom—and one would argue rightly so, given the one-directional, passive nature of the medium. But, television has had an impact on the classroom and the curriculum by transforming the world within which education operates.

In this chapter, we suggest that while particular technologies may not directly enter the classroom, their broader impacts on society often necessitate changes in educational approaches and priorities. As McLuhan (1964) argued, “we become what we behold” (p. 29). In a world of pervasive television, we become television-people, humans who develop a preference for an image-heavy experience, clever sound bites, and education as entertainment. In a world of pervasive social media, we become social-media-people, humans whose attention changes to prefer short and intimate bursts of content. In a world of generative AI, we will become artificial-intelligence-people.

Consider the moving picture, the subject of the quotes above from Devereux (1933). While the moving picture itself did not dramatically alter classroom activities, the rise of cinema fundamentally reshaped society in ways that necessitated changes in educational thinking. As film rapidly expanded into a dominant form of entertainment and communication, it became a force of socialization and a tool of propaganda, deeply influencing how people understood themselves and the world. Schools could not ignore cinema's profound impacts; curricula responded by incorporating film literacy and critical viewing skills.

A similar pattern can be seen with digital and networking technologies such as the Internet and social media. Though these technologies did not enter educational spaces to the extent predicted, they have had an influence on schools, schooling, and society. These platforms, designed to maximize engagement and advertising revenue, have affected the mental health of youth worldwide (Wells et al., 2021). Issues like anxiety, depression, and body image struggles have become endemic among students, profoundly shaped by endless social comparison and the commodification of identity online. Thus, even if social media itself has not entered the classroom in a significant manner, it has forced education systems to respond to its broader societal impacts. Schools now grapple with social-emotional learning, digital citizenship, and fostering self-worth in the age of the influencer.

It is in this context that we probe the advent of new Artificial Intelligence (AI) technologies. The rapid development of AI and machine learning tools will transform industries and the world of work in profound ways. Further, AI has already caused harm to those pushed to the margins of society, leading to false arrests of Black people (Kentayya, 2020); over-policing of poor, Black, and Latinx communities (O'Neil, 2017); unequal opportunities in lending for women and People of Color (Bartlett et al., 2022); unjust body searches and surveillance of trans people (Costanza-Chock, 2020); and poor healthcare interventions for Black women as algorithms improperly compute their physical pain (Benjamin, 2019). This requires educators researching and teaching with AI to look beyond classroom interventions and consider new curricula that prepare students to live and prosper in an AI-saturated world.

It has been extensively argued, particularly with the advent of generative AI tools, that this new technology has the potential to transform various aspects of human life, including the way we work, communicate, and express ourselves creatively (e.g., Harwell & Tiku, 2023; Roose, 2023). As more aspects of human labor can be performed by AI tools, it will reduce the value of human labor and expertise in certain domains. As jobs become automated, there will be job losses for some and increased profits for others. The demand for certain professions will rise, while the need for other professions may decline. Moreover, the power of these tools to customize messages through multiple media has significant implications for human communication and decision-making. Trust and transparency are critical for human flourishing, and these new AI-based creations can significantly undermine that through algorithms that are biased or systems that do not understand the nuances of human interaction. As AI permeates society, ethical concerns like privacy, surveillance, and algorithmic bias will require continuous evaluation, regulation, and guidelines. Finally, these tools can undermine originality, creativity, and other critical human abilities and raise questions about authenticity, truth, and what it means to be human. Clearly, these topics go beyond the hand-wringing that we have seen recently about how these new tools (particularly large language models such as ChatGPT and Bard) can allow students to cheat on their examinations or other assessments. This is a narrow, short-sighted, and limited view of how we should think of these technologies and their impact on education.

That said, it is difficult to predict just what shape these changes will take. Cultural change happens in complex, non-linear ways, favoring some while disadvantaging others. Technology weaves itself into the fabric of society, and without collective human work spinning threads toward justice, technology can strengthen the tapestries of inequality. However, individual and collective human intention can direct and re-braid technological uptake. It becomes important, in this context, for educators to explore and interrogate these broader forces with students. This is one way to help young people grow their capacity for agency and action. Educators can support students' questions and critiques of technologies in order to make informed and ethical choices toward more just technological futures (Krutka et al., 2022).

It is here that philosophers and historians of technology can provide guidance, given their ability to look beyond the immediate to broader narratives and societal implications. Grounding their work in theories of media, communications, histories, and sociologies, they consider the potential of new technologies: which aspects of technological potential are emphasized and which get ignored; how certain views get essentialized and normalized and which do not; who gets to control the discourse and who does not, and most importantly, on whom does the burden of new technologies fall.

THE POSTMAN ALWAYS RINGS TWICE

Neil Postman was a prominent American media theorist, cultural critic, and educator who made significant contributions to the study of media, technology, and culture throughout the latter half of the 20th century. He wrote extensively about how technologies and media have transformed society and culture. He is best known for his critique of the transformative impacts of television on society, which he discussed extensively in his foundational book, *Amusing Ourselves to Death* (1985). In this work, Postman posits that the medium of television, with its emphasis on entertainment and its non-linear structure, has fundamentally altered the nature of public discourse, diminishing the value of rational argument and serious conversation.

Postman's arguments align (and differ in nuance and focus) from other media theorists such as Marshall McLuhan (1964), Walter Ong (1982), Jacques Ellul (1964), and others. Postman was aligned with scholars such as McLuhan and Ong and their arguments on how the medium shapes the nature of the content it carries (hence McLuhan's famous dictum, *The Medium is the Message*). Postman, however, was more concerned with the societal implications of media's influence, focusing on the consequences for public discourse and politics. Similarly, even while agreeing with Ellul's concerns about technological determinism, the idea that technology shapes society's values and goals, Postman placed a heavier emphasis on cultural and media critiques.

In this chapter, we focus on the ideas Postman raised in his 1998 talk, "Five Things We Need to Know About Technological Change." We chose this work because it offers accessible insights into Postman's extensive research on the relationship between technology and society. Further, we have found these ideas particularly helpful in our own work in analyzing educational technologies. In his talk, Postman observes:

1. We always pay a price for technology.
2. When it comes to technology, there are always winners and losers.
3. Embedded in every technology, there are one or more powerful ideas—and biases.
4. Technological change is not additive, it is ecological.
5. Technologies are fictions.

In the rest of this essay, we take each of these ideas and explore what they mean for educators and educator preparation in a world changed by Generative AI.

1. We Always Pay a Price for Technology

Postman argued that technological change always involves a trade-off, a Faustian bargain in which technology both gives and takes away. As Postman articulates, the inquiry "What will a new technology do?" holds equal importance to the question, "What will a new technology undo?" In fact, the latter question is arguably more significant because it is so rarely asked. As he wrote:

The question, "What will a new technology do?" is no more important than the question, "What will a new technology undo?" Indeed, the latter question is more important, precisely because it is asked so infrequently... I would forbid anyone from talking about the new information technologies unless the person can demonstrate that he or she knows something about the social and psychic effects of the alphabet,

the mechanical clock, the printing press, and telegraphy. In other words, knows something about the costs of great technologies.

Postman suggests that discussing new information technologies should be reserved for those who can demonstrate an understanding of the social and psychological impacts of historical advancements such as the alphabet, mechanical clock, printing press, and telegraph. For instance, when humans embraced the technology of an alphabet, we gained the ability and opportunity to share ideas more easily and rapidly. We could take ideas out of our heads and store them in a reservoir of letters. However, as Plato worried, literate humans traded our memory as a repository for knowing. Further, as humans shifted from an oral-based culture to a literacy-based culture, we traded the truth and authority of the spoken word for the truth and authority of a written contract. The alphabet did more than make knowledge more accessible. It changed the way humans think and what humans value.

Of course, it is not lost on the two of us that we repeat Plato's argument here through the technology of writing, and the chances are high that you are reading this not printed on paper but rather on some digital device. We note that Postman framed this notion of technological undoing as "technology giveth, and technology taketh away" (p. 1). While Plato concentrated on what the alphabet took, we (Punya and Marie) continue to use, value, and often take great delight in the written word. However, returning to Postman's initial argument, society and individuals often concentrate our imaginations on what technology gives and rarely on what it takes away.

Another key trade-off may be that of balancing between the personalization offered by AI and the human connection that teachers bring into the learning equation. While AI tools can offer personalized learning experiences tailored to individual student's needs, they offer a simulacrum of connection, which may actually cause more harm than good for student emotional and social development. Striking a balance between these two competing yet important goals is a critical trade-off that educators must navigate. Moreover, as AI becomes more integrated within educational contexts, we must be careful not to rely too heavily on technology, and educators will need to carefully evaluate when and how to deploy AI tools. Finally, educators need to find a balance between the data-driven decision-making powers of AI and the personal and professional knowledge they have of individual learners. An overreliance on AI may undermine individual expertise and understanding of their students.

Another price we may pay for AI technology is what and how we consider learning and intelligence. McLuhan (1964) argued we become more like our machines, and so we wonder, is the price we pay that we become artificial-intelligence-humans? Similar to Plato's critique of the alphabet as "a recipe not for memory, but for reminder," we may end up shifting what and how we come, collectively, to know.

Struggle with the unknown is vital to human learning. Vygotsky termed that liminal space between confusion and understanding the zone of proximal development (Rowe & Wertsch, 2002). Generative AI appears to know no such struggle. As far as we can tell, in our attempts to peer into its black box of code, there is no space for wrestling with discomfort as it computes to produce. For AI, the next word emerges from a probabilistic calculation based on what has come before. A soupçon of noise added to the code helps AI produce language that feels authentic and "generative" to the human reader; as Emily Bender and colleagues noted, "...the tendency of human interlocutors to impute meaning where there is none can mislead both NLP researchers and the general public into taking synthetic text as meaningful" (Bender, et al., 2021, p. 611). We don't have an answer to the question, what does it mean for learners to trade off the zone of proximal development for ease of access to the creation of knowledge? But we think that it is a worthy question for educators and scholars -- those of us who are particularly concerned with the question of learning -- to pause and consider.

2. When it Comes to Technology, There are Winners and Losers

The second point that Postman argues is that the pros and cons of emerging technologies are not equally distributed among the population. There are always those who benefit and those who lose out, as well as individuals who remain unaffected by the technology. As he noted:

The questions, then, that are never far from the mind of a person who is knowledgeable about technological change are these: Who specifically benefits from the development of a new technology? Which groups, what type of person, what kind of industry will be favored? And, of course, which groups of people will thereby be harmed?

It is important to acknowledge that beneficiaries of a technology are often unaware of those who are not reaping the benefits or attempt to persuade others that they, too, are reaping the rewards. Most importantly, the distinction between winners and losers is frequently drawn along the lines of existing disparities within the current

system. Therefore, as Postman suggests, we must consistently question who specifically gains from the advent of new technologies, which groups, types of individuals, or industries are favored, and, of course, which segments of the population may be adversely affected.

Access to technologies is not equitably distributed, and that will be true of AI tools as well. Moreover, this also impacts teachers' access to these tools and capabilities, which may lead to two tiers of educators, further emphasizing these disparities. Thus, the implementation of AI tools in education has the potential to exacerbate existing inequalities among students, teachers, schools, and communities, resulting in widening the digital divide and gaps in educational outcomes based on socioeconomic status, geographical location, and other factors.

Further, there may be a shift in emphasis on what is taught and learned in schools where AI-based educational tools may be a better fit for certain subjects or approaches over others. Unlike machine learning and other AI that have been used for at least a decade in STEM fields, for example, in computer science, to help write code, generative AI is particularly compelling in the ways it aligns with creative disciplines. Generative AI's stories, poems, art, songs, and AI-generated architecture and design can be surprisingly delightful and moving. However, we wonder who the winners and losers in this artificial intelligence introduction to humanities and arts may be. If we do become what we behold, what does it mean to develop disciplines of artificial-intelligence-humanities (a term which feels particularly oxymoronic) or artificial-intelligence-arts. This could further widen previously existing gaps or even remove certain key disciplines from the curriculum.

As educators prepare children for life in a world with generative AI, we should consider that the possibility exists for greater injustice and stratification within society. Bender and colleagues note, "Combined with the ability of LMs to pick up on both subtle biases and overtly abusive language patterns in training data, this leads to risks of harms, including encountering derogatory language and experiencing discrimination at the hands of others who reproduce racist, sexist, ableist, extremist or other harmful ideologies reinforced through interactions with synthetic language" (Bender, et. al. 2021, p. 611). Generative AI has already begun to colonize the work of indigenous creators, scraping their art and culture, repackaging it, and selling it back to a wider, whiter, audience for consumption and profit (Marx, 2023; Hendrix, 2023). In what ways might algorithmic injustice and capitalism intersect with generative AI to widen representation and gaps in the discipline of the arts and humanities? As public educators working toward educating citizens for a more robust and multi-racial democracy, what should we be teaching about generative AI to work toward more just technological futures?

3. The Medium is the Message

The third point Postman emphasizes is that every technology embeds concealed, influential ideas and biases which, despite their abstract nature, impact the way people think, behave, and interpret their surroundings. These concealed factors shape our experiences and interactions with technologies, even though we may not be consciously aware of them. Technologies are NOT neutral with regard to their effects on individual and social cognition. Different technologies (or media) engender different mind-sets or ways of thinking, and these characteristics are inherent in the nature of the media itself and, thus, often invisible to the users of these media (McLuhan, 1964).

It is essential to consider what forms of understanding and knowledge are supported or suppressed by particular media. Different media shape cognition by preconfiguring how we process and develop cognitive structures. We borrow the idea of prefiguring from Hayden White's concept of "prefigurative scheme," where he argued that these are precognitive and precritical biases that guide how we perceive concepts within it and their interrelationships (Mishra, Spiro & Feltovich, 1996; White, 2014). As Postman wrote:

Every technology has a prejudice. Like language itself, it predisposes us to favor and value certain perspectives and accomplishments. In a culture without writing, human memory is of the greatest importance, as are the proverbs, sayings and songs which contain the accumulated oral wisdom of centuries. But in a culture with writing, such feats of memory are considered a waste of time, and proverbs are merely irrelevant fancies. The writing person favors logical organization and systematic analysis, not proverbs. The telegraphic person values speed, not introspection. The television person values immediacy, not history.

In other words, the key question for us to consider is that if oral cultures prioritize memory and print cultures emphasize systematic organization, what types of knowledge will AI systems foster?

The idea of media having a “prejudice,” as Postman puts it, plays out at two levels when it comes to generative AI. First, is that the tools themselves are prejudiced, trained as they are on human data, with all its imperfections. There is increasing evidence that these AI tools have built-in biases, reflecting broader social biases that already exist (Benjamin, 2020). Thus, these tools may inadvertently perpetuate existing biases or introduce new ones into educational content and resources, leading to the exclusion or underrepresentation of certain cultural, social, or historical perspectives, limiting students' exposure to a diverse range of ideas and knowledge (Warr, Oster, & Issac, 2023). Furthermore, these biases may lead to unfair treatment of students, perpetuating stereotypes, or unfairly disadvantaging certain groups.

There is also a deeper sense of prejudice that may be important for educators to consider. These are the concealed, almost below the level of conscious introspection, ideas that influence how we think, shape our experiences and interactions, and the kinds of meanings we make and value. This requires us to better understand how these systems work and interact with us.

Generative AI systems, at least in the form they currently exist, have certain unique characteristics, different from any technology that has come before it. Specifically, these generative AI technologies possess the unique capability to communicate with humans using language, a trait previously exclusive to humans. Moreover, these technologies can create and communicate not just with text but also through voice and image. They can read, see, and hear. Secondly, they can participate in extended dialogues, recalling past exchanges, taking turns in conversation, and more. Thirdly, they can adeptly simulate various interaction styles, personalities, and genres of interaction. Lastly, LLMs are equipped with vast knowledge spanning countless domains, though they can sometimes provide inaccurate or fabricated information (Mishra et al., 2023). The initial three capabilities endow these software entities with a semblance of personality and independent thought, making them appear psychologically tangible to us (Mishra et al., 2001). As a result, we often attribute to them cognitive emotions and intentions, such as beliefs and desires. In essence, these advanced, interactive technologies have become genuine social participants in our lives, interacting in a manner unparalleled by any preceding technology. Their expansive knowledge, coupled with their propensity to occasionally fabricate information, positions them as powerful influencers with the potential to reshape various societal systems, including the educational sector (Mishra, Warr & Islam, 2023).

Mishra et al. (2023) list a series of questions that we may be forced to consider going forward. Speaking specifically of teachers, they ask:

What does it mean to teach in an era where GenAI becomes part of our everyday life? In a time when it will be increasingly difficult to distinguish between AI-generated and human-generated content? As the boundary between AI- and human-generated content fades, how will it impact trust in information sources, institutions, and widely held social beliefs? Will GenAI technologies strengthen or erode these beliefs? Will they fuel confusion, skepticism, and anxiety, further exacerbating societal divisions, similar—or perhaps beyond—what we see happening with social media? ... How will our tendency to anthropomorphize, or attribute human traits to non-human entities, complicate matters further? Will these generative technologies, with their creativity, language-using, and seemingly social characteristics, heighten this confusion, creating a deceptive illusion of real, human-like interaction? What will this mean for children and youth who are still developing their sense of self and identity? How will the ripple effects of these developments affect educational systems that are already over-burdened and over-extended? ... Is there a risk of these institutions being perceived as ineffective or complicit in spreading misleading content? Moreover, how will they cope with the mental health consequences that may emerge, and how will they provide support to students navigating a world where truth is elusive and social and emotional confusion prevails? (p. 246).

Just as television emphasized the image over thought, generative AI will, we believe, over-emphasize the social nature of interaction. In an era where GenAI permeates daily life, discerning synthetic AI-generated content from human-created content will be almost impossible. As they write, this blurring boundary raises critical questions about our trust in information sources and societal institutions. Could generative AI, with its convincing, agentic language capabilities, amplify the mistrust, confusion, and divisions we've witnessed with social media? Could existing institutions be seen as perpetuating falsehoods or be deemed redundant? The ability to create new, plausible, realistic media about any topic whatsoever has significant implications for how we think about news, information, and politics. The kinds of critical knowledge skills required to recognize false information require educators and learners alike to understand the kinds of cognitive biases that bad actors will seek to exploit.

Furthermore, our inclination to anthropomorphize these technologies complicates matters further, intensifying the illusion of genuine human interaction. The availability of para-social agents, almost indistinguishable from real humans, requires that our students have the tools (cognitive, interpersonal) to navigate these interactions that will feel extremely real. Consider, for instance, the implications for youth, still shaping their identities, and what these “interactions” will mean for them and their development. There are significant developmental and mental health implications of living in a world where truth is elusive and societal confusion is rampant that may most surely fall on educators to address. With the ongoing GenAI race, as corporations prioritize competitive edge over societal implications, educators might once again bear the brunt of unforeseen consequences.

4. Technological Change is not Additive. It is Ecological.

Technological change is not a mere addition; it is ecological, meaning that the introduction of a new technology alters the entire landscape. As Postman wrote:

A new medium does not add something; it changes everything. In the year 1500, after the printing press was invented, you did not have old Europe plus the printing press. You had a different Europe. After television, America was not America plus television. Television gave a new coloration to every political campaign, to every home, to every school, to every church, to every industry, and so on.

Once a novel technology emerges, there is no turning back. A new medium doesn't just supplement existing elements; it transforms everything. For instance, the advent of print or television reshaped every aspect of society, from political campaigns and homes to schools, churches, and industries (Postman, 1985). Social media didn't just connect us to each other; its use transformed politics through the creation of information bubbles that blinkered our access to alternative perspectives and viewpoints (Vaidhyanathan, 2018). This process of hearing from and speaking just to those who agree with us changed our politics (for the worse) and facilitated the spread of misinformation. The emphasis of social media platforms to prioritize engagement and time spent on the platform over any other goal had a negative impact on the social-emotional well-being of teenagers across the world. These are often unforeseen consequences, but it is important to recognize that they exist, though they are hard to predict (Tenner, 1997). Moreover, the ramifications of such change are vast, unpredictable, and irreversible, making decision-making in this space too crucial to be left solely in the hands of any individual or group.

Though the impacts of AI on society at large are difficult to predict, there are some things that we do know. First, these large multinational companies at the forefront of the AI race are more committed to increasing shareholder profit than to the broader social good. This is apparent from the almost cavalier manner in which these AI tools were unleashed on the world, with little or no discussion or engagement with broader society. We now have an arms race between a small number of large multinational companies that are, for the most part, led by middle-aged men with a relatively narrow range of experience outside of Silicon Valley. Further, recent history (and lawsuits) with social media tools demonstrate that when advertising is the foundational economic model, companies will scrape our most intimate data to profile us for targeted advertising and suggest mis- and dis-information which keeps us engaged on the app (Zuboff, 2019). The danger of these new AI tools is that, given their social nature, they can be trained to be tools of persuasion—whether the goal is to buy particular products or to vote a certain way. Their deep knowledge of us makes us particularly vulnerable. If lies and misinformation on social media created epistemic tensions in society, imagine the shift in what we believe to be truth and reality when bad actors can harness the twin powers of microtargeting and generative AI.

This new technology of AI won't just add a feature to our existing societal framework but, as technologies that came before it, will reshape it entirely, altering how we perceive and interact with information. AI systems are not just gigantic information reservoirs; they have begun to shape our trust and faith in digital entities. This elevated trust in machines comes with the risk of manipulation, given AI's potential to navigate and exploit human cognitive biases seamlessly and imperceptibly. This potent capacity to persuade will most definitely be exploited by companies and political actors seeking to achieve their narrow goals. Thus, AI doesn't just supplement our decision-making processes but also introduces a new variable into our cognitive and ethical equations, inevitably affecting our perceptions of truth, authenticity, and morality.

This transformative dynamic between humans and AI could bleed into various aspects of society, influencing human interaction, psychological well-being, institutional trust, and broad societal norms. As AI systems become embedded in our social and institutional frameworks, they can inadvertently shape human interactions and societal values, sometimes enhancing connectivity and efficiency while, at other times, eroding interpersonal trust and emotional authenticity. We already see our culture often overly venerates technological rationality over human

intuition and emotion. The domino effect of this transition could impact our psychological and social landscapes, where our affiliations, alliances, and even dissent are potentially mediated by algorithmic influence, thereby reshaping societal structures, norms, and, ultimately, our collective human experience.

Of course, all this is extremely speculative, and it is difficult, if not impossible, to figure out what kinds of changes these new AI technologies will bring to society at large. That said, our students must be prepared for a world that may look very different than what it looks like today.

5. Technologies are Fictions

Technologies are frequently seen as an inherent component of the natural order, making them appear exempt from scrutiny (Postman, 1998). However, Postman highlights that technologies are human-made constructs developed within specific political and historical contexts. When a technology becomes mythic, however, it runs the risk of being accepted unquestioningly and is, therefore, not amenable to alteration or control. We need to recognize that, at the end of the day, these technologies are created for humans by humans and to understand that their potential for good or ill depends entirely on human awareness of their effects on us and our actions. As he wrote:

Media tend to become mythic — we think of our technological creations as if they were God-given, as if they were a part of the natural order of things. Cars, planes, TV, movies, newspapers—they have achieved mythic status because they are perceived as gifts of nature, not as artifacts produced in a specific political and historical context. When a technology become mythic, it is always dangerous because it is then accepted as it is and is therefore not easily susceptible to modification or control. The best way to view technology is as a strange intruder, to remember that technology is not part of God’s plan but a product of human creativity and hubris, and that its capacity for good or evil rests entirely on human awareness of what it does for us and to us.

This idea of technology becoming mythic is also applicable beyond technology as well. In fact, it is important to recognize that most of what constitutes our everyday world is artificial, or designed by humans. This includes physical objects like food and pets, which we often perceive as “natural” but have, in fact, been shaped over time through intentional human processes like artificial selection. Also, the scope of ‘artificial’ extends beyond physical artifacts to encompass intangible elements like race, gender, technologies, processes, systems, and culture. For instance, the educational system, with its schools, classes, credits, and degrees, has been designed (either intentionally or by historically contingent factors) and can be redesigned. Speaking in a different context, Yuval Harari speaks to this issue of the “designed” or “created” nature of our world. As he wrote:

Human rights aren’t inscribed in our DNA. Rather, they are cultural artifacts we created by telling stories and writing laws. Money, too, is a cultural artifact... What gives money value is the stories that bankers, finance ministers and cryptocurrency gurus tell us about it (Harari, 2023).

Recognizing the artificiality of things opens them up for questioning, reimagining, and redesigning. This “design” lens provides agency to enact change, as it counters claims that aspects of our world are inherently natural or essential. This is particularly relevant to education, which has often been treated as a natural phenomenon rather than a human creation.

These issues become even more salient in an age of generative AI. Speaking of these capabilities, particularly its language generation and dialogic capabilities, Yuval Harari argued that “AI has hacked the operating system of human civilization.” He goes on to write that “Language is the stuff almost all human culture is made of.” He goes on to ask:

What would happen once a non-human intelligence becomes better than the average human at telling stories, composing melodies, drawing images, and writing laws and scriptures? (Harari, 2023).

Though it is difficult to predict what that would mean in the long run, it is important to recognize that these “designs” are not necessarily intentionally created. In fact, it could be argued that some of the seemingly designed aspects of technology are often unintentional byproducts of broader systemic choices and decisions. For instance, there was no necessity for the economic underpinning of much of the Internet and social media to be based on

advertising. But once that choice was made, it was relatively inevitable that these platforms would move towards finding ways to collect data on people to predict their purchasing choices, keeping them on the platforms for longer durations of time by offering more extreme content and more. Thus, as we think of AI, we need to think beyond the propensities (or, as Postman says, “prejudices”) to the broader socioeconomic structure within which it functions. Ted Chiang, in a recent interview, said,

I tend to think that most fears about A.I. are best understood as fears about capitalism. And I think that this is actually true of most fears of technology, too. Most of our fears or anxieties about technology are best understood as fears or anxiety about how capitalism will use technology against us. And technology and capitalism have been so closely intertwined that it's hard to distinguish the two... (Chiang, 2021).

But distinguishing between the two is a must. And this is emergent from the idea that recognizing that technologies, media, educational systems, and most aspects of our environment are "fictions" in the sense that they have been designed by humans empowers us to redesign and reimagine them (Close et al., 2023). It also encourages a focus on ethical and responsible use in education and finding ways of ensuring these are embedded in how these tools are designed for the future.

CONCLUSION

In his essay, on which this piece is based, Postman described the ideas as “the sort of things everyone who is concerned with cultural stability and balance should know and I offer them to you in the hope that you will find them useful in thinking about the effects of technology.” We believe that his insights stand true even today in an extremely different cultural, social, economic, and technological context. We believe that a deeper introspection into these ideas and what they mean for our world offers deep insights for educators as we seek to navigate this complex landscape.

We close with the same question that we opened the essay with, “Why has the promised boom in educational technology failed to appear—and why was the technology that *did* appear not very good?” but raise it in the context of Generative AI. Will AI go the same way as did MOOCs, or is there something fundamentally different about this technology? We have aimed for a nuanced approach as we speculated on this answer. It suggests that seeing the presence of a particular technology in classrooms or other formal educational spaces may *not* be the only question worth asking. We must recognize that the classroom does not sit in isolation; it responds to how emerging innovations shape culture and the lived experiences of students outside school walls. While a new device may not change classroom activities overnight, its broader disruption of society frequently necessitates educational systems to respond. Thus, we argue, we must look beyond direct applications and consider how emerging innovations alter the cultural fabric, knowledge ecosystems, and human relationships that comprise the milieu in which learning occurs. Even when specific technologies are not directly employed in classrooms, they still affect education by altering the “ecology” within which education functions. This means that the impact of generative AI may not be immediately apparent within the classroom but is experienced more broadly throughout society. Thus, educators need to factor this into their practices to better prepare their students for an indeterminate yet transformed future.

The impact of technologies on the world at large is outside of the direct control of individual educators. Broader economic and social structures influence and determine the ways in which these technologies are taken up in society. Nonetheless, these are educational issues insofar as they change the context within which education functions and change the way we teach about the role of these technologies in our lives.

What is clear is that these technologies are here to stay. They will be a part of our children’s future. However, it is as important to acknowledge that the future is not written, and *how* and *when* and *to what extent* citizens decide to engage with generative AI is still emerging (Warr, Close, & Mishra, 2023). We, as educators, must be engaged in creating educational experiences that will help our learners embrace their individual and collective agency to flourish in this new world. The point is, regardless of whether these technologies enter the world of school, they *will* change the broader ecological social matrix that our students will live in, which needs to be factored into our practice.

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Applying Frameworks to Impact Teaching Practices

Integrating AI in Teacher Education Using the Teacher Educator Technology Competencies

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INTRODUCTION

Teachers, students, and teacher educators have entered the age of Artificial Intelligence (AI). Like earlier transformative information and communication technologies (e.g., printing press, telegraph, telephone, television, personal computer, and the Internet), AI includes impacts that are intended and unintended, seen and unforeseen, helpful and harmful. These technologies produce usable information and share harmful misinformation; supercharge creativity and unfairly profit off copyrighted creative materials; increase worker productivity and exacerbate societal and digital inequities; reach learners in new ways and put traditionally marginalized students at greater risk of harm. No wonder, when asked, teachers said they regard AI as both “friend and foe” (St. George & Svrluga, 2023, para. 6).

In this chapter, we make the case that AI’s (specifically Generative AI) immediate and longer-term educational impacts will depend in large part on how teacher educators and new teacher candidates understand it and make plans to integrate it critically and creatively into teaching and learning practices in schools and classrooms. We use the TETCs (Teacher Educator Technology Competencies) as a framework for what teacher educators need to know about and be able to do in their educational practice as AI-using educators.

AI IN EDUCATION

Artificial Intelligence (AI) refers to technologies with “an ability to deal with new situations; the ability to solve problems, to answer questions, to devise plans, and other functions that involve using methods based on the intelligent behavior of humans and other animals to solve complex problems” (Coppin, 2004, p. 4). Well before the surge of generative AI tools, AI-based technologies impacted many aspects of education, from administrative tasks (e.g., robo-graders) to teaching and learning (e.g., intelligent tutoring systems). Now the release of generative AI technologies (i.e., tools that generate new content, including text, images, audio, and video) have spurred more uses, as well as misuses, of AI in education.

What does AI do well in educational settings? While the answer to this question is still evolving, there are areas where AI chatbots, such as ChatGPT, provide multiple benefits for teachers and students (Baidoo-Anu & Ansah, 2023). For teachers, chatbots are an always-available teaching assistant and instructional planning resource to aid in generating learning plans, test and quiz questions, assessment rubrics, topics and questions for class discussions, feedback for students about their writing, and background information about people and events in a field of study. For students, chatbots can provide support for personalized learning, creative thinking, assessment, reading, writing, and research (Trust et al., 2023a). AI can help summarize complex readings, provide step-by-step directions for completing a learning activity, produce podcast and video scripts for class projects, offer support with each step of the writing process (e.g., brainstorming, drafting, revising, publishing), write computer code, translate text, and help overcome writer’s block.

At the same time, significant limitations and persistent issues accompany generative AI's entry into educational settings (Qadir, 2023). Given that chatbots are designed to mimic human writing, these tools have made it easy for students to generate content that they submit as their own – that is, to plagiarize homework and other school assignments. Many educational institutions have turned to AI text detector tools to determine if student work has been produced by AI, even though the results from these tools are rather unreliable (Dien, 2023; Nah et al., 2023). Educators worry that students may use AI tools for generating work with little or no critical or analytical thinking on their part, and studies have demonstrated the harmful impact of generative AI tools on students' critical thinking abilities (Sok & Heng, 2023). AI chatbots are also notably unreliable resources that make errors in mathematical calculations, confuse historical events, distort research findings, and in some cases, present totally made-up information (Tyson, 2023), a process known as “hallucination,” - a term that refers to “the phenomenon of a machine, such as a chatbot, generating seemingly realistic sensory experiences that do not correspond to any real-world input” (Alkaissi & McFarlane, 2023, p. 3).

AI technologies have incorporated inaccurate data and flawed algorithms and can present biased output. Kleiman (2023) noted that “the online texts used to train AI language models can include racist, sexist, ageist, ableist, homophobic, antisemitic, xenophobic, deceitful, derogatory, culturally insensitive, hostile, and other forms of adverse content. As a result, AI models can generate unintended, biased, derogatory, and toxic outputs. There is added danger of people using AI to create such content intentionally” (para. 36). Despite the efforts made by OpenAI, the creator of ChatGPT, to implement safeguards against biased and stereotypical output, users have still come across occurrences of, and methods to elicit, the generation of detrimental and biased content from the tool (Note: This sentence was revised and improved by ChatGPT).

Perhaps AI's most significant limitation is that users fundamentally misunderstand the tool and how it functions. As educators Angela Duckworth and Lyle Ungar noted, AI “knows everything on the Internet but doesn't really *think* anything” (2023, para. 10). Take ChatGPT, for example – in response to a prompt from a user, ChatGPT uses complex math and a massive dataset to predict which words should go together to generate the most human-sounding response (May, 2023). ChatGPT does not, and cannot, think reflectively or creatively; it is simply executing a programmed function. A chatbot is basically a “very sophisticated text prediction machine” (Mollick & Mollick, 2023, para. 10).

Developing an informed view of what GenAI technologies can and cannot do is an essential first step for teacher educators and teacher candidates before they can begin utilizing these tools effectively in schools and classrooms. That view includes being able to decide when to use them, when to not use them, and how to develop thoughtfully designed human-AI collaborations.

Learning With and About AI Technologies

With the emergence of AI technologies in K-12 schools, classroom teachers, teacher educators, new teacher candidates, and students now face a dual learning challenge: They must be prepared to teach *with* and *about* AI (e.g., Trust et al., 2023b). To teach *with* AI technologies involves providing students with the opportunity to explore and try out various AI-based tools, including intelligent tutoring systems and intelligent assistants (e.g., SIRI, Alexa) for personalized learning support; AI writing tools (e.g., ChatGPT, Bard, Quillbot) for creative thinking, reading, and writing support; and recommendation algorithms (e.g., Google search, YouTube, Facebook, TikTok) for building new content knowledge and skills. To teach *about* AI technologies means engaging students in critically investigating and questioning the role of these tools in education and society. Students need opportunities to reflect upon the ways AI is currently shaping their lives (e.g., Netflix recommendations, facial recognition for iPhone access, intelligent assistants built into smartwatches) and consider how AI will shape their futures. They must learn how to interact with AI in the most effective and productive ways (e.g., prompt generation). They need opportunities to critically engage with, learn about, and advocate for or against the use of these tools across all subjects and grade levels, and learn to make informed decisions about if, when, and how to use AI tools in their learning, personal lives, and future careers.

Shortsightedly, some schools, districts, states, and even countries have looked into banning – or have outright banned - AI technologies. Given the proliferation of AI technologies in society, banning these tools in educational settings or reverting to old-fashioned, low-tech teaching techniques like handwritten essays and oral exams will create a new type of digital divide between students who have access to and know how to use AI to improve their thinking, learning, and communication, and those who do not. Therefore, integrating AI technologies into teacher education is essential.

TECHNOLOGY IN TEACHER EDUCATION

For decades, the U.S. Department of Education Office of Educational Technology has noted that teachers often leave their teacher education programs ill-prepared to use technology in their practice (2010; 2016). The shift to emergency remote teaching (Hodges et al., 2020) made it clear that this lack of preparation can negatively impact a sizable number of students in schools.

For teacher educators, efforts to prepare teacher candidates to use technology are often beset by an overriding complexity. In theory, and most teacher educators probably agree, “technology should be used in classrooms and schools when it can afford new teaching and learning experiences that are not possible without the technology. Technology should redefine and transform learning, not just enhance it” (Trust, 2018, para. 2). But in many K-12 schools, “passive, rote-oriented learning focused on basic skills and memorization of disconnected facts has been and remains the dominant practice today” (Darling-Hammond & Oakes, 2019, p. 16). Teacher candidates get one vision for technology use from their college and university classes and another from their school placements. Many find themselves caught in the middle where “tradition and standardization trump new ideas and diversity” (Darling-Hammond & Oakes, 2019, p. 16).

Most teacher candidates say they want to use technology in the classroom because they believe it will positively impact student learning. But those same teacher candidates struggle to envision ways to use computers and other digital tools to generate student-centered learning experiences (Starkey, 2020). While most candidates believe they have the knowledge, skills, and attitudes to be technology-using educators, survey results have revealed that teacher candidates report low levels of technology literacy in terms of knowledge and skills (Dincer, 2018). Even as teacher candidates increase their use of technology during student teaching, many prefer working with pre-set technology templates rather than designing their own technology-based learning activities (Zakrzewski & Newton, 2022).

The COVID-19 pandemic and the shift to emergency remote teaching challenged the technology knowledge and skills of teachers and those becoming teachers in new and unprecedented ways. While educators increased their use of digital tools, the ways teachers used these technologies often supported traditional forms of classroom communication, information delivery, and management practices (Trust & Whalen, 2021). With the pandemic-era student learning losses, particularly in math and reading, well documented (Kuhfeld, Soland, & Lewis, 2022), educators now face a crucial choice as to whether a return to longstanding teacher-centered teaching and learning practices that might enable students to regain lost learning gains or take the risk of trying out new technology-driven pedagogical approaches with unproven results for improving student learning.

TEACHER EDUCATOR TECHNOLOGY COMPETENCIES

While teacher education often plays a catch-up role in response to the introduction of new technologies in society (Cuban, 2018), the rapid pace at which AI is evolving and impacting education and society demands a more proactive approach to preparing current and future teachers. Integrating AI into the Teacher Educator Technology Competencies (TETCs; Foulger et al., 2017) is one such approach to meet this demand.

The TETCs were designed to address the ongoing concern that teacher candidates leave their teacher education programs insufficiently equipped to teach with technology. Foulger and colleagues (2017) noted that “the Teacher Educator Technology Competencies (TETCs) were developed to support the redesign of teaching in teacher education programs so that ALL teacher educators are prepared to model and integrate technology in their teaching. Teacher candidates who receive consistent and appropriate experiences with technology throughout their teacher education programs will be more prepared to integrate technology into their own classrooms” (para. 1).

The TETCs consist of the knowledge, skills, and attitudes that are necessary for preparing teacher candidates to design high-quality 21st-century technology learning experiences. Since the TETCs were developed before the current AI revolution, we adapted the 12 TETCs to support teacher educators and in turn, teacher candidates in developing their AI literacy skills and knowledge. In the following section, we offer a description of each revised competency [*italics in each TETC indicates revised language*].

TETC 1: Teacher educators will design instruction that utilizes and encourages teachers to critically evaluate content-specific AI technologies to enhance teaching and learning.

Teacher educators and teacher candidates can use college courses and field experiences as opportunities to evaluate AI's usefulness as a content-specific instructional resource. Assessing content-specific AI is exactly what the Newark Public Schools, the largest school district in New Jersey, have been doing with Khanmigo, an AI tutoring tool developed for use in K-12 schools by Khan Academy. Educators have had mixed reactions. The tool provided useful resources in response to queries, but it also provided incorrect and even racially, gendered, and culturally biased information. In some instances, AI made up completely fake materials. Even more troubling to the educators was that AI could get in the way of independent thinking and problem-solving by students, helping them, in the words of one group of users, obtain information "too much, too fast" (Singer, 2023, para. 23). As increasingly more content-specific tools embed AI into their platforms (e.g., Duolingo recently integrated GPT-4), teacher educators need to provide current and future teachers with the opportunity to critically analyze the influence of these tools on student learning and academic success (e.g., do these tools support higher-order thinking and social interaction? Does the integration of AI into the tool improve students' abilities to meet the content-specific learning objectives?).

After evaluating content-specific AI technologies, teacher candidates should have the opportunity to design instruction using these technologies. Teacher educators can model how to do this by integrating these tools into their teacher preparation courses. Researchers Mollick and Mollick (2023, p. 4) have proposed seven ways for teachers to use AI in classrooms: an AI-tutor offers direct instruction; AI-coach prompts reflection; AI-mentor offers feedback; AI-teammate gives alternative viewpoints for learning groups; AI-tool supports getting specific tasks done; AI-simulator organizes learning through practice; and AI-student present explanations. There are potential benefits and potential risks for each. Teacher educators and teacher candidates might use this framework as a guide for considering what role they would like AI to play when teaching specific content and then designing instruction featuring content-specific AI technologies.

TETC 2: Teacher educators will incorporate pedagogical approaches that prepare teacher candidates to effectively use, and critically interrogate AI technology.

Critically examining the results one gets from AI technology, as presented in TETC 1, is just one essential evaluation approach for educators. To fully understand AI tools and how they may impact students and schools, teacher educators and teacher candidates also need to evaluate the social impacts of the technology itself, utilizing a "Civics of Technology" framework which assesses the effects of various technological developments on the lives of individuals and communities (Krutka, Heath & Smits, 2022).

From a civics of technology perspective, every technology generates both intended and unintended impacts. As historian Thomas P. Hughes (1989) showed in his study of technological change from the mid-19th to the mid-20th century, major innovations like incandescent light bulbs, television, gas-driven automobiles, and airplanes transformed American life but also produced unforeseen consequences that remain with us today: Environmental pollution from automobiles, airplanes utilized as lethal weapons of war, television promoting mass consumption of goods. Moreover, there were the social problems that followed from the "mechanization and systematization of life and from the sacrifice of the organic and the spontaneous" (Hughes, 1989, p. 4).

To fully examine the impacts of AI technologies, teacher educators and teacher candidates can adopt a perspective that explores both the intended and unintended impacts of the tools. Such a perspective is not easy to achieve. Technologies once regarded as novel are now taken for granted as commonplace and routine, so it takes a concerted effort to understand them more fully. For example, many people use apps on smartphones and other digital devices without ever examining the app's privacy policies that put their personal data at risk (Kelly et al., 2023). Users enjoy what the app provides without considering possible drawbacks.

Like other recent digital age technologies, AI tools, now new, may quickly recede from critical view as the conveniences they provide override concerns about reliability, accuracy, and over-reliance. A critical perspective, as the Civics of Technology curriculum urges, involves constantly asking who is harmed and who benefits from AI tools, and what are the unintended and unexpected benefits and consequences of using this tool for teachers and students.

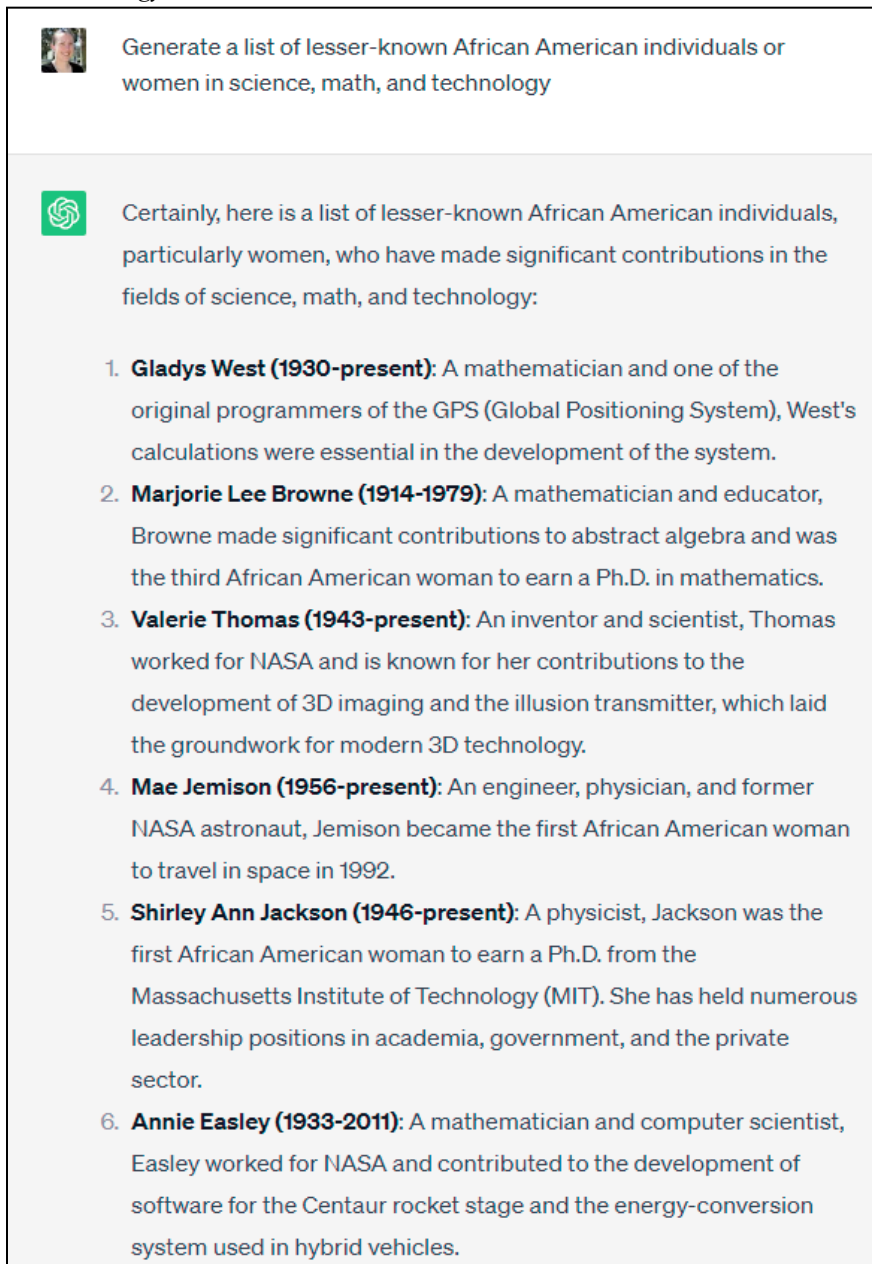
TETC 3: Teacher educators will support the development of the knowledge, skills, and attitudes of teacher candidates as related to teaching with AI technology in their content area.


Looking at how one university teacher education program implemented TETCs in secondary-level teaching methods courses, including those for mathematics, science, and social studies teacher candidates, researchers found that technology use in these courses was very content-specific (Burrows et al., 2021). University teacher educators mainly used technologies that were common in their subject field; mathematics faculty used 3D printing, Geogebra, robotics, and Sketchpad, among other technologies, while the social studies methods instructors introduced datasets, GPS, spreadsheets, and atlas. The researchers concluded that there was a need for a “more systematic and holistic reform approach, represented by the TETCs, to promote technology integration” (Burrows et al., 2021, p. 18).


Like the previously listed content-specific tools, AI technology can offer academic content area support for teachers. The amount of material an AI system can access and display is truly staggering. However, as it generates written language, an AI chatbot is repetitively executing a programmed function, but it is not thinking reflexively in the human sense of the term. Teacher educators and teacher candidates can turn to generative AI to obtain content-specific information, ideas, and materials; however, they must continually evaluate the results they get from their inquiries. For example, let’s say a science or history teacher asks ChatGPT to generate a list of lesser-known African American individuals or women in science, math, and technology. AI will do so, and the results may be impressive in speed and scope (see Figure 1). However, the AI chatbot has not made judgments about who or who is not “lesser known.” A distinction between known and lesser known is beyond the current capacities of the system. The information provided may also be incomplete and/or incorrect. For this reason, with the AI response in hand, users need to critically assess the credibility, trustworthiness, and authenticity of the content-specific information. AI’s response is just a starting point, not an endpoint for content-specific information and learning.

Figure 1

ChatGPT Response to “Generate a list of lesser-known African American individuals or women in science, math, and technology”



 Generate a list of lesser-known African American individuals or women in science, math, and technology

 Certainly, here is a list of lesser-known African American individuals, particularly women, who have made significant contributions in the fields of science, math, and technology:

1. **Gladys West (1930-present):** A mathematician and one of the original programmers of the GPS (Global Positioning System), West's calculations were essential in the development of the system.
2. **Marjorie Lee Browne (1914-1979):** A mathematician and educator, Browne made significant contributions to abstract algebra and was the third African American woman to earn a Ph.D. in mathematics.
3. **Valerie Thomas (1943-present):** An inventor and scientist, Thomas worked for NASA and is known for her contributions to the development of 3D imaging and the illusion transmitter, which laid the groundwork for modern 3D technology.
4. **Mae Jemison (1956-present):** An engineer, physician, and former NASA astronaut, Jemison became the first African American woman to travel in space in 1992.
5. **Shirley Ann Jackson (1946-present):** A physicist, Jackson was the first African American woman to earn a Ph.D. from the Massachusetts Institute of Technology (MIT). She has held numerous leadership positions in academia, government, and the private sector.
6. **Annie Easley (1933-2011):** A mathematician and computer scientist, Easley worked for NASA and contributed to the development of software for the Centaur rocket stage and the energy-conversion system used in hybrid vehicles.

TETC 4: Teacher educators will use *and critically investigate the use of online AI-based tools* to enhance teaching and learning.

Evaluating the use and design of online AI-based tools (e.g., ChatGPT, Dall-E, Bard, Stable Diffusion, Slides AI, Claude, Jasper AI, Quillbot) benefits from a critical media literacy perspective. Media literacy is “the knowledge, skills, and competencies that are required in order to use and interpret media” (Buckingham, 2003, p. 36). Critical media literacy extends the concept of media literacy to include an exploration of how power dynamics,

ownership, production, representation, audience, and distribution influence users' engagements with media (Butler, 2021).

To support educators in, as set forth in TETC 4, *critically investigating* the use of online AI-based tools, we developed a critical media literacy guide (<https://bit.ly/cmlguidesai>; Maloy et al., 2021). This guide features a series of prompts that teacher educators, teachers, and students can use when interrogating AI-based tools. The prompts focus both on the forward-facing content produced by AI tools as well as the behind-the-scenes of each medium and address both representations of the power of construction and of distribution. To examine AI writing tools, educators could ask, among other questions, “Who created the AI writing tool, and why did they create it?” “Who trained the AI writing tool?” “What dataset was used to train the AI writing tool?” “How does the diversity (or lack thereof) of the dataset influence the output of the AI writing tool?” and “How does this tool make money?”

To examine the text produced by AI tools, educators might ask, “What information is presented?” “What information is missing?” “Why do you think that information is missing (consider that ChatGPT generates text based on its training dataset)?” “What type of language and word choices are used to convey ideas and information in the text?” All these questions invite teacher educators and teacher candidates to decide for themselves who is benefiting and who is potentially harmed by online AI-based tools and what educational policies and practices are needed to maximize benefits and minimize harm when using these tools.

TETC 5: Teacher educators will use *and critically investigate* the use of AI technology to differentiate instruction to meet diverse learning needs.

Individualizing or personalizing learning for every student has been a long-sought and largely unrealized goal of 20th and now 21st-century education. To individualize learning means that teachers are able to reach every student where they are academically and provide them with the optimal combination of resources and support they need to move forward to learn what they want and need to learn. Individualizing learning is often discussed in terms of DI (differentiated instruction) and UDL (universal design for learning), where teachers make adjustments to instruction to reduce barriers and accommodate the learning needs of each student.

Using technology to make individualized learning possible has a long history, reaching back to the early years of the 20th century (Watters, 2021). Researchers and psychologists Sidney Pressey and B.F. Skinner envisioned machines “giving students immediate feedback on their errors and allowing them to move at their own pace until they’ve mastered a concept” (Watters, 2021, p. 246). In the 1960s, Mathematician Seymour Papert – originator of the learning philosophy of “constructionism” and the Logo computer language – viewed the role of technology very differently. He sought to design ways for children to use computers for open-ended explorations of their ideas, as in his classic statement that the child needs to be free to program the computer rather than let the computer program the child (Papert, 1993).

Today’s schools include multiple technologies intended to personalize learning for students, including intelligent tutoring systems, assistive technologies, smart devices, and now AI chatbots. Papert’s understanding of the competing relationships between children and machines frames the challenge facing teacher educators and teacher candidates: Does AI technology control the student, or can the student control their use of AI technology? Current and future educators must critically assess how personalized learning is actually happening in classrooms and whether AI tools are expansively differentiating instruction or promoting mainly the memorization of factual and procedural information over creative and critical thinking.

TETC 6: Teacher educators will *critically investigate* the use of AI technology tools for assessment, *paying close attention to the biases built into these tools that can negatively impact learning and academic success.*

Every teacher is constantly involved in assessing student learning. Assessment is how teachers answer the ongoing “I taught, but what did students learn?” question. Assessment, done formatively and summatively, provides a framework for what content to teach and when and how to teach it. Knowing what students are learning and still need to learn is so essential that the widely used Understanding by Design (Wiggins & McTighe, 1998) instructional planning framework insists that teachers decide before they teach how they intend to evaluate what students have learned and are able to do with the material presented.

AI tools offer resources for the assessment of learning that can be tremendously useful to teachers. AI chatbots can produce rubrics to evaluate student work, test/quiz practice questions, study guides, formative and

summative assessment ideas, and summaries of textbooks and teacher presentations for students to review before an exam. These tools can also analyze student data that teachers upload and offer advice and insights based on the data.

However, OpenAI (2023), the creator of ChatGPT, noted that “it is inadvisable and against our Usage Policies to rely on models for assessment purposes. Models today are subject to biases and inaccuracies, and they are unable to capture the full complexity of a student or an educational context. Consequently, using these models to make decisions about a student is not appropriate” (para. 22). Given the time constraints and demands of the profession, it is likely that teachers may turn to AI tools to aid with their assessment design and practices without realizing that these tools are not designed to be assessment tools. Therefore, teacher educators must role model the critical investigation of these tools and determine when these tools might aid assessment practices and when their use for assessment might harm students’ learning outcomes and academic success.

TETC 7: Teacher educators will *critically investigate how AI technologies might influence teaching online and/or in blended/hybrid learning environments.*

Online learning in K-12 education is now a vast enterprise that includes combinations of fully online courses, hybrid or blended instruction, synchronous and asynchronous interactions, and virtual schools where students never enter brick-and-mortar buildings. In theory, teacher education programs are expected to prepare new teachers for all these educational formats – a huge undertaking given that identifying and documenting best practices in online learning in K-12 education is a still-emerging field of educational research.

Looking at hundreds of research papers for a comprehensive review of K-12 online learning practices in the U.S., researchers from North Carolina State University found that best practices are still being identified and established (Johnson et al., 2022). Based on their research, they identified seven key pillars of effective online education: 1) evidence-based course design, 2) connected learners, 3) accessibility, 4) supportive learning environment, 5) individualization and differentiation, 6) active learning, and 7) assessment. Interestingly, the researchers found that many practices deemed effective in online settings are exactly those previously found to be effective in face-to-face settings (Johnson et al., 2022). They also noted a pressing need for research on how to prepare new teachers for online learning situations.

With the increase in availability of generative AI tools, it is likely that these tools will play a role in teaching in online, blended, and hybrid learning environments - but what role will they play? Teacher educators might use the seven key pillars of effective online education as a starting point to examine whether and how AI technologies might aid digital and blended instruction. Indeed, teacher educators and teacher candidates could conduct their own action research investigations as they experiment with how AI can be used in these settings. Those case studies from the field can inform and expand everyone’s understanding of how learning happens in all educational settings.

TETC 8: Teacher educators will use AI technology to connect globally with a variety of regions and cultures.

The United States is a multicultural and multilingual society. The organization Translators Without Borders (2023) estimates that between 350 and 430 languages are spoken in the U.S., including more than 40 million Spanish speakers. The Census Bureau (2022) reports that after Spanish or Spanish Creole, the next most frequently spoken languages other than English (LOTE) at home are Chinese, Tagalog, Vietnamese, and Arabic, each with well over 1 million speakers. The number of English Learner (EL) students in public schools has continued to increase to some 5 million learners, which is 10% of the national student population (National Center for Education Statistics, 2023). All these multiple language speakers bring a wide variety of cultural traditions and backgrounds to classroom learning activities.

AI technologies offer unparalleled ways for teacher educators and teacher candidates to connect education to students’ languages and experiences. For example, no single educational organization can translate curriculum materials from English into every language spoken by students in a school, but AI can do that instantly. AI translators are expanding from text-based translations to spoken language translations. In 2022, Meta AI announced that it had developed a speech-to-speech translation system for Hokkien, a widely spoken Chinese language that lacks a written form. Meta is continuing to expand AI translation resources through its *No Language Left Behind* and *Universal Translator* Initiatives. AI technologies, like the ones created by Meta and the ones not yet invented, will likely play a role in global commerce, communication, and collaboration. Teacher educators need to provide teacher candidates with the opportunity to explore these tools and consider ways to break down the walls of their classrooms to create global, multicultural learning experiences.

TETC 9: Teacher educators will address the legal, ethical, and socially responsible use of AI technology in education.

Concerns about illegal, unethical, and socially irresponsible uses of AI technologies are on the rise. Teachers are concerned about students using AI to plagiarize assignments, but unscrupulous individuals and corrupt organizations are using AI to easily generate and widely disseminate fake and false information in many areas of society. Political campaigns are making use of deep fake videos and voice cloning. AI-generated art creates forgeries and copyright violations. AI image generators produce materials that promote and perpetuate racial and gender biases. AI facial recognition software puts people's privacy at risk in new ways. The need for greater ethical use of AI prompted all 193 member states of UNESCO to adopt "Recommendations on the Ethics of Artificial Intelligence" in November 2021. Additionally, the United States White House produced a Blueprint for an AI Bill of Rights (2022) that, they stated, was designed for "the older Americans denied critical health benefits because of an algorithm change. The student [who] was erroneously accused of cheating by AI-enabled video surveillance. The fathers [who] were wrongfully arrested because of facial recognition technology. The Black Americans [who] were blocked from a kidney transplant after an AI assumed they were at lesser risk for kidney disease. It is for everyone who interacts daily with these technologies—and every person whose life has been altered by an unaccountable algorithm" (para. 11).

Teacher educators and teacher candidates must ensure they understand how to use AI in ways that are legal, ethical, and socially responsible. While there are no AI-specific frameworks for investigating the legal, ethical, and socially responsible use of technology in education, educators can turn to the Civics of Technology website (<https://www.civicsoftechnology.org/>) for curriculum materials organized around critical questions for teachers and students to consider as they examine the impact of computers, smartphones, and other digital tools on their own lives and society in general. Or teacher educators might collaborate with teacher candidates in designing their own responsible use guide for AI in education.

TETC 10: Teacher educators will engage in ongoing professional development and networking activities to improve the *critical* integration of AI technology in teaching.

More than five decades ago, sociologist Philip Jackson (1968) described teaching as a state of being lonely in a crowded room. Jackson was responding to the pressures teachers faced from long hours, large classes, incessant demands to cover the required curriculum, and increased administrative and recordkeeping functions. Surrounded by youngsters all day long, teachers were isolated from colleagues with limited opportunities for collaborative curriculum planning and professional development discussions. Little has changed over the years in the work lives of many educators, even as new technologies like AI are generating enormous changes in how students learn and how schools function.

PLNs (professional learning networks) and blended communities of practice are proactive ways for teacher educators and teacher candidates to respond to teacher isolation and the need for ongoing professional development and networking among educators. PLNs are "uniquely crafted and dynamic learning ecosystems, consisting of people, spaces, and tools that meet an educator's professional needs, interests, and goals" (Trust et al., 2022, para. 1). While blended communities of practice provide opportunities for teachers to interact professionally through online discussions, meetings, and conferences and promote growth as individual educators, classroom innovators, and school leaders (Trust & Horrocks, 2016).

PLNs and blended communities of practice offer teacher educators and teacher candidates opportunities to document, discuss, and contribute to decisions about issues and policies related to AI technology in their schools and classrooms. Multiple formats, including X (formerly Twitter) chats, webinars, online conference workshops, participant-driven unconferences, and interactions on social networks, can support professional learning about AI. A key is for teacher educators and teachers to be active action researchers who are continually investigating the impacts of AI in their practice and sharing their experiences with colleagues. Shared exchanges limit isolation and expand understanding about how AI is and can be used productively for teaching and learning across grade levels.

TETC 11: Teacher educators will engage in leadership and advocacy for or against using AI technology based on their own critical analysis and research on AI in education.

Teacher leadership is one of those terms used by nearly everyone in education. It has been called the “heart of transformation in any school” (National Education Association, 2018, para. 2), a way to “build the entire school’s capacity to improve” (Harrison & Killion, 2007, para 1); it enables educators to “facilitate meaningful change and support better outcomes for their students” (American Institutes for Research, 2022, para. 1). Many college and university educator preparation programs stress that they prepare licensure candidates who will be both teachers and leaders, and many teacher educators see themselves as leaders and advocates for change.

Any teacher can be a leader. Leadership is not tied to multiple years of seniority in a school, having a position on a building or district administrative team, earning a high salary, or being the most dominant voice in meetings or gatherings. Leadership happens when teachers focus on making equitable and impactful educational outcomes happen for students, colleagues, and families within the curriculum and culture of the school. Teachers lead formally and informally, first and foremost through interpersonal interactions and instructional activities with students but also “when they share their knowledge and experience with other teachers, lead professional learning opportunities, serve on ad-hoc and formal committees and task forces, and work with parents and families” (Levin & Schrum, 2017, p. 4).

Within this view of teacher leadership, teacher educators and teacher candidates can neither completely embrace nor totally reject the presence of AI technologies in schools. On its current scale, AI is still too new for sweeping definitive judgments about all good or all bad. No technology is ever just one or the other. Every tool must be thoughtfully considered and thoroughly examined to identify its impacts. Teacher research, meaning to “re-search” or look again and again, is essential when considering any technology, especially one evolving as rapidly as AI.

Action research offers every teacher educator and teacher candidate opportunities to critically examine AI technologies, develop positions for or against certain applications based on evidence, and share those insights with others using print and social media. In building more equitable educational outcomes, teacher-based action research needs to be grounded in a “critical participatory action” framework that is committed to “documenting, challenging, and transforming conditions of social injustice” (Fine & Torre, 2021, p. 1). In this way, teacher researchers not only examine issues and problems but actively engage in addressing them while documenting their work so as to inform the teaching practices of other educators.

TETC 12: Teacher educators will apply basic troubleshooting skills to resolve AI technology issues.

Computer literacy was a much-used term decades ago at the beginning of the technological revolution in education. Computer-literate students and teachers were expected to know the basics of computer hardware and software, everything from the names of key components (mouse, RAM, CPU) to essential system commands (“control + S means save”). Today, with digital tools being integral parts of nearly every aspect of daily life, educators need to think more broadly in terms of digital literacy for themselves and students. Digital literacy encompasses all aspects of the digital experience through “the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills” (ALA Literacy Clearinghouse, 2023).

Using digital technologies all the time has tended to minimize people’s understanding of their technical inner workings. Students, and many teachers too, just assume new technologies are going to work rather than spending time “looking under the hood” to figure out how they work. The result is that most students are less prepared to troubleshoot a digital tool when issues arise, and issues are constantly emerging, especially in the case of AI technology.

Teacher educators and teacher candidates can benefit immensely from learning how AI tools function technically and how users can troubleshoot their use. For example, AI chatbots are not super search engines but systems that draw from the information on which they have been trained. Such systems are incredibly powerful but also capable of producing inaccurate responses, biased information, and potentially damaging misinformation known as “hallucinations.” Developing a troubleshooting perspective as part of teacher preparation classes would be a way to bring the issues of misinformation and hallucinations to everyone’s attention.

Acting as informed and prepared troubleshooters, teacher educators and teacher candidates can learn to critically evaluate the results that they get from AI chatbots. Troubleshooting can also mean developing skills as “prompt engineers” who know how to effectively phrase information requests, what one observer called “golden prompts,” to increase the likelihood of getting useful and credible responses from AI systems (Chen, 2023, para. 9). Golden prompts give chatbots more precise parameters for its responses to inquiries. For example, when seeking assistance in preparing for a high-stakes exam, a user might prompt the system to “act as if” you are a tutor for the SAT. To study the work of writers in history, a user might prompt the system to “write in the style of . . .” and then compare the AI chatbot’s responses to actual text from the writer. The more users interact with AI tools, the more opportunities they have to build their knowledge and skills for troubleshooting these new technologies.

CONCLUSION

AI is already deeply embedded into society and is shaping the way people think, communicate, and behave – including providing recommendations for what to watch, eat, buy, read, write, and even how to travel. The rapid growth of computing power and access to BIG data means that AI will continue to be programmed to be even more “intelligent.” New AI tools, apps, and platforms are being launched nearly every day. AI will be a large part of everyone’s future. In NFX’s Generative Tech Open Source Market Map, Currier (2022) highlighted more than 450 generative tech (AI) tools being built by startup companies, which have raised more than \$12 billion in funding. Many of these tools will have an impact on education. The time is now to prepare current and future teachers to teach *with* and *about* AI. Revised and AI-updated, the TETCs offer future-focused guidance for teacher educators as they seek to prepare pre-service and in-service teachers to navigate the ever-changing, technologically advanced educational landscape.

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Pedagogical Models and Generative AI Fluency: A Three-Tiered Empirical Framework Approach

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INTRODUCTION

The Horizon Report (2023), a collaboration between the New Media Consortium (NMC) and Educause, identifies emerging technology trends in education and predicts the time from recognition to exploration to adoption. With each iteration of the annual report, the report's panelists are careful to point out that, even though many trends have ultimately been adopted into and are actively used in instructional spaces, understanding the long-term impact on teaching and learning is in its relative infancy, particularly with the marked increase in the use of AI multimodal platforms to deliver instructional content. As noted in the 2023 report, AI now plays a ubiquitous role in how and where teachers and learners interact within multimodal generative learning spaces. With the insertion of these technologies into traditional spaces, the lines between human-to-human, hybrid, and virtual learning are becoming increasingly blurred, resulting in educational institutions using a variety of curricula, frameworks, platforms, and terminologies to design and deliver instruction. While AI has been a trending topic in educational literature over the past decade, the launch of ChatGPT in November 2022 accelerated the need for PK-20 educational institutions to consider the short- and long-term implications of using generative AI-powered technologies in human-to-human or virtual classrooms. Here, it is important to note that while educators may recognize the name AI and have heard of some AI programs such as ChatGPT and Cactus AI, for most, their understanding of how these programs and affiliated technologies can impact teaching and learning is *beginning to developing* at best which can directly impact their confidence, implementation, and readiness to teach in AI modalities (Ayanwale et al., 2022; Hall et al., 1975). Therefore, educators must employ the best teaching and ethical practices and have the accompanying digital skills/levels of use necessary to integrate AI in the classroom for positive learning outcomes, especially with the variety in implementation and modalities. Therefore, these digital literacy skills and levels of use must be scaffolded within a best practices framework (e.g., Technological, Pedagogical, and Content Knowledge or TPACK). Understanding AI within a best practices framework enables educational stakeholders to address the multifaceted implications of integrating generative AI into teaching and learning spaces, such as pedagogy, governance, and operation within an educational setting (Chan, 2023). This is especially important when integrating generative AI, as there must be appropriate gatekeepers to ensure the interactions meant to mimic human interactions using texts, sounds, and images are responsive to any potential manipulation that would negatively alter the curricular content and circumvent the intended learning outcomes, such as seen with deep fakes (digital alteration of a person's face or body in a video to alter the original content to spread misinformation). A parallel issue of the disruption of direct human-to-human contact raises significant ethical questions about abdicating select or all teaching and abdicating select or all learning to generative AI modalities. Generative AI programs have enabled content developers to alter, manipulate, or completely change images and video within digital teaching and learning spaces, some to the extent that recognizing the difference between the original and edited versions is almost indistinguishable. In short, generative AI uses deep learning techniques such as neural networks to create text, sounds, and images that mimic human creations and interactions, which must be properly vetted through a framework such as TPACK to address the hermeneutical circle and ethical questions in digital content as translated from the human-to-human experience using generative AI.

In considering the introduction of generative AI programs into traditional teaching and learning modalities, it is important to consider the intersection of theory and practice. In an era where emerging technologies profoundly influence teaching practices and learning spaces, educators find themselves at the crossroads of being innovative while at the same time maintaining instructional integrity. As traditional human-to-human classrooms are reimagined to include digital learning spaces, it is imperative to harmonize instructional spaces with a proven empirical framework or frameworks to scaffold successful implementation. Accordingly, in this chapter, the author explores the hermeneutical interplay between TPACK through the empirical lenses of the Johari Window and Hall et al. (1975) Levels of Use (LoUs). Central to this exploration is the type of scaffolding and LoUs needed to facilitate

learners navigating the complex terrain of generative AI learning modalities and spaces. Here, the awareness of the digital self and its proximity to the AI modality is essential for actualizing teaching and learning outcomes. Using a layered approach, the author curates an ensemble of theoretical frameworks to proffer a three-tiered scaffolded approach to inform best pedagogic practices in the evolving landscape of AI-enabled education. The Technological Pedagogical and Content Knowledge (TPACK) Framework, an established pedagogic framework, is the foundational scaffold for a comprehensive integration of technology, pedagogy, and content in AI-powered teaching modalities. In tandem with this, the Johari Self-Perception Window presents a lens through which the nuances of individual cognitive perceptions and hermeneutic cyclical interpretations merge, creating a synergistic interplay between learners, educators, and the AI-mediated learning environment. The Levels of Use (LoU) framework completes the third tier by capturing digital literacy and technical growth as educators and learners navigate the intricacies of AI-powered modalities.

The work of Eshet-Alkai (2004), who delineated the digital literacy skill subsets, is central to understanding how the three-tiered framework reveals the discreet and requisite cognitive and technical proficiencies needed to interrelate digital proximal self-awareness to progression among the LoUs. These digital skill subsets inform the three-pronged framework by revealing how intentional scaffolding explains effective AI teaching and learning. Each framework's embedded scaffolding guides educators and learners toward cognitive adaptability and technological readiness within AI-driven modalities. While several notable AI programs can be examined as impacting the transition from human-to-human to human-to-technology learning environments, this writing focuses on ChatGPT. This generative AI program exemplifies the emergence and integration of conversational AI into traditional teaching and learning practices. Further, considerations of how effective instruction scaffolded within the three-tiered framework approach can apprise the criticality of preparing learners to understand their digital self-perception, discern their proximity and positionality within the AI-powered space, and respond proficiently to the intricacies of digital self-perception through a hermeneutic lens. The convergence of the three-tiered framework approach with discrete digital literacy skills forms a synergistic nexus where traditional human-to-human teaching and learning interactions are merged and intertwined within generative AI programs.

Intentional Scaffolding: Nurturing Cognitive Adaptability in AI Learning Spaces

The selection of the three-tiered framework was deliberate. First, the TPACK framework integrates technology and pedagogy to facilitate cognitive development contextually situated within subject-area content, enabling a synergistic interplay between generative AI learning modalities and effective teaching strategies. The TPACK framework's fusion of technological proficiency, pedagogic best practice, and contextualized content provides the anchor tier within the three-tiered approach. Second, the Johari Window extracts the cognitive and contextual components of the TPACK framework, interlacing them among individual cognitive perspectives and positionalities, fostering a deeper awareness of the self and others in digital learning spaces. Within generative AI modalities, where human-to-technology interaction develops, the Johari Window's quadrant of "blind spots" and "hidden selves" demonstrates the need to enable learners to implement appropriate digital proximity and positionality by facilitating introspective awareness. This awareness syncs the development of metacognitive strategies, thus empowering learners to critically assess their engagement with AI-generated content, enhancing their digital proximal perceptions and analytical judgment. Third, the LoU framework provides a process that addresses the stepped progression of technical aptitude, which provides a structured approach that harmoniously integrates TPACK and Johari within a hermeneutic cycle. Navigating generative AI programs requires understanding deeper technical adeptness and a logical progression demonstrated in the LoU framework. Stages III-VI of the LoU framework capture the gradual evolution from mechanical utilization to fluid integration, mirroring learners' digital learning path in AI-powered modalities. The LoU's emphasis on technical proficiency dovetails TPACK's technological facet, collectively creating an empirical symmetry where cognitive agility and malleability develop alongside technical dexterity.

Ultimately, the three-tiered framework approach aims to understand the transitional implication of generative AI programs and learning spaces on the human-to-human versus the human-to-technology generative teaching and learning relationship. As AI-enabled tools empower educators to streamline instructional content, context, and delivery, they can invest greater time and energy into fostering nuanced human connections by creating more personalized learner experiences. Ironically, the educator's evolving role underscores the value of human-to-human experiences in educational contexts. However, it is important to note that the rise of generative AI in pedagogical spaces raises ethical questions about the proper balance between human expertise and algorithmic instruction. As generative AI becomes an important modality in teaching and learning, educators must thoughtfully navigate the boundary between delegation and empowerment to ensure that AI remains a complement rather than a

replacement for human-to-human interactions. The three-tiered framework is designed to embed cyclical iterations so educators can reassess instructional design and learning outcomes based on learner performance on content instruction and key assignments completed using generative AI.

THE THREE-PRONGED FRAMEWORK: SITUATING GENERATIVE AI (CHATGPT) WITHIN CURRENT EDUCATIONAL FRAMEWORKS

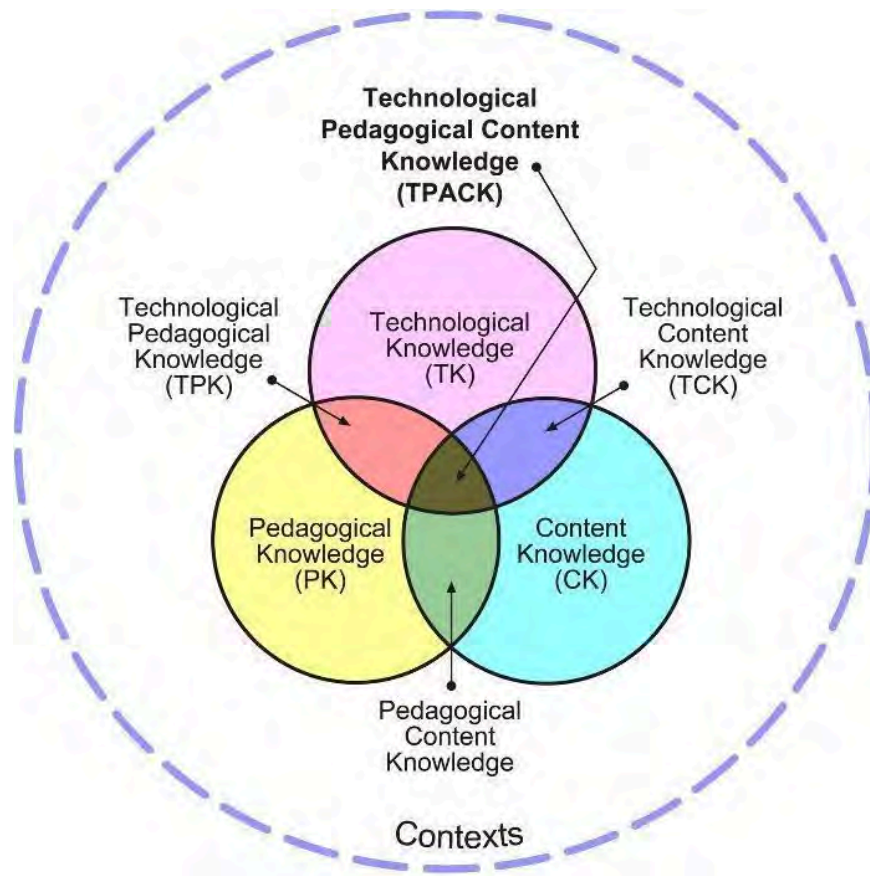
Framework 1 TPACK: Integrating Technology, Pedagogy, and Content Knowledge

The TPACK framework, developed by Mishra and Koehler in 2006, is an extensively researched empirical framework educators can use to bridge the gap between technology, pedagogy, and content (context) knowledge. Recognizing technology's emerging and rapid integration in human-to-human learning, Mishra and Koehler introduced the technology component to Shulman's (1986) existing pedagogical content knowledge model. The original TPACK framework was conceptualized at the beginning of the 21st century when routine technology integration in educational contexts was in its relative infancy. The framework's underlying epistemology is that effective teaching and learning occur at the intersection of three main domains and their related subdomains (see Figure 1). Prensky (2013) noted that the technology-driven brain functions within a different cognitive plane, resulting in the need to reimagine the relationships among teachers and learners as they interact, think, learn, and create in digital spaces. This is especially true when teaching and learning are supplemented or occur entirely in generative AI programs. Prensky further posits a new way to demonstrate content acquisition using higher-order, context-based solutions to real-world issues, aligning with TPACK domains and subdomains. As Lee (2021) asserted, scaffolding learners' epistemic cognition while working across different virtual modalities is essential to ensure learners' contextual proximity and perception are not negatively impacting or interrupting learners' cognitive growth. This is imperative when human-to-human interactions are supplemented or replaced with AI-powered modalities.

When considering the implementation of generative AI like ChatGPT, educators must balance integrating modalities while maintaining subject matter integrity and scaffolding learners' digital literacy skills filtered through their current level of use. In the context of digital literacy skills, the Technological Content Knowledge (TCK) subdomain helps educators scaffold the human-to-human to generative AI transition by emphasizing that it is not enough for learners to possess generic technical competence. Rather, they must also comprehend how to use AI tools purposefully within the context of their learning objectives with a more discrete set of digital literacy skills that must be scaffolded and intentionally taught. This type of supportive scaffold would be what Lantolf & Thorne (interpreting Vygotsky's theory of the Zone of Proximal Development, 2006) denotes as being "other" regulated. The other regulation occurs as the educator scaffolds learners through technology to reach learning objectives using specific digital literacy skills. Even though generative and predictive AI were already integrated into technologies traditionally used by educators and learners, their use was less intentional and more mechanical. These include technologies such as word processing programs with predictive spell and grammar checks. These programs allow animation, stylized presentations, and workbooks with data sorting and analysis. Such technologies are characterized by their normative, static use and are used for more linear-processed outcomes. Thus, the LoU would be Level III, or mechanical, informed by information literacy as a discrete skill. In this state, the learner would be learning as the "blind self," indicating that the educator knows information about their digital literacy unknown to themselves. Under this framework, the objective of using ChatGPT would be for the learner to interact with subject matter content using the AI chatbot to evolve into the known self and become self-regulated by transitioning to higher LoUs informed by photovisual contextual reproductive digital skills. For educators in educator preparation programs (EPP), the TPACK framework is the anchor for the three-pronged approach with its infusion of technology knowledge in content and pedagogy. Faculty can use the TCK and TPK subdomains as best practice reference points when developing learning outcomes, creating key assignments, and designing instruction infused with generative AI modalities.

Figure 1

The Technological Pedagogical and Content (Context) Knowledge Model conceptualized by Mishra & Koehler, 2006



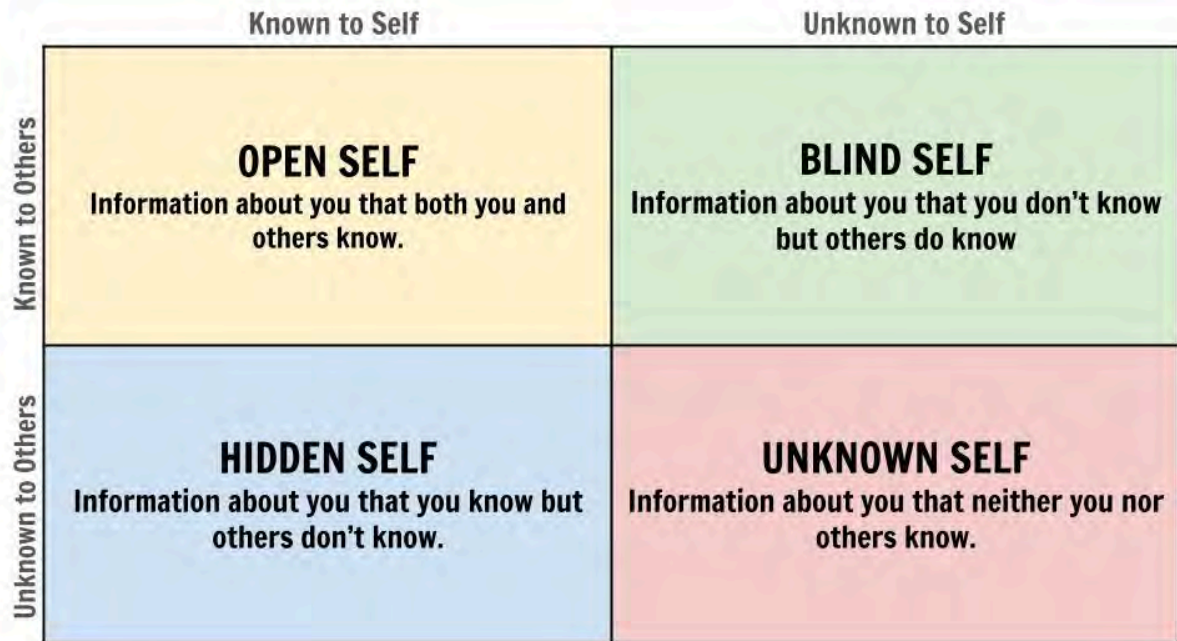
Note. Retrieved from <http://tpack.org> and reproduced with permission of the publisher, © 2012.

Framework 2: The Johari Window: Navigating Digital Cognitive Perspective Realities

Luft and Ingham's (1955) Johari Window offers a distinctive perspective on individual self-awareness. The model distributes knowledge about the self among four areas: the open self (known to self and others), the hidden self (known to self but hidden from others), the blind self (unknown to self but known to others), and the unknown self (unknown to both self and others). In digital learning spaces, the Johari Window provides a lens through which a learner's self-perception informs their human-to-human and generative interactions. Understanding one's cognitive positionality becomes especially pertinent when learners engage with generative AI. As they interact with AI algorithms, their self-perception influences their ability to assess and interpret AI-generated content critically. Thus, awareness (emphasis on digital awareness) of the self can empower learners to successfully navigate generative AI spaces by positioning their digital consciousness between what is known of the self and what is known to others (in this case, the chatbot). As learners continue to engage with ChatGPT, the chatbot learns their digital behaviors and identities and adjusts its algorithms to be responsive. Thus, each learner's experience can be more personalized through algorithmic changes, and the learner can reciprocally teach the chatbot using custom instructions changed in the chatbot's preset settings. With each interactive iteration, the learner becomes more cognitively self-aware within the chatbot. Conversely, the chatbot anticipates learner responses by correlating cognitive migrations from the unknown to the open self. For educators in EPP, understanding learner cognitive and psychological perceptions and positionalities when transitioning between human-to-human and human-to-technology learning spaces can help inform SLOs and instruction by scaffolding learners to move from other to self-regulation when using generative AI.

Figure 2

The Johari Window of Personal Awareness was conceptualized by Luft & Ingham, 1955



Note. The Johari Window adapted by author from Luft, J., & Ingham, H. (1955). The Johari window, a graphic model of interpersonal awareness. *Proceedings of the western training laboratory in group development*, 246.

Framework 3 Levels of Use (LoU): Assessing Technical Aptitude

Hall's et al. (1975) Levels of Use (LoU) model (see Figure 3), introduced in 1975, provides a structured framework for assessing an individual's existing technical proficiency and readiness to adopt new technology. LoU classifies users into six levels, from the lowest level of non-use (Level 0) to the highest level of integration and innovation (Level VI). This model is particularly relevant when considering learners' technical readiness to engage with AI-powered programs like ChatGPT. LoU highlights the importance of progressing through these levels, ensuring learners acquire the necessary technical skills to become self-regulated. Here, it is important to note that these progressions may not necessarily occur linearly. As new technologies are introduced, individuals can move between the different levels based on changes in context and modalities. It also helps educators gauge how much and what types of scaffolding are needed as learners deploy their digital literacy skills to actuate learning outcomes when generative AI is introduced into the learning process. When working with generative AI, especially newer programs such as ChatGPT, educators must perform a digital literacy skill evaluation before using the chatbot for direct instruction, supplemental instruction, or assignment completion. Requiring a learner to interact with a new technology for which they may not possess adequate digital literacy skills may result in the opposite intended effect. Rather than cognitively progress through technology integration, an unprepared learner with limited LoU may regress and ultimately reject the technology, resulting in cognitive delay. Vygotsky (1978) described such cognitive lapses as microgenetic regression. For example, a learner may demonstrate competencies in content in a human-to-technology interaction at LoU III/IVA, Mechanical Use and Routine, by creating an interactive PowerPoint to present a topic in an online course using the share screen function in Zoom. During the presentation, the learner demonstrates acumen in mastering the PowerPoint functionalities while, at the same time, displaying competencies in explaining the content. If the learner has another presentation and exhibits the same digital aptitude but enhances the presentation and content, s/he may be considered at LoU IVB, Refinement. Thus, microgenetic regression would occur if the educator introduced generative AI too early in the human-to-technology transition when a learner's LoU is still developing. Initial considerations should supplement instructional modalities with generative AI rather than replacing human-to-human or human-to-technology teaching and learning. By so doing,

the likelihood that microgenetic regression occurs is mitigated through a stepped digital skill practice and acquisition process informed by scaffolding through the TCK subdomain and understanding of the known and unknown digital self.

Figure 3

Levels of Use to explain an end-user's technology integration as conceptualized by Hall et al. (1975).

0 - Nonuse

- State in which the user has little or no knowledge of the innovation, has not involvement with the innovation, and is doing nothing to become involved.

I - Orientation

- State in which the user has acquired or is acquiring information about the innovation and/or has explored or is exploring its value orientation and its demands upon the user and the user system.

II – Preparation

- State in which the user is preparing for the first use of the innovation.

III – Mechanical Use

- State in which the user focuses most effort on the short-term, day-to-day use of the innovation with little time for reflection. Changes in use are made more to the meet user needs than client needs. The user is primarily engaged in a stepwise attempt to master the tasks required to use the innovation, often resulting in disjointed and superficial use.

IVA – Routine

- Use of innovation is stabilized. Few if any changes are being made in ongoing use. Little preparation or thought is given to improving innovation use or its consequences.

IVB – Refinement

- State in which the user varies the innovation to increase the impact on clients within immediate sphere of influence. Variations are based on knowledge of both short- and long-term consequences for clients.

V – Integration

- State in which the user is combining own efforts to use the innovation with the related activities of colleagues to achieve collective effect on clients within their common sphere of influence.

VI – Renewal

- State in which the user reevaluates the quality of the use of the innovation, seeks major modifications or alternatives to the present innovation to achieve increased impact on clients, examines new developments in the field, and explores new goals for self and the system.

Note. Levels of Use adapted by author from Hall, G. E., Loucks, S. F., Rutherford, W. L., & Newlove, B. W. (1975). Levels of use of the innovation: A framework for analyzing innovation adoption. *Journal of Teacher Education*, 26(1), 52–56. <https://doi.org/10.1177/002248717502600114>

APPLYING CHATGPT IN EDUCATIONAL CONTEXTS

Content Creation: Learner Response versus ChatGPT Response

To illustrate the practical application of the three-pronged framework, the author selected a key assignment submission from an undergraduate teacher education methods course. Learners in the course were Elementary and English Education Majors taking the methods-based course as part of their ESOL-infused program (English for Speakers of Other Languages). The program, which results in an ESOL Endorsement upon passage of the state professional licensing exam, student teaching semester, and graduation, is required by the state where the Educator Preparation Program (EPP) for this chapter is located. The anchor course introduces learners to the theory and best practices for working with children whose first language is other than English from diverse educational, cultural, and linguistic backgrounds. The assignment required learners, after reading the textbook chapter on Second Language Acquisition (SLA) Theory and watching a webinar, to answer the following questions about how second languages are acquired:

1. Contrast Krashen's concept of (i+1) with Vygotsky's ZPD. Do you think of them as similar or different?
2. How do the major second-language acquisition theories relate to your thinking about teaching English Language Learners (ELLs)?

To match the expected high-quality response from ChatGPT, a non-random technique was used to select the learner whose response would be compared to the ChatGPT's answers. The learner was selected based on the quality of her response, her overall grade of A in the course, and the observation of the implementation of theory into practice during her student teaching semester. The learner was also selected because the submission was in the Spring 2022 semester before the launch of ChatGPT in November 2022, meaning that she would not have had prior knowledge of the chatbot to complete her assignment. At the time, the learner was a Senior majoring in Elementary Education who completed her student teaching in Spring 2023, matriculated, received her ESOL Endorsement, and passed all required certification exams. The author selected not to include demographic identifiers. When the identifiers were introduced for ChatGPT to adjust the response, there was not much corpora difference between the original and modified responses to justify further examination. The next section examines the corpora differences between the learner and ChatGPT responses.

Examining the Responses and Corpora: Cirri and Relative Frequencies

Below are the responses to the two questions related to the differences between SLA theories in teaching young children, followed by a more specific question on how SLA theories inform a learner's thinking about working with English Language Learners (ELLs). The online corpus-generating tool Voyant (<https://voyant-tools.org/>) was used to generate the cirrus and relative frequencies for the responses. Cirrus is a word cloud that visually represents the most frequent words within a document. Voyant's results represent high-frequency words and phrases that characterize the learners' and ChatGPT's responses. There was no minimum or maximum word count required in either response. A discussion of the differences between human and ChatGPT responses follows (OpenAI, 2023).

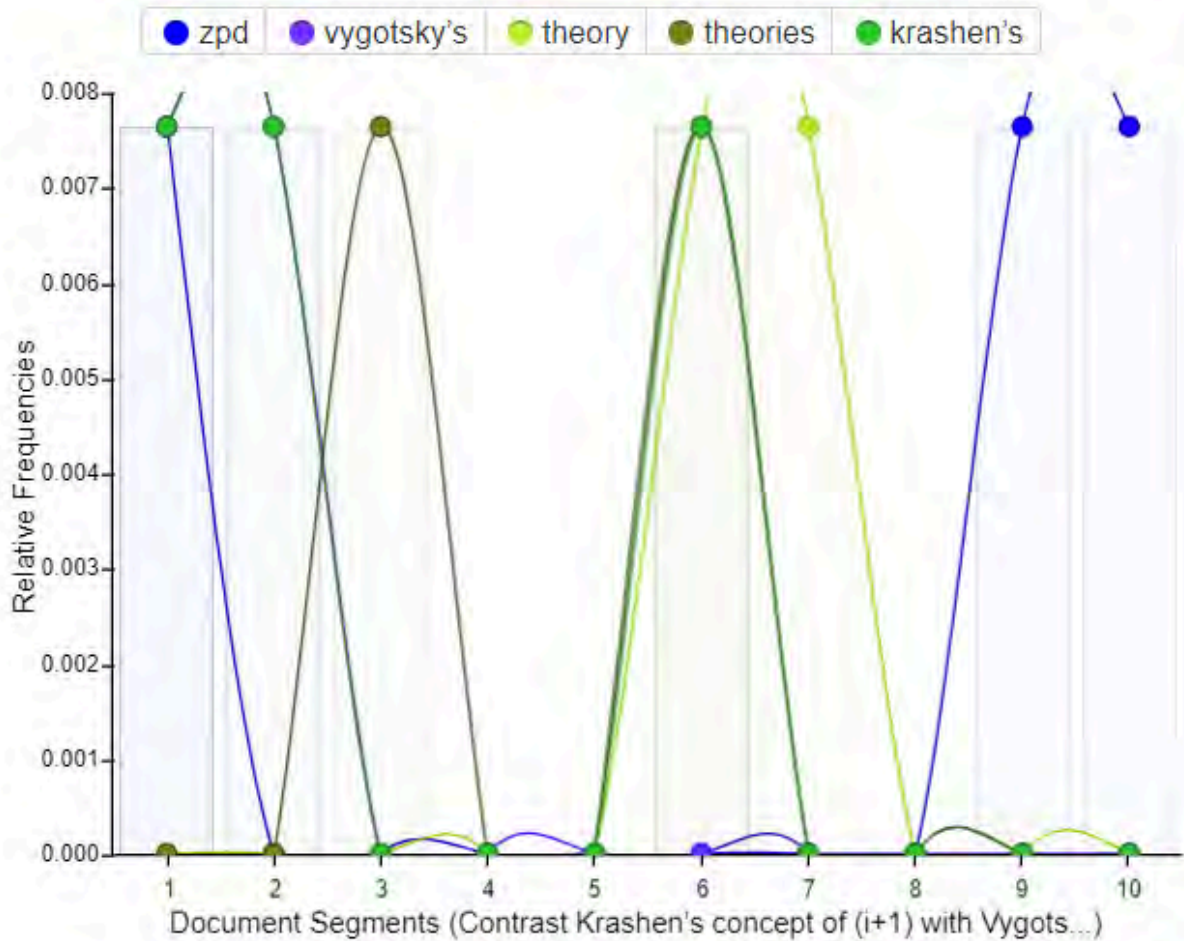
Question No. 1 – Learner Response – Word Count = 112.

It may appear as though Krashen's and Vygotsky's theories are the same. They both focus on ensuring educators understand what a child already knows and building upon it to increase their level of knowledge. However, methods in which educators guide learners through different knowledge levels or the execution of the theories differ.

Krashen's theory focuses on what information teachers provide to learners. Using Krashen's theory, the focus would be on lecturing and providing the learners with information through books, handouts, homework, etc. In contrast, Vygotsky focuses on the teacher providing an authentic social learning environment to increase their ZPD. Social interactions with peers and elders play an essential role in the ZPD.

Figure 5

Relative Word Frequencies of Learner Response to Question Number One



Question No. 1 – ChatGPT Response – Word Count = 499.

From the perspective of an Elementary Education Major, I can contrast Krashen's concept of (i+1) with Vygotsky's Zone of Proximal Development (ZPD). While they both relate to learning and development, they are distinct concepts with some differences.

Krashen's (i+1):

Meaning: Krashen's (i+1) refers to the idea that language acquisition occurs most effectively when learners are exposed to language that is slightly beyond their current level of proficiency but still comprehensible. The "i" represents the learner's current level, and "+1" represents the next stage of language development.

Focus: It primarily focuses on language acquisition and is often used in the context of second language learning. It emphasizes the importance of providing input that is just challenging enough to stimulate growth without overwhelming the learner.

Individualistic: Krashen's theory is more individualistic, with a focus on the learner's internal cognitive processes and the role of input in language development.

Vygotsky's Zone of Proximal Development (ZPD):

Meaning: Vygotsky's ZPD refers to the gap between what a learner can do independently and what they can do with guidance or support from a more knowledgeable person, often a teacher or peer. It represents the potential for learning and development.

Focus: It is a broader concept that applies to various areas of learning and development, not limited to language. It underscores the importance of social interaction and the role of cultural and social contexts in learning.

Sociocultural: Vygotsky's theory is more sociocultural in nature, highlighting the social and collaborative aspects of learning and emphasizing the role of interaction with others in the learning process.

Comparison:

Both Krashen's (i+1) and Vygotsky's ZPD are concerned with facilitating learning and development. They recognize the importance of challenging learners but in slightly different ways.

Krashen's (i+1) focuses on the level of difficulty in the input provided to learners, particularly in language acquisition contexts. It suggests that learners should receive input that is just beyond their current level but still understandable.

Vygotsky's ZPD emphasizes the role of guidance, scaffolding, and social interaction in learning. It suggests that learners can achieve more with support than they can on their own and that learning occurs through interaction with more knowledgeable individuals.

Difference:

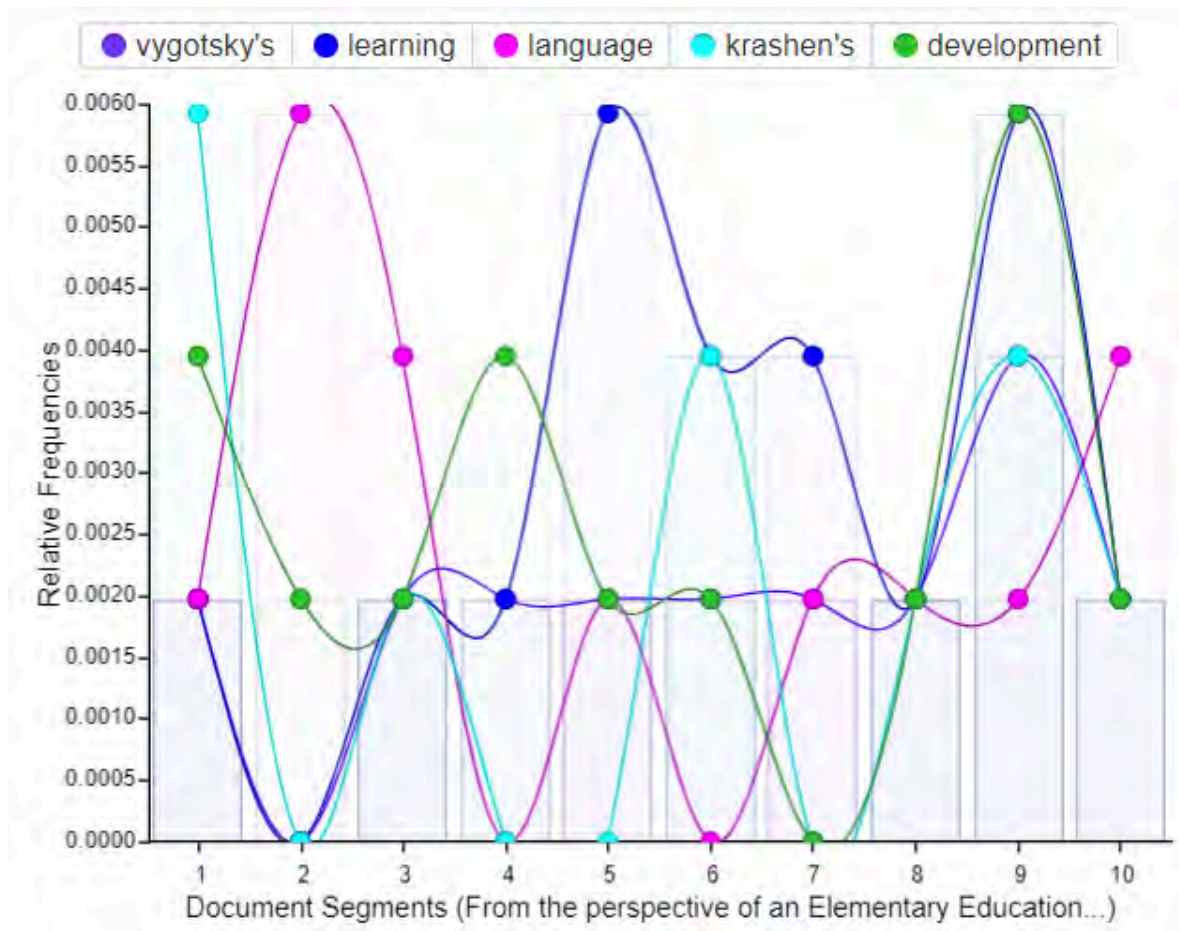
The key difference lies in their scope and emphasis. Krashen's (i+1) is primarily concerned with language input and individual cognitive processes, while Vygotsky's ZPD is a broader concept that encompasses various aspects of learning and development, highlighting the sociocultural context of learning.

Krashen's theory focuses on language acquisition and the role of comprehensible input, while Vygotsky's theory applies to a wider range of learning and development, including cognitive and social development.

In summary, Krashen's (i+1) and Vygotsky's Zone of Proximal Development are related in that they both pertain to learning and development, but they are distinct in their scope and emphasis. Krashen's concept is primarily used in language acquisition contexts and focuses on the level of difficulty in language input, while Vygotsky's ZPD is a broader theory that highlights the role of social interaction and support in learning across various domains (OpenAI, 2023).

Figure 7

Relative Word Frequencies of ChatGPT's Response to Question Number One



Question No. 2 – Learner Response – Word Count = 94.

During my journey to become a teacher, my college education has focused on culturally relevant pedagogy. After reading chapter five, the interactionist and sociocultural theory align with my ideas about teaching learners in a culturally relevant environment. Children thrive on opportunities to learn from each other, including through play. A thriving environment would also include implementing small-group options, thematic units on subjects the kids enjoy, and allotting time for learning through play. There would be some adjusting to ensure my EL learners would have an equitable learning experience, but the theories would still apply.

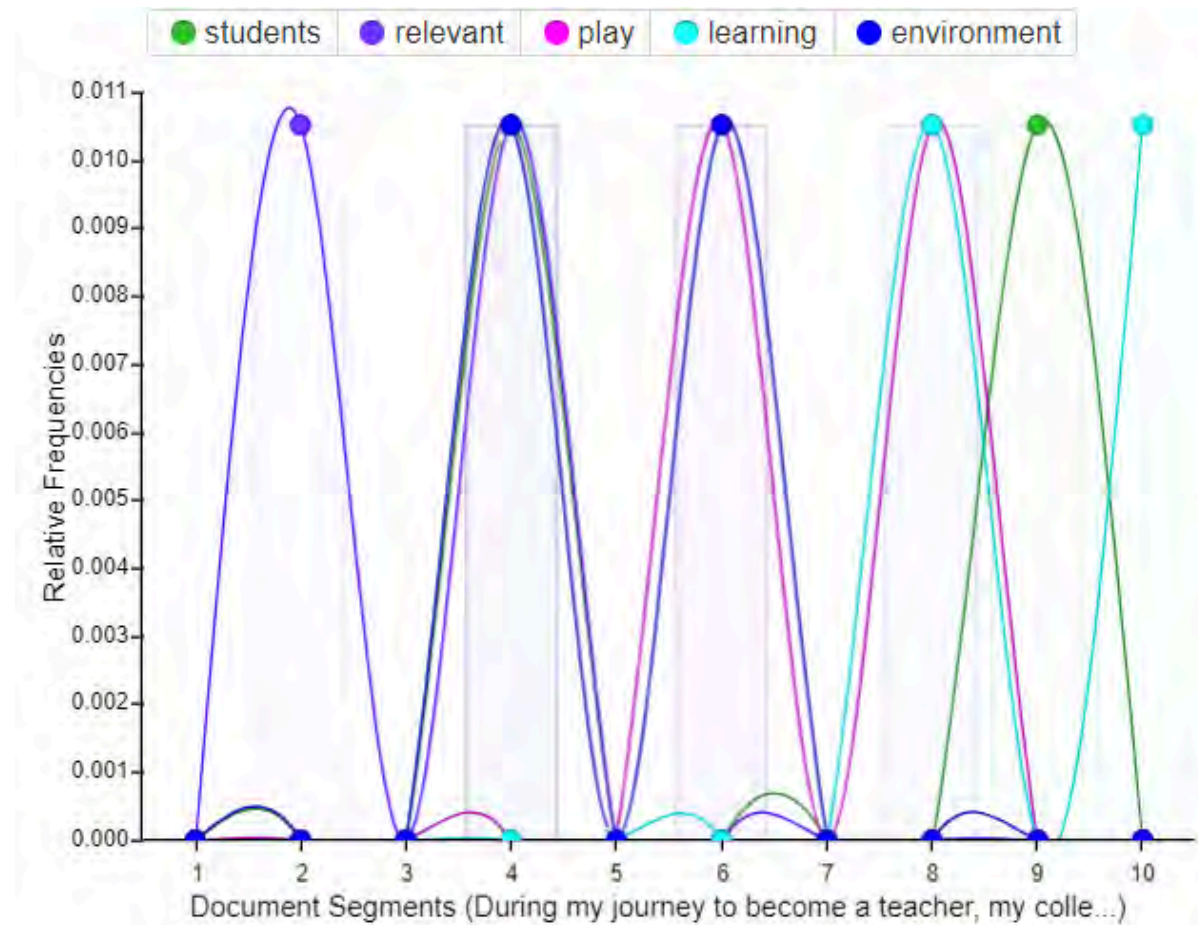
Figure 8

Cirrus of Learner's Response to Question Number Two



Figure 9

Relative Word Frequencies of Learner's Response to Question Number Two



Question No. 2 – ChatGPT Response – Word Count = 386

As an undergraduate learner majoring in Elementary Education, I'll share my perspective on how major theories of Second Language Acquisition (SLA) relate to teaching young learners, especially those whose first language is other than English.

1. Krashen's Input Hypothesis: Krashen's theory emphasizes the importance of comprehensible input in language acquisition. In my teaching practice, I would ensure that I provide a supportive and immersive environment where learners can understand and engage with the language at their own pace. This might involve using visuals, gestures, and simple language structures to make the content more accessible.
2. Vygotsky's Socio-cultural Theory: Vygotsky's theory emphasizes the role of social interaction and scaffolding in language development. When teaching young learners whose first language is not English, I would create opportunities for peer interactions and collaborative learning. I would also provide support and guidance (scaffolding) to help learners bridge the gap between their current language proficiency and the target language.
3. Chomsky's Universal Grammar: Chomsky's theory posits that humans are born with an innate capacity for language. While this theory is more relevant to understanding first language acquisition, it suggests that language learning should be a natural and intuitive process for young learners. In my teaching, I would strive to create a language-rich environment that encourages exploration and experimentation with language.
4. Piaget's Cognitive Development Theory: Piaget's theory emphasizes the importance of cognitive development in language learning. When working with young learners, I would take into account their

cognitive development stage and tailor my teaching methods accordingly. For instance, I would use concrete examples, hands-on activities, and age-appropriate materials to support language acquisition. Incorporating these SLA theories into my teaching philosophy would involve creating a balanced approach that respects individual differences among learners. I would recognize that young learners may have varying levels of language proficiency in their first language, and I would be sensitive to their cultural backgrounds and experiences. Additionally, I would continuously assess and adapt my teaching methods to meet the evolving needs of each learner as they progress in their language acquisition journey. Ultimately, my goal as an elementary education major would be to foster a positive and inclusive learning environment where all learners, regardless of their first language, feel supported and empowered to develop their language skills while also respecting and celebrating their linguistic and cultural diversity (OpenAI, 2023).

Figure 10

Cirrus of ChatGPT's response to question number one

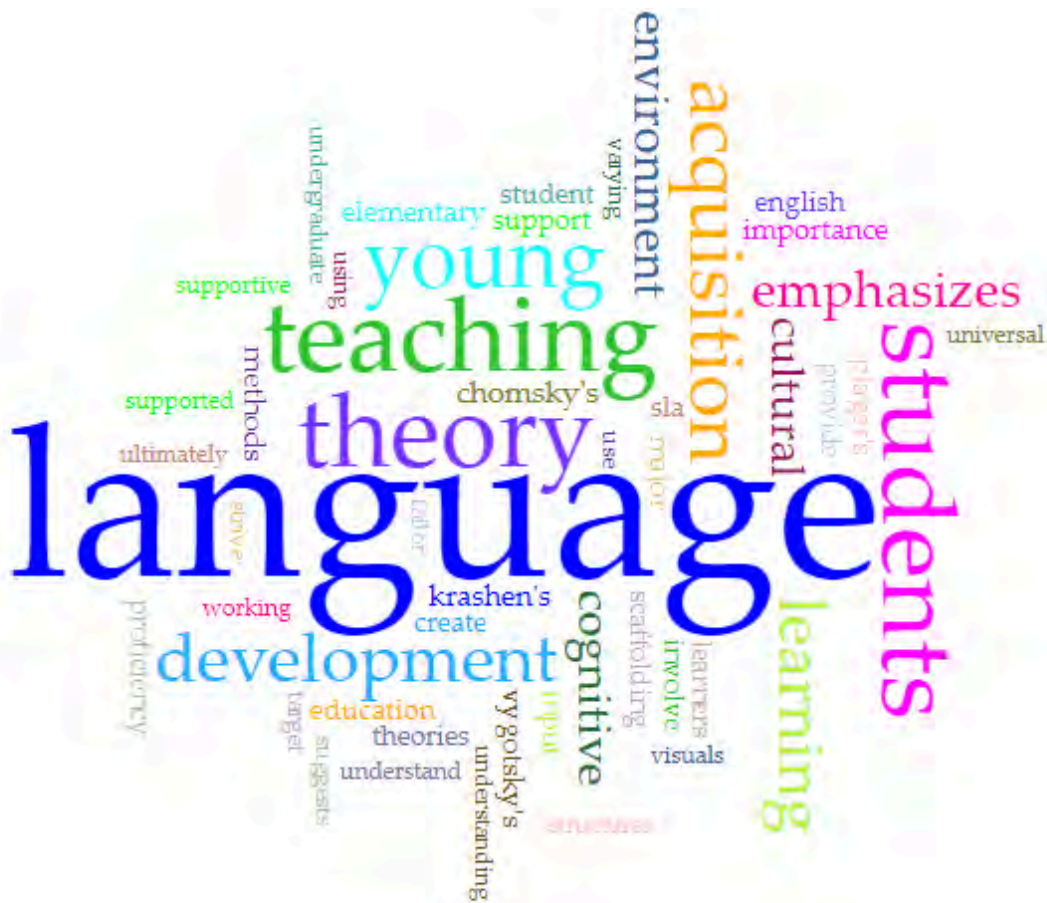
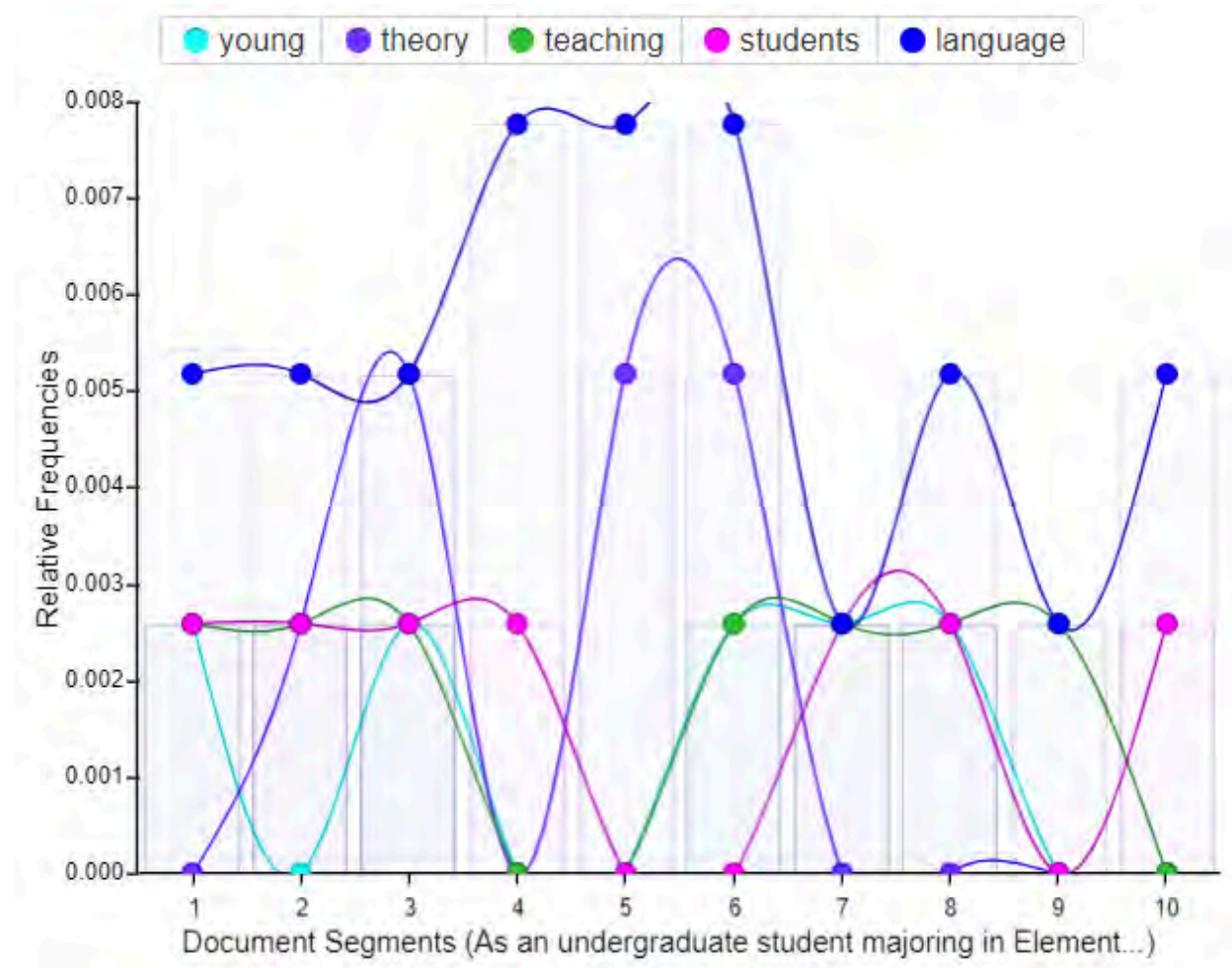


Figure 11

Relative word frequencies of ChatGPT's response to question number two.



Comparing and Contrasting the Human and Generative AI Responses

The most obvious difference between the human and generative AI responses is response length. The learner's average response was 103 words, while ChatGPT's average response was 442.5 words. While no word length was required for the human or ChatGPT response, the difference in response length was 23%. While this could be considered a significant number, it is important to remember that there was no word limit for the learner or ChatGPT. The only parameter set for the learner response in the assignment instructions was to answer "efficiently," which, in examining her response, was indeed direct and efficient. No such direction was given to ChatGPT. As a comparison, question number one was again selected for ChatGPT's response; this time, more explicit instructions were provided.

Prompt and Question: Answer the following question from the perspective of an Elementary Education undergraduate major in 100 words or less. 1. Contrast Krashen's concept of (i+1) with Vygotsky's ZPD. Do you think of them as similar or different?

ChatGPT (2023) Response:

Krashen's (i+1) and Vygotsky's Zone of Proximal Development (ZPD) both aim to challenge learners, but they differ in focus and scope. (i+1) is Krashen's concept in language acquisition, advocating exposure to slightly more advanced language input for effective learning. In contrast, Vygotsky's ZPD is a broader educational theory emphasizing a learner's potential development with guidance from a more knowledgeable person. While they share the goal of pushing learners beyond their current abilities, (i+1) is language-specific, whereas ZPD applies to various learning contexts. In essence, they are similar in intention but distinct in application and scope.

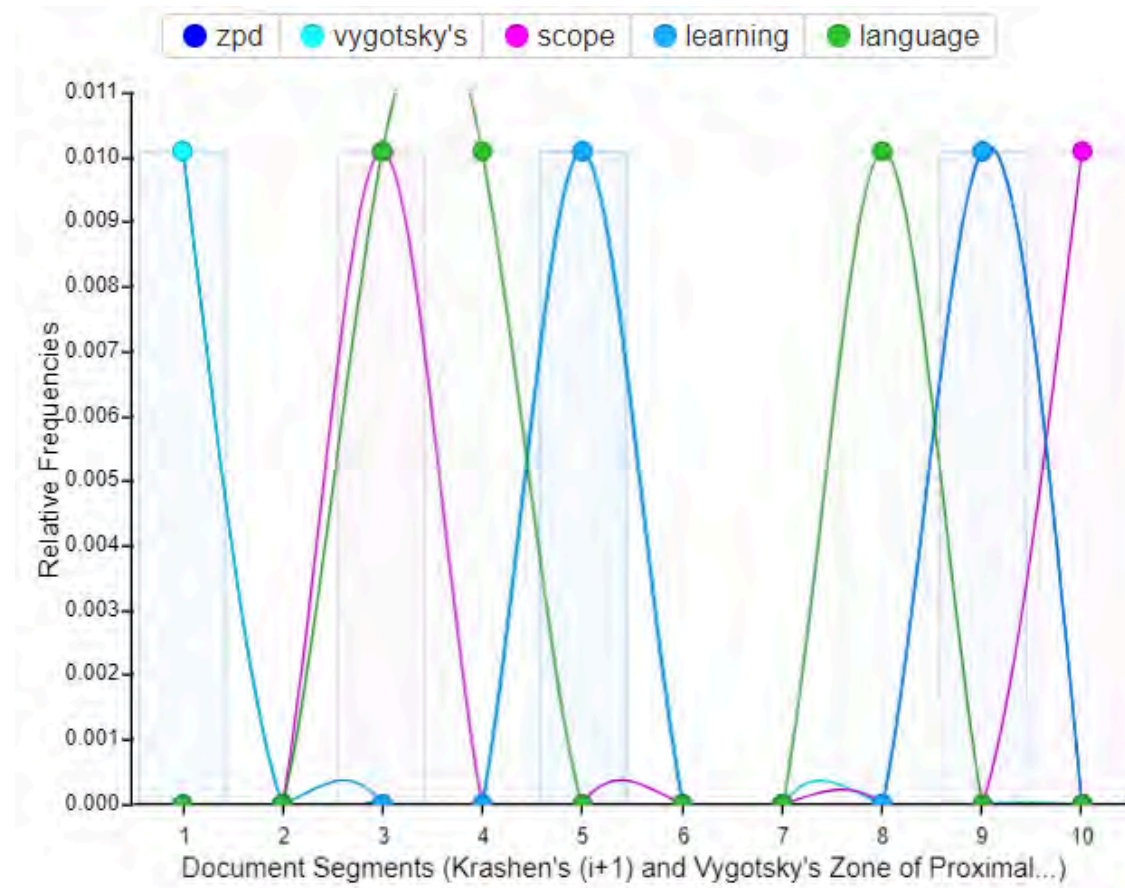
Figure 12

Cirrus of ChatGPT Response to Revised Question Number One Prompt



Figure 13

Relative Word Frequencies of ChatGPT Response to Revised Question Number One Prompt



Learner's Response to Question No. 1:

It may appear as though Krashen's, and Vygotsky's theories are the same. They both focus on ensuring educators understand what a child already knows and building upon it to increase their level of knowledge. However, methods in which educators guide learners through different knowledge levels, or the execution of the theories, differs. Krashen's theory focuses on what information teachers provide to learners. Using Krashen's theory, the focus would be on lecturing and providing the learners with information through books, handouts, homework, etc. In contrast, Vygotsky focuses on the teacher providing an authentic social learning environment to increase their ZPD. Social interactions with peers and elders play an essential role in the ZPD.

Once ChatGPT was given more specific guidance for creating a response, it was noted that the revised response closely paralleled the learner's response in tone and language. ChatGPT's original response was more detailed and semi-formal in content and tone. ChatGPT responded in a more essay-type format, which could have resulted from the initial prompt to write the response as an undergraduate Elementary Education major. In examining the cirri and relative word frequencies between the original and revised ChatGPT responses, it is noted that they are closer to the learner's response. Tables 1 and 2 compare the cirri and relative word frequencies between the learner's and ChatGPT's responses to questions one and two. Table 3 compares the learner's response to question number one and ChatGPT's response after revising the question prompt. The top three words were selected for their frequency in the responses. While relative consistencies exist between the cirri and frequencies, notable differences exist between the learner and ChatGPT word use from the original prompt. However, when the prompt was revised for question one, the cirri and frequencies were more similar. In terms of practical application for EPPs, this suggests how educators must employ the three-tiered scaffolded framework to cause the generative AI modality to mirror the

human-to-human experience and response more closely. The Technological, Pedagogical, and Content Knowledge (TCK) subdomain filtered through LoUs Levels III to IVA contextualized within the known or unknown digital self would provide the balanced scaffolding needed to transition human-to-human teaching and learning modalities to generative AI spaces.

Table 1

Cirrus and Relative Word Frequency Comparisons Question No. 1

Respondent	Cirrus	Relative Word Frequency
Learner	ZPD	ZPD
	Krashen	Vygotsky
	Knowledge	Theory
ChatGPT	Development	Vygotsky
	Vygotsky	Learning
	Learning	Language

Table 2

Cirrus and Relative Word Frequency Comparisons Question No. 2

Respondent	Cirrus	Relative Word Frequency
Learner	Learner	Learner
	Environment	Relevant
	Learning	Learning
ChatGPT	Language	Theory
	Teaching	Teaching
	Learner	Learner

Table 3*Cirrus and Relative Word Frequency Comparisons ChatGPT Revised Prompt*

Respondent	Cirrus	Relative Word Frequency
Learner	ZPD	ZPD
	Krashen	Vygotsky
	Knowledge	Theory
ChatGPT	ZPD	ZPD
	Language	Vygotsky
	Vygotsky	Scope

Practical Application for Educator Preparation Programs – Implications for Using Generative AI in Content-Based Methodology Courses

These comparative examples demonstrate how educators can harness the power of generative AI to facilitate learning. Referring to the three-tiered framework, by completing a side-by-side comparison of the human and ChatGPT responses, faculty teaching methodology courses can scaffold learning and adjust pedagogic practice to deepen long-term concept retention, reinforce digital literacy skills, and improve learning outcomes. This requires educators to engage in a multi-layered instructional planning process. They simultaneously and intentionally teach learners to acquire content-based methodologies and critically engage with and evaluate AI-generated content. Educators must employ a backward design approach and start the instructional planning process by understanding the learner’s known or unknown digital self. If the learner does not have digital self-perception, they cannot effectively transition from static to dynamic technology use (Atoyan et al., 2023). Once the digital self is identified, educators must examine the learner’s digital literacy skills by identifying their current and potential LoUs. This can be accomplished by taking content and having learners generate responses across different generative and non-generative technologies. The final step is to scaffold digital self-perception and accompanying literacy skills by situating instructional planning within the TPACK framework. The process must be repeated each time an instructional transition is made between human-to-human and human-to-generative technology. The following is an example of how faculty can use a generative AI program like ChatGPT to inform the language reduction in a higher-order learner learning outcome (SLO) to make it more approachable for their learners.

The original SLO, as written, is an extension of questions 1 and 2 from the learner’s weekly assignment and thematic course module focusing on Second Language Acquisition (SLA) theories and their practical application when creating modified lesson plans for English Language Learners (ELLs) with accommodations specific to the ELL’s language and cognitive needs. The original SLO was then placed in ChatGPT with the exact prompt and instruction to make it more understandable for an undergraduate learner (OpenAI, 2023). The results are below.

Original SLO in Learner Course Syllabus

Type of Learning Outcome

SLO 1. Create a phoneme and scaffolded lesson plan with ELL modifications and accommodations.

Apply

The Teacher Candidate will be able to:

- Apply ELL modifications and accommodations to a phoneme-based and scaffolded lesson plan;
- Identify the main phoneme from the multicultural anchor text around which to build the phoneme-based lesson plan; Formative Assessment: Identify the main phoneme with explanation of why the phoneme was selected based on the results from the SOLOM Language Inventory administered to the ELL during the

field clinical experience. Include ELL first language, language level (i.e. L1, L2, L3, etc.), and language interference.

- Modify the lesson plan based on the language and cognitive level of the ELL with whom the teacher candidate is working in the clinical experience (summarize ELL's BICS and CALP).
- Summative Assessment: Create and submit Draft #1 of the lesson plan using the College of Education's Standard Lesson Plan Format and following the lesson plan rubric in Taskstream.
- Evaluate
- The Teacher Candidate will be able to:
- Validate the effectiveness of modifications and accommodations in the ELL phoneme-based and scaffolded modified lesson plan by practicing elements of the plan with the assigned ELL in the field clinical experience.
- Formative Assessment: Practice one (1) modified assessment and one (1) modified enrichment activity from the ELL modified phoneme-based and scaffolded lesson plan with the assigned ELL in the field clinical experience. Receive feedback from cooperating classroom teacher using feedback checklist.
- Summative Assessment: Submit final phoneme-based and scaffolded lesson plan incorporating feedback from Drafts #1 and #2, field clinical practice, and cooperating teacher feedback following the rubric and standard lesson plan format.

ChatGPT Interpretation (OpenAI, 2023)

Learner Learning Goal: By the end of this assignment, you'll be able to evaluate, apply, and create phonemes effectively, design lesson plans with ELL (English Language Learner) support, and assess your lesson plans both during the process and at the end.

Assignment Explanation: In this assignment, we're going to focus on teaching phonemes, which are the sounds that make up words in a language. This is important because it helps people read and pronounce words correctly. You'll also learn how to create lesson plans for a diverse group of learners, including those who are learning English as a second language.

Here's what you'll do:

1. **Evaluating Phonemes (Checking and Learning):** First, you'll learn about different phonemes in a language and how they work. Think of it as understanding the building blocks of words. We'll provide feedback and have discussions to help you learn.
2. **Creating Lesson Plans (Putting Your Knowledge to Work):** Once you understand phonemes, you'll use that knowledge to create a lesson plan. This plan will include activities and ways to teach phonemic awareness to different learners, including those who are still learning English. We'll also give you feedback on this part to help you improve.
3. **ELL Modifications (Helping English Language Learners):** You'll learn how to modify your lesson plan to make it easier for English Language Learners to understand. This might involve using pictures, simpler words, or other tricks to help them. Again, we'll provide feedback here.
4. **Summing It Up (Final Assessment):** After you've made improvements based on feedback, you'll submit your final lesson plan. We'll assess how well you've incorporated all the things you've learned, and this will be your final grade for the assignment.

By the end of this assignment, you'll not only know a lot about phonemes and teaching strategies, but you'll also have experience in creating and improving lesson plans while keeping ELL learners in mind. It's a hands-on learning experience with lots of guidance along the way to help you succeed.

Notice the stark contrast between the two learning outcomes. The original SLO is very clinical; the language is high-level and may not be approachable to all learners. As a result, learners may not read through the SLO to better understand the learning expectations and outcomes for the SLA course module and key assignment. In contrast, the ChatGPT version of the original SLO is much more approachable, using language that is reduced to a clear, stepped process that learners can more easily follow and understand. For example, the original SLO was written using language associated more with academic writing versus the more conversational tone generated by ChatGPT. Regarding best practices in differentiating instruction and personalizing the learning experience, faculty could publish two versions of the SLOs and even further create a visual SLO pathway using the ChatGPT-generated response.

Finally, integrating generative AI technology into content-based methodology courses in EPPs holds immense potential for revolutionizing teacher training. In today's digitally saturated era, educators need to adapt to a

rapidly changing educational landscape, and AI can play a pivotal role in facilitating this adaptation. Generative AI can be harnessed to create adaptive and personalized learning materials, catering to today's technology-savvy learners' diverse needs and learning styles. For instance, it can generate interactive lesson plans, real-world classroom scenarios, and assessment materials that align with the latest pedagogical research and teaching standards. This enhances EPP program quality and equips educators with the tools they need to be successful in the era of technology-driven modern classrooms. Furthermore, generative AI can assist in developing dynamic educational resources by continuously updating content to reflect the most recent trends and research. EPPs can harness AI-driven content generation to curate a collection of up-to-date materials, enabling educators to stay current with best practices. Moreover, AI-powered tools can provide immediate feedback to learners, helping them refine their teaching strategies and classroom management techniques in a more iterative and data-driven manner. This is especially the case with ChatGPT, as learners can personalize their settings to enable the chatbot to provide more individualized responses. While integrating generative AI in EPP promises numerous advantages, it also raises important ethical and pedagogical considerations. Educators must ensure that AI remains a supplement rather than a replacement for human expertise. Furthermore, they must address issues related to data privacy, algorithmic bias, and the potential for overreliance on AI-driven materials. EPPs must strike a balance between harnessing AI's capabilities and preserving the essential human elements of education, such as empathy, creativity, and critical thinking. In essence, the implications of using generative AI in content-based methodology courses call for thoughtful planning and continuous evaluation to maximize the benefits while mitigating potential drawbacks.

A Digital Hermeneutic Vision for the Future of Generative AI in Educator Preparation Programs

In considering the future of generative AI in education and EPPs, a hermeneutical primer to align the Technological, Pedagogical, and Content Knowledge subdomains (Mishra & Koehler, 2006) and Levels of Use (Hall et al., 1975) descriptors is used. These frameworks are further contextualized within Vygotskian's (1978) object/other to self-regulation Sociocultural Theory (Byrnes, 2008) to inform the best teaching practices. Such practices can mitigate potential contextual misperceptions and ethical concerns within digital instructional content when human-to-human teaching and learning are transferred to generative AI modalities. Accordingly, as noted in the proposed hermeneutical primer, providing appropriate digital context combined with Eshet-Alkalai's (2004) digital literacy descriptors, Guess et al.'s (2020) digital literacy skill intervention and Prensky's (2013) call for higher-order problem-solving tasks has the potential to become a model framework to simultaneously mitigate ethical concerns while supporting learners through scaffolded best practices using the TPACK framework as its epistemological foundation to support digital contextual interpretation (Lee, 2021). Hermeneutics can be valuable in informing digital literacy skills and mitigating misperceptions by providing individuals with critical thinking tools and a deeper understanding of the context and authenticity of digital content. A hermeneutic lens can be used as an interpretive tool to align specific TPACK subdomains with digital literacy critical thinking skills to reduce contextual misperceptions. Specifically, a hermeneutic lens is applied to the TPACK subdomains across the following areas: hermeneutics operates at the intersections of content knowledge, pedagogical knowledge, and technological knowledge: 1. Contextual Understanding (PCK); 2. Evaluating Sources (TPK); 3. Understanding Intentions (TCK); 4. Hermeneutical Circle in Digital Contexts (TCK); 5. Cultural and Linguistic Awareness (PCK); 6. Ethics of Interpretation (PCK); and 7. Application of Interpretation (TPK). By incorporating hermeneutics into digital literacy education framed within the TPACK subdomains, individuals can develop critical thinking abilities and become more discerning digital content consumers and creators. By incorporating hermeneutics into the TPACK framework, educators gain the necessary tools to teach learners how to interpret, analyze, and critically evaluate digital content related to the subject matter they are studying. This encourages learners to actively participate in learning by connecting their existing knowledge to new digital information and making informed judgments about its credibility and relevance. Hermeneutics aligns with the three-tiered framework by enhancing content, pedagogical, and technological knowledge related to digital literacy and information evaluation. Educators can empower learners to navigate the digital world more effectively and responsibly by incorporating hermeneutical approaches into teaching practices, making them informed and discerning consumers. This, in turn, can help mitigate the impact of contextual misperceptions and ethical interpretive concerns when teaching and learning are transferred into the generative digital landscape (Fickers et al., 2022).

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Generative AI and TPACK in Teacher Education: Pre-service Teachers' Perspectives

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INTRODUCTION

Artificial intelligence (AI) has been playing increasingly essential roles in people's daily lives and is widely used in various research areas (McCarthy, 2007; Su et al., 2023; Yang, 2022). Scholars defined AI as "the science and engineering of creating intelligent machines" (Su et al., 2023, p.1). AI-enabled tools have been utilized in education for a long time (Barnes et al., 2017; Ng et al., 2021; Su et al., 2023) and there is some existing research on AI in different teaching and learning areas, such as early childhood (Lin et al., 2020; Williams et al., 2019; Yang, 2022), K-12 classrooms (Gardner-McCune et al., 2019; Su et al., 2022, 2023), and higher education (Chatterjee & Bhattacharjee, 2020; Popenici & Kerr, 2017; Zawacki-Richter et al., 2019); however, there is a need for more, especially in the area of generative AI.

While using generative AI in education has become a trend, more debates are tied to integrating generative AI in teacher education. Examples of the debates include the opportunities and challenges that arise from the integration of generative AI in education (Su & Yang, 2023; Su et al., 2022, 2023; Yang & Evans, 2019) and how it can be used to enhance teaching and learning practices in K-12 settings (Su et al., 2022, 2023).

Related to this debate, generative AI in K-12 teacher education attracted the attention of Technological Pedagogical Content Knowledge (TPACK) scholars. TPACK is a framework used in education to understand and promote effective technology integration in teaching and learning. It was developed by Mishra and Koehler in 2006. TPACK (Angeli & Valanides, 2005; Koehler & Mishra, 2005; Mishra & Koehler, 2006, 2007; Mishra, 2019; Niess, 2005; Pierson, 2001) emphasizes the importance of three types of knowledge for educators: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). When these three knowledge domains intersect, they create a synergy that supports effective teachers' teaching of their discipline with technology.

As a developing and emerging field, TPACK scholars have been concerned with generative AI in teacher education (Celik, 2023; Kim et al., 2021; Mishra et al., 2023). For example, Celik (2023) points out that AI affordances still need to be explored in education. Teacher education must attend to generative AI-specific technological and pedagogical knowledge in a TPACK framework to effectively integrate generative AI into education.

ChatGPT, as a conversational generative AI powered by the GPT-3.5 architecture, can play a role in supporting educators and learners in the context of TPACK (Technological Pedagogical and Content Knowledge) by providing assistance, information, and guidance related to technology integration in education (Mishra et al., 2023). For example, teachers can use ChatGPT to generate information about pedagogical methods as references to design their lessons and prepare to help their students acquire content knowledge.

Mishra, Warr, and Islam (2023) argue that the TPACK framework can discuss the knowledge teachers require to use generative AI tools effectively, and they highlight "the qualities of Gen[generative] AI that make it like other digital technologies (they are protean, opaque, and unstable) as well as qualities that make it revolutionary (namely, they are generative and social)" (p. 1). They describe how these traits affect specific knowledge domains (TK, TPK, TCK, XK, and TPACK) and explore implications for educators. Additionally, Mishra and colleagues called for more expansive descriptions of Contextual Knowledge (XK), going beyond the immediate context to consider how generative AI will change individuals, society, and the broader educational context. Our chapter responds to this call. We will discuss each domain in our findings, including the XK.

There is a need for more research focused on using generative AI in teacher education. Even less literature has explored specifically elementary preservice teachers' perspectives on using generative AI, such as ChatGPT, in

their classrooms. Responding to Mishra and colleagues' call to understand generative AI such as ChatGPT, we consider it essential to understand preservice teachers' perspectives and narratives about their individual and social context of educational use of ChatGPT. In particular, we aim to explore the preservice teachers' perspectives on the opportunities and challenges that arise from the integration of generative AI in teacher education. Based on the analysis of the teachers' narratives, we also discuss implications informed by the data and develop a model of the use of generative AI in teacher education.

This topic is important and needed. On the one hand, limited research has addressed these emerging areas. On the other hand, to help address these aims about generative AI and education, the fundamental and crucial way is to understand the actual pre-service teachers' perspectives, which can impact the integration of generative AI in K-12 education. Thus, grounded in the literature on using AI in elementary education, this chapter describes pre-service teachers' perspectives on using generative AI tools, specifically ChatGPT, for teaching and learning in a Southeast United States teacher education program. Implications and a model of the use of generative AI in teacher education are also illustrated in this chapter.

THEORETICAL PERSPECTIVES AND LITERATURE REVIEW

The study draws upon the technological pedagogical content knowledge (TPACK) framework. The initial definition included pedagogical content knowledge (PCK) (Shulman, 1986). Later, scholars have added the component of technological knowledge (TK) to emphasize the crucial role of digital technology in teaching and learning (Angeli & Valanides, 2005; Koehler & Mishra, 2005; Mishra & Koehler, 2006, 2007; Mishra, 2019; Niess, 2005; Pierson, 2001).

TPACK is an essential framework for exploring teacher education and technology as it is “an overarching conception of their subject matter about technology and what it means to teach with technology” (Niess, 2005, p. 511). All three components (pedagogy, content, and technology) need to be integrated to support better instruction. The topic of the use of technology is not new, but how to use cutting-edge digital and emerging generative AI technology, such as ChatGPT, in meaningful and effective ways in education is still new and needs attention and research.

Scholars have explored using TPACK in teacher education (Baran et al., 2019; Chai et al., 2010; Pamuk, 2012; Voogt & McKenney, 2017; Wang et al., 2018). Voogt and McKenney (2017) conducted a research study to explore how teacher education programs help students with TPACK development. Based on their findings on various factors that influenced the prospective teachers' learning of how to use technology in literacy instruction, the authors recommend that “future directions towards promoting the integration of technology in the teaching and learning of subject domains should be concerned with pre-service teacher educators” (p. 80). In their study, Baran et al. (2019) examined pre-service teachers' perspectives on how the teacher education programs helped them with TPACK development, and they found that teacher educators played essential roles in supporting the pre-service teachers and providing feedback. Chai, Koh, and Tsai (2010) described the challenges pre-service teachers face while experiencing technology integration in teaching, and their findings emphasized the importance of helping the pre-service teachers develop TPACK through real teaching experience. All the studies supported the theme that supporting pre-service teachers with TPACK development is essential in teacher education.

As AI tools have brought more attention to everyday lives, more research has been conducted to explore the usage of AI tools in education. The limited literature has drawn upon the TPACK framework to study AI tools in teacher education (Celik, 2023; Park, 2021) before the generative AI ChatGPT became popular starting in November 2022. Using TPACK as the framework, Park (2021) examined a group of Korean pre-service teachers' experiences with the previously available AI tools and found that the more pre-service teachers received AI learning, the higher their interest in AI education, the more experienced in previously AI education in their majors, they perceived AI more positively. They had low resistance to AI education, and they thought that elementary AI education was necessary. Hence, Park (2021) postulated that AI learning is an essential factor in learners' perception of AI; the AI curriculum should be researched so that AI education in teacher education programs can be systematically progressed. In other words, in Park's study, TPK (Technological Pedagogical Knowledge) in AI learning is related to Korean pre-service teachers' interest in and positive attitude toward AI education. Even though generative AI is not the focus, Park's (2021) study is invaluable for AI and its application for teacher education. We can draw upon Park (2021) and postulate that given that generative AI such as ChatGPT is massive in discussion, the more we prepare preservice teachers for learning about it, the more positive their perception of generative AI and the more progress they can pass along for their classroom teaching at the K-12 level.

In another study, by discussing the ethical issues related to using AI tools, Celik (2023) described measurement methods to help teachers assess decisions and use the tools. The study calls for more attention to “teachers’ knowledge and skills to integrate AI-based tools” (Celik, 2023, p. 9). Similarly, we also found that little research has focused on pre-service teachers’ knowledge and experiences tied to integrating generative AI tools into teaching. To expand on the literature, the present study aims to explore the pre-service teachers’ perspectives on the opportunities and challenges that arise from integrating generative AI in teacher education. We also hope to combine the theoretical perspectives on TPACK with the study findings to develop a model of the use of generative AI in teacher education.

TPACK is directly relevant to generative AI in teacher education. First, Content Knowledge (CK) refers to a preservice teacher’s deep understanding of the subject matter they are teaching. In the context of generative AI, we must explore how educators can develop a fundamental understanding of generative AI, the foundation of AI concepts, algorithms, and applications. The knowledge allows them to select appropriate AI-related content and tasks for their students.

Second, Pedagogical Knowledge (PK) involves teaching strategies, instructional methods, and classroom management. In this chapter, we consider pre-service teachers’ perspectives on adapting their teaching methods to incorporate AI-related content into their curriculum effectively. We also consider their needs to design activities and assessments that align with AI concepts and ensure that students can grasp and apply the knowledge.

Third, Technological Knowledge (TK) pertains to understanding the technology tools and systems available for teaching. In the case of AI, in this chapter, we consider the pre-service teachers’ opinions on how they should be familiar with AI tools, software, and platforms that can enhance their teaching and engage students and, to this end, pre-service elementary teachers’ ideas about how to use these technologies effectively to support AI-related learning.

Fourth, Technological Pedagogical Knowledge (TPK) is the intersection of technological and pedagogical knowledge. In the context of AI, TPK can involve knowing how to use AI tools and platforms to enhance teaching and learning. In this chapter, we explore how pre-service teacher educators might use generative AI tools to personalize student instruction.

Fifth, Technological Content Knowledge (TCK) is the intersection of technological and content knowledge. In the context of AI, TCK can involve using technology to teach AI concepts effectively. In our interviews, we explore the participating pre-service teachers’ perspectives, including potentially using AI programming environments to help students better understand generative AI principles.

Sixth, Pedagogical Content Knowledge (PCK) is the intersection of pedagogical and content knowledge. For AI education, PCK can involve teaching generative AI concepts in a way that aligns with best practices in teaching and learning. In our explorations, we aim to understand what it means for pre-service teachers to understand how to explain complex AI ideas in ways that students can comprehend and apply.

Finally, Technological Pedagogical Content Knowledge (TPACK) is the ultimate goal, where technological, pedagogical, and content knowledge intersect effectively to promote meaningful learning experiences with AI. In our finding section, with the support from Mishra and colleagues (2023) in focusing on Contextual Knowledge (XK), we probe how a particular US-based teacher education program’s preservice teachers with TPACK can seamlessly integrate generative AI into their teaching, using appropriate technology to enhance the learning of AI-related content. We summarized these areas of TPACK related to AI perspectives in explorations in Table 1.

Table 1*TPACK Aspects Related to Generative AI Perspectives in Exploration of this Chapter*

TPACK Areas	Definition in this Chapter	Generative AI explorative areas in this Chapter
Content Knowledge (CK)	Pre-service teacher’s deep understanding of the subject matter they are teaching	Select appropriate generative AI-related content and tasks for their students
Pedagogical Knowledge (PK)	Pre-service teacher’s knowledge of teaching strategies, instructional methods, and classroom management	Design activities and assessments that align with the basic theories and knowledge about generative AI (e.g., what is ChatGPT?), ensuring that students can grasp and apply this knowledge
Technological Knowledge (TK)	Pre-service teacher’s understanding of the technology tools and systems available for teaching.	Use these technologies effectively to support generative AI-related learning
Technological Pedagogical Knowledge (TPK)	The intersection of technological knowledge and pedagogical knowledge	Pre-service teacher educators might use generative AI-driven tools (e.g., ChatGPT) for teaching
Technological Content Knowledge (TCK)	The intersection of technological knowledge and content knowledge	Using generative AI programming environments to help students gain a deeper understanding of AI principles
Pedagogical Content Knowledge (PCK)	The intersection of pedagogical knowledge and content knowledge	Explain complex generative AI ideas in ways that students can comprehend and apply
TPACK and Contextual Knowledge XK	Contextual Knowledge (XK) in integrated TPACK knowledge	A particular US-based teacher education program’s pre-service teachers with TPACK can seamlessly integrate generative AI into their teaching, using appropriate technology to enhance the learning of generative AI-related content

METHODOLOGY

Participants

This book chapter is based on a research project on teachers’ perspectives on digital literacy and technology. Although a total of 16 pre-service teachers who were enrolled in the elementary education program participated in the project, this chapter focuses on eight participants who provided detailed descriptions of their perspectives on using generative AI tools (e.g., ChatGPT) in education (See Table 2). The participants were recruited through the program. The recruitment inclusion criteria included asking the participants if they were

pre-service teachers who had been taking classes and getting B.A. degrees in an elementary education program. Author 1 and Author 2 co-designed the research project. Author 2 recruited the participants through the teacher education program at a U.S. public university in the Southeast United States. Approval was received from the institutional review board at the same university before conducting the project. All consent forms were obtained from all the participants prior to data collection.

Table 2

Participants (All Names Are Pseudonyms)

Pseudonyms	Gender	Race and Ethnicity	Educational Background	College Level
Daisy	Female	Multiethnic (English & American)	Athlete (Women's Soccer); Elementary Education Major	Sophomore
Sandy	Female	Asian Korean American (Second Generation)	Elementary Education Major.	Sophomore
Kathy	Female	Multiracial American (Jewish & Taiwanese)	Major in History. Minor in Art. Gifted and talented IB curriculum in a multicultural high school. 5 th year master in Elementary Education Major.	Senior
Andy	Female	White	Elementary Education Major with Computer Science Minor	Sophomore
Esther	Female	White	Sociology and History major. Going to a 5th-year master's in Elementary Education.	Senior
Elsa	Female	Multicultural (White & Latino)	Elementary Education Major and a Double Major in Psychology.	Sophomore
Odelia	Female	Second Generation of A White Immigrant Family from Europe	Elementary Education Major	Sophomore
Winnie	Female	Jewish	Elementary Education Major	Sophomore

Data Collection

This is a case study (Tellis, 1997; Yin, 1984). We used this qualitative research design to gain a better understanding of the participants' perspectives on generative AI (e.g., ChatGPT) in teaching and learning. Primary data sources for this project included semi-structured interviews, and secondary data sources included informal conversations with the participants to ensure the study's trustworthiness. It took approximately 60 minutes to conduct each interview with each participant. All the interviews were conducted via Zoom, and all the interviews were audio recorded. Examples of the semi-structured interviews included "What are your perspectives on using digital technology?" "What do you think about using digital technology or even AI, artificial intelligence?" We also had informal conversations with the participants for member checking, which means "sharing drafted findings with the participants and mapping potential misunderstandings during the informal conversations" (Glesne, 2011). This step allowed us to ensure the trustworthiness of the research study.

Researcher Positionality

We noted that researchers' positionality is essential in qualitative research (Yao & Vital, 2018). We interviewed the participants as educational researchers working with pre- and in-service teachers in higher education. Both our research interests focus on literacy and digital technology. As teacher educators, we valued the importance of using digital technology in education and also wanted to explore more about using more cutting-edge digital technology in the field. Our backgrounds as teacher educators allowed us to build rapport with the participants. On the other hand, we also realized our potential subjectivities. Throughout the research design, data collection, and analysis, we had regular meetings to design the research study and engaged in reflexive practices (Yao & Vital, 2018) by sharing our notes and writing reflective memos.

Data Analysis

We began preliminary data analysis once we started collecting data. In particular, we transcribed the interview immediately after each interview was completed by using an AI-enabled transcription program. Following the step, Author 2 reviewed each interview transcript and wrote down analytical memos that noted the data related to the participants' perspectives on using AI in education. After the period of data collection was finished, we engaged in focused data analysis. We had group meetings and decided on the progress together, and then we began data analysis separately. The focused data analysis included three steps. First, we read the interview transcripts and coded the transcripts using open coding, which means "a first cycle, open-ended approach to coding" (Saldaña, 2016). As the participants shared their experiences related to digital literacy and technology, which was a broad topic and included many interview questions, we identified the data, which was especially focused on the participants' perspectives on generative AI.

We utilized the TPACK framework as the theoretical foundation to support our coding. Specifically, we did not list each individual knowledge area as a code to target the specific aspect separately because we valued the integration of different TPACK domains and we wanted to identify possible elements of the TPACK framework naturally demonstrated in the participants' narratives. We used markers to highlight words, phrases, and statements closely tied to generative AI and TPACK aspects. At this step, we coded the data separately and documented our analytic memos. For example, Author 1 coded each interview transcript in the first weeks, and Author 2 analyzed the same data in another few weeks. Additionally, we had group meetings and compared notes to identify the focal data. Based on our meetings, at the third step, we engaged in coding the focal data and identified patterns. This step generated two major patterns: the benefits of using AI and the participants' concerns about using AI and their future students' learning. Qualitative data analysis included coding, categorizing, and identifying patterns.

FINDINGS

The pre-service teachers had different experiences related to using generative AI tools in their life experiences and had different perspectives on using the tools in education. However, the participants' narratives shared two major themes: the benefits of using generative AI and the participants' concerns about using generative AI and their future students' learning. In the following sections, we present examples to illustrate the themes. The key findings can be found in Table 3 below.

Table 3*Key Findings and TPACK Mentioned by Participants in Frequency*

	Key findings	Frequency counts
The Benefits of Using AI	Using generative AI to support teaching and learning in various TPACK aspects, such as CK, TK, PK, as well as TPK, TCK, and TPACK in integration, and being culturally responsive	CK (4 out of 8 participants) TK (2 out of 8 participants) PK (5 out of 8 participants) TPK (3 out of 8 participants) TCK (3 out of 8 participants) TPACK integration (all mentioned) Culturally Responsive (all mentioned)
Concerns of Using AI	Various concerns	Cheating (2 out of 8 participants) Misinformation (2 out of 8 participants) Inabilities and insufficiency in AI knowledge (1 out of 8 participants)

The Benefits of Using AI

The data analysis generated the first major theme: the benefits of using generative AI. While the participants had various experiences related to using generative AI tools in their everyday lives, their narratives indicated their perspectives on the benefits of using generative AI to support teaching and learning in various TPACK aspects, such as CK, TK, PK, as well as TPK, TCK, and TPACK in integration. We found the integration of these domains in the participants' narratives, so we did not separate them into different sub-themes. Andy, who pursued her Elementary Education major and Computer Science minor, connected her learning experience to depict the positive side of using generative AI,

For example, for like, my math class [Here it is about “TPACK content area”], I just say oh, like I’m going to try ChatGPT and then I say give me some questions about like, x and x and x, and then it’ll give it [a math question] to me and I’ll solve it and they’ll tell me if I got the answer right or not. So it’s a good study tool [for CK].

The statement indicates Andy’s use of the generative AI tool, ChatGPT, to support her content-specific (CK) math learning. She provided a specific example of asking the ChatGPT to provide a math question for her to test whether or not she understood and solved the math problem correctly. In other words, she strategically navigated the tool to review the math content knowledge. This is an example of using ChatGPT for CK in the development of TPACK AI competencies. These competency guidelines and development could unite cultural responsiveness in helping all students with their generative AI learning and developing knowledge of content and pedagogical videos. Another student, Odelia, who was a sophomore in Elementary Education, stated,

I think that technology and videos you can show your kids are great ways to teach them not only about what subject you’re trying to teach, but also about like the culture [“culturally responsive competencies using videos”]. Like you can have like a science video like, Bill Nye, and you can have like, multiple different children from different backgrounds, a scientist can look like anything and you can also learn about like oxygen, so you can learn so many different things from videos [this is about “developing knowledge of content pedagogical videos” from generative AI].

In this statement, Odelia used the words “modern,” and “technological advances” to describe generative AI tools. She thought the tools afforded opportunities for the teachers to generate information and references related to possible videos, and teachers could use these videos to explain the content knowledge (e.g., science) to children from different backgrounds. This is an example of using generative AI for Technological and Content Knowledge development (TCK). Odelia is a second-generation immigrant from Europe. Her responses to other interview

questions showed that as a child from an immigrant family, she valued children's diverse cultural backgrounds. Toward this end, generative AI tools can support more inclusive practices in pedagogy and education. In other words, this is an example of using AI for Pedagogical Knowledge (PK) development.

The Participants' Concerns About Using AI

Although the participants valued the benefits of using AI as described in the previous section, another major pattern shared by the participants' narratives is that they also had concerns about using AI in teaching and learning. When she was asked to share her perspective on AI tools, Elsa, a sophomore in Elementary Education and Psychology double major, said, "I think it has like a negative effect on education because like, it makes it easier for students to cheat and like, not gain much." The statement shows that AI tools may have a negative impact on students' learning. Another student, Winnie, a sophomore in Elementary Education stated her concern,

This [ChatGPT] is gonna take away what humans are good at which is personal connections, and kind of having creative, original thoughts. And I think the more we can do it for the wrong things that are, that we go from what it means to be a human and what it means to be a person and create an action.

The statement shows that Winnie thought humans might rely on generative AI tools, such as ChatGPT, and lose their ability to create original thoughts. Similarly, another student, Andy shared her concern,

I feel like it's very toxic for students because they're relying on technology for everything, like, they may like put it, I think. To ChatGPT, and let it write it, and they'll submit it. They're not really learning the material, and I feel like there's like a lot of detectors for it, anyway, but like, what I'm trying to say is that I feel like it's very toxic for student learning because it's not the learning, is just like someone doing all the work for them.

Andy's narrative is connected to Winnie's statement. Both of them thought that people might depend on ChatGPT and generate information without thinking. Andy particularly shared her perspectives on how her future students may potentially and possibly use ChatGPT to generate writing or essays and submit them to her. She thought this was not real learning. Instead, this way would have negative impacts on students' writing and learning. These concerns enable teacher educators to consider how to use generative AI appropriately for effective teaching. The ways of using generative AI are very important.

DISCUSSION

This study explored pre-service teachers' perspectives on using AI tools in education. The TPACK framework was utilized to support our inquiry. Based on the analysis of semi-structured interviews, two major themes were identified. Findings indicate that some students believe that generative AI is a beneficial tool for teachers. For example, one participant, Andy, connected her learning experience to state that using ChatGPT helped her review her math content knowledge while taking a course in her teacher preparation programs. Odelia valued the use of generative AI tools to create more opportunities and possibilities to allow their future students to share culture in classrooms.

The findings also illustrate that the participants had concerns related to using AI in their future elementary classrooms. For example, one participant, Andy, was worried that her future elementary school-aged students would rely on AI and let AI and other technology do their homework. Another participant, Winnie, was also concerned that AI tools would influence her future students to acquire skills, such as building relationships and creativity, by saying, "This [ChatGPT] gonna take away what humans are good at, which are personal connections and kind of having creative original thoughts." These various concerns enable teacher educators to carefully consider how to help pre-service teachers explore appropriate ways of using generative AI for effective teaching.

Identifying Pathways Toward Developing Teacher Knowledge Using Generative AI

We consider that using ChatGPT as an emerging generative AI tool can be a relevant topic to TPACK research development. Drawing upon previous TPACK literature, the findings of the study, and ChatGPT, we consider four pathways for developing preservice teachers' TPACK. Our participants' narratives indicate the

benefits of using generative AI (e.g., one participant mentioned using ChatGPT to help the participant with math content knowledge learning). This enabled us to make connections between the use of ChatGPT and the CK domain of the TPACK framework. Therefore, we included the perspective on including ChatGPT in the new model, particularly in the third pathway (see Figure 1). While providing this example to explain how we drew upon the findings and the TPACK framework to design the model, we highlight that the new model includes four pathways described in the following sections. These four pathways are not meant to be exclusive and independent. Depending on the teacher's needs, they can be used independently or together in any combination.

Figure 1 represents the four pathways that emerged from our research, previous TPACK literature, and some conversations we had with Chat GPT. Here is one example of the conversation:

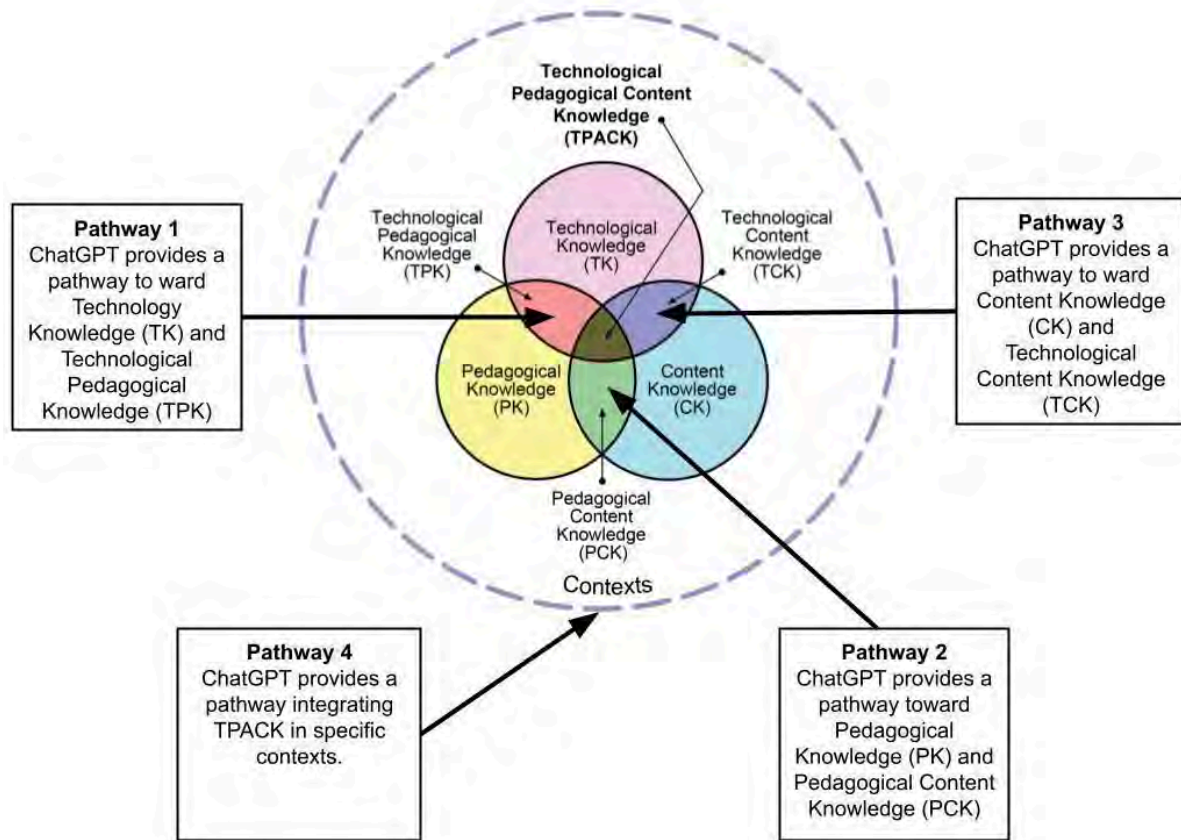
Authors: Create a diagram with the four pathways.

ChatGPT: I can describe the model using a textual representation, but I can't create diagrams directly. However, I can describe how you might create diagrams for this model using a tool like Microsoft PowerPoint, Google Slides, or other diagramming software (ChatGPT, personal communication, November 9, 2023).

Using this feedback from ChatGPT, we utilized the original TPACK Venn diagram (Mishra & Koehler, 2006) and added the four defined pathways that can support preservice teachers' development of TPACK. ChatGPT's query response said, "Pathway 1: Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK). Create a Venn diagram with two overlapping circles. Label one circle 'TK' and the other 'TPK.' The overlapping area represents the intersection of TK and TPK, where ChatGPT provides knowledge about technology integration in pedagogy." Based on this response, aligned with previous literature on TPACK, we indicated each pathway illustrated in Figure 1.

Figure 1

The Model of the Four Pathways for Teacher Education Programs



Note: This image is adapted from the The Technological Pedagogical and Content (Context) Knowledge Model conceptualized by Mishra & Koehler (2006) and uses the original image retrieved from <http://tpack.org> and reproduced with permission of the publisher, © 2012.

For the first pathway, Technological Knowledge (TK), ChatGPT can provide information and explanations about various technologies, including educational technology tools and software. Teacher educators can engage their pre-service teachers in exploring ways of asking generative AI to get information about technology knowledge effectively and can practice input/question-ask skills in the classroom. Educators can interact with ChatGPT to learn about the latest tech trends, tools, and their potential applications in the classroom. Toward this end, in the sub-area of Technological Content Knowledge (TCK), ChatGPT can offer guidance on using technology to teach specific content. Of course, the information needs to be carefully explored and validated before use. For example, it can provide coding examples, simulations, or resources for teaching STEM (Science, Technology, Engineering, and Mathematics) subjects. However, whether these resources and simulations are helpful and useful in specific contexts, such as classrooms, will depend on the XK (context of such knowledge) as guided by the TPACK framework.

The second pathway is regarding Pedagogical Knowledge (PK); ChatGPT can offer suggestions and strategies for effective teaching and learning practices. Teacher educators can engage in differentiated instruction, active learning, and formative assessment. For example, in formative assessment, teacher educators, pre-service teachers, and students can first engage in processes of identifying study goals and objectives, using generative AI (e.g., ChatGPT) in group/individual work in asking questions and information about the subject matter. Second, using classroom spaces or online interactions, ways of engagement with ChatGPT can be re-negotiated between the

teacher candidates and the faculty-preservice via formative feedback. The formative feedback can be centered on revising ChatGPT uses in the participants' classroom; for example, we practiced "how to draft a question about PK" in ChatGPT, such as "how to design an active classroom in an elementary classroom," and more specifically, "how to design an active classroom in 4th-grade math with rural students in Virginia." The formative assessment is helpful in supporting teachers in developing PK using ChatGPT. Educators can discuss their pedagogical concerns and get recommendations on how to adapt their teaching methods using technology. In terms of Pedagogical Content Knowledge (PCK), ChatGPT can provide teaching strategies and approaches that are tailored to specific content areas. Educators can discuss their content-related challenges and receive suggestions on how to address them effectively.

The third pathway is about Content Knowledge (CK); ChatGPT can provide explanations and resources related to specific content areas. For instance, educators can use ChatGPT to access information on subjects they teach or to gather additional content to supplement their lessons. Related to CK, Technological Content Knowledge (TCK), ChatGPT can offer guidance on using technology to teach specific content, such as the mentioned scientific videos in the findings section.

In the fourth pathway, educators can use ChatGPT in more contextualized ways in their specific sociocultural context in formal schools, teacher education programs, and K-12 multimodal learning situations. Regarding XK, ChatGPT can help educators develop their TPACK knowledge by offering insights at the intersection of technological, pedagogical, and content knowledge. It can assist in designing technology-enhanced lessons and activities that align with educational goals.

Overall, ChatGPT can be a valuable tool for educators seeking to enhance their TPACK. By engaging in conversations with ChatGPT, educators can gain insights, ideas, and resources to integrate technology into their teaching practices better while considering the unique intersection of technological, pedagogical, and content knowledge in education. The model in Figure 1 shows the advantages of using ChatGPT to offer pathways for the participants and other preservice teachers' development of AI-related TPACK domains.

Using Generative AI in Teacher Education

The model described previously informed practical implications for using AI tools in teacher education. First, faculty, clinical faculty, cooperative teachers, and teacher education partnership school leadership can revisit the teacher education program's technology integration courses, curriculum, website, and accreditation discourse and examine how their curriculum and existing educational practices may need updates by including a generative AI perspective, especially like ChatGPT. Our findings recommend including pre-service perspectives and adding more discussions about using generative AI tools in teacher education programs to better prepare prospective teachers for using generative AI tools in their future classrooms. Using digital technology is not a new topic, as many research studies have focused on the area. The existing literature has also shown the integration of pedagogical content knowledge and technological knowledge, which was emphasized by the TPACK framework (Angeli & Valanides, 2005; Koehler & Mishra, 2005; Mishra & Koehler, 2006, 2007; Mishra, 2019). Aligning with the literature, the present study also aims to highlight the importance of helping pre-service teachers with TPACK development and use of generative AI.

To this end, based on the findings (e.g., the participants described their use of ChatGPT to review content knowledge and benefit their learning), our recommendation in pedagogical implication is to consider the present development of generative AI in teacher education as an opportunity. Specifically, teacher education programs should consider offering generative AI tools and resources for prospective teacher candidates to explore how to use generative AI to benefit their teaching and learning. Offering the resources and course materials associated with TPACK and generative AI could help pre-service teachers gain better knowledge and explore more possibilities for using TPACK and generative AI.

Figure 1, illustrated previously, provides a specific four-pathway model for teacher educators to integrate generative AI (e.g., ChatGPT) into their classrooms to help pre-service teachers build their technological, pedagogical, and content knowledge. For example, teacher educators can model how to use ChatGPT to search for information and suggestions for effective teaching and invite pre-service teachers to engage in the practice of using ChatGPT to design their lessons. As explained in the previous sections, we drew upon the TPACK framework and navigated ChatGPT to create the four-pathway model. We suggest that teacher educators and pre-service teachers can also explore and use ChatGPT or other generative AI tools to create their own models for teaching and learning based on specific content areas and contexts.

In terms of implications for research, we also found a limited amount of scholarship has paid attention to using the TPACK framework to explore AI tools in teacher education (Celik, 2023; Park, 2021). Thus, the present

study expands on the literature and advances the area by learning from pre-service teachers' perspectives on AI use in education. While the findings especially demonstrate that the participants thought there were both benefits and concerns related to AI tools and education, the study recommends that the pre-service teachers' perspectives and experiences should be included in class discussions in teacher education programs. For example, teacher educators or course instructors need to provide more reading materials about the TPACK framework, generative AI, and education for pre-service teachers to read and discuss. During class discussions, course instructors could ask the pre-service teachers to make connections between the readings and their use of generative AI to learn more about the teachers' perspectives and explore more possibilities for using generative AI for effective teaching.

The present study also suggests that more research needs to be continued using AI tools in teacher education. While AI technology has been primarily utilized in computer science education programs (Barnes et al., 2017; Ng et al., 2021; Su et al., 2023), it has played more essential roles in everyday life. As it is becoming widespread, many discussions are tied to using generative AI tools in education (Su & Yang, 2023; Yang, S., & Evans, 2019). How can teacher education programs help pre-service teachers explore AI tools, specifically generative AI, in their future teaching and learning? How can pre-service teachers be prepared to use cutting-edge technology to help their prospective students to become digital citizens? Even though a limited body of scholarship has paid attention to this emerging area, more research studies are needed to find more possibilities and solutions to address these questions. By describing pre-service teachers' perspectives, the present study is a pilot project informing our future research directions. Our future research will also involve teacher educators' perspectives on preparing pre-service teachers for using generative AI tools and add more data-collection methods, such as observations or interventions, to gain insights into how generative AI tools can benefit teaching and learning in classroom settings.

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Creating Guidelines and Examining Ethical Issues

Locked In Generative AI: The Impact of Large Language Models on Educational Freedom and Teacher Education

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INTRODUCTION

Recently, large language models (LLM, also known as a text-generating form of generative AI) received much attention, with its most famous example being ChatGPT (OpenAI, 2023a). Discussions emerged on how large language models influence education, teaching, and learning (Opara et al., 2023). We have seen research on how ChatGPT can be used for creating learning content, creating student assessments, creating summaries for longer texts, and how it can be used for evaluating and grading student assignments in various educational domains (AlAfnan et al., 2023; Piccolo et al., 2023; Shidiq, 2023). Consequently, large language models may change educational processes at their core. The impact of LLM on education is seen as so relevant that several universities and researchers have published guidelines for teachers and learners on how to use LLM for their teaching and learning and how to react in teacher education (Carbonel, 2023; KU Leuven, 2023; Neumann et al., 2023; Open University, 2023; Rawas, 2023; Whalen & Mouza, 2023)—and even UNESCO took a detailed stance on it (Sabzalieva & Valentini, 2023). OpenAI, the developer of ChatGPT, has also prepared resources for educators to get started with ChatGPT (OpenAI, 2023b).

We have also seen studies that try to find the limitations of ChatGPT and its competitors. An early version of ChatGPT shows issues with mathematics: It cannot really calculate, use math functions, or do estimations well (Nguyen et al., 2023). In addition, ChatGPT has issues when it comes to consistency in long texts and dialogues, a phenomenon known as hallucination (Alkaissi & McFarlane, 2023; Shahriar & Hayawi, 2023). Furthermore, issues in the factuality of ChatGPT's answers have been discovered (Tyson, 2023). These issues, however, are the current picture and vary already from the free ChatGPT version and its current paid version, ChatGPT-4. In particular, the use of plug-ins reduces such issues tremendously.

However, one important risk is overlooked quite often: namely, that most publicly available large language models, such as MidJourney, ChatGPT, and others, are owned and run by commercial companies. These companies do not necessarily share the interests of free, transparent, and democratic education. In our point of view, education needs to remain free, open, and teacher-led. The large language models owned by commercial companies do not fulfill this requirement: what we see are models that appear to be black boxes from the outside. We do not know how these models were built, on what data input they were built, or how these models function, and we cannot judge how a model gets to a specific result on a specific input (Buolamwini, 2017; Liesenfeld et al., 2023).

Thus, if we accept that large language models will play a significant role in education, we need to seek ways to overcome the issues mentioned. If we want to keep control over the educational processes and avoid the risk of putting education into the hands of a few commercial companies that have their own interests, then we need to find ways to gain control over large language models and their qualities.

In this article, we first look into the affordances of large language models for education. Based on observed issues and shortcomings, we then derive requirements for large language models to be safely used within education before looking into solution perspectives. We conclude with the impact LLM may have on teacher education.

AFFORDANCES OF LLM FOR EDUCATION

Before we take a closer look into the affordances of LLM for education, we need to look into human learning and education per se: A specific advantage of us human beings is that we possess the ability to transfer what we have come to experience to other humans—and not only to those in close proximity—but also to those, who live miles away or centuries apart (for a deeper exploration of this topic, see Harari, 2015). This uniquely sets us apart from other animals and allows us to grow as a society as we do not have to learn over and over again, but we can build directly on the shoulders of our ancestors (Nelson & Nelson, 2002). But how do we do this? We do this by transferring what we have experienced, encountered, and figured out onto a durable artifact—from which others can learn. We started doing this already in Stone Age cave paintings. However, these were limited and could easily be misunderstood. The first revolution came with the occurrence of scripture—a systematic way of conveying information—even abstract concepts in an efficient manner. Still, this knowledge transfer was limited to a slim elite who had access to the clay tables or, later on, to the handwritten papyrus and medieval books. A second revolution came about when these scriptures could be mass-produced, and this was largely enabled by Gutenberg, who introduced printing. He achieved the democratization of access to information. All of a sudden, the common people could read for themselves whether the information spread by the elite clerics was indeed true. A third revolutionizing step was the digitalization of these knowledge artifacts. It started off with radio and television, which allowed widespread access to even more information on an even more global scale. Next, the internet enabled almost infinite and permanent access to information, while for the first time in our human existence, it gave a voice to the common people, who could spread their knowledge, skills, and opinions just like any elite could. Still, to be meaningful, this was time-consuming and effortful. Currently, we are in yet another revolutionizing state, where the production of digital artifacts is being democratized by the widespread introduction of generative AI. You do not have to be a yearlong trained painter possessing expensive painting equipment anymore to transform your vision into a digital visualization within seconds. And, of course, the same goes for producing texts. With tools like ChatGPT, seemingly everyone is capable of producing beautiful prose or philosophical essays within seconds. But is this really true? And how can we make the best use of this novel technology for education?

When ChatGPT—a text-generating software that is gratis AND seemingly easy to use for everyone—appeared on 30th November 2022, a new area began, and it quickly became the fastest-growing software application (Hu, 2023). But almost immediately, concerns from education occurred: Is this a blessing or a threat to our established educational system? We would like to argue that it is neither; it is a chance that we should take so we do not get left behind. In the following, we outline how ChatGPT can be useful for students and teachers.

Generative AI as a Tutoring Tool for Students: The Example of ChatGPT

Is ChatGPT every student's dream that they were longing for an automated homework machine? To get straight to the point, this is going too far. Still, ChatGPT can be very helpful to students in several areas.

ChatGPT can quickly provide a brief explanation or definition, especially when it comes to rare technical terms or concepts that are not easily found on Wikipedia or only described in little detail. For example, try to search for an explanation of "sensemaking." An ordinary Internet search, for instance, on Wikipedia would yield a detailed historical background, mathematical formulas, and extensive interpretations, as well as a plethora of links to related topics. With ChatGPT, however, you get a short explanation within seconds for someone without a background in physics.

This tool can also help generate ideas. Suppose you get stuck somewhere or do not know where to begin; ChatGPT is a really good start. If you start with a new topic, you can ask it for the most relevant aspects. You can also use ChatGPT to generate different ideas for titles or headings. This tool itself can help you come up with research questions or break down research questions into different sub-questions.

ChatGPT can help bring structure to a story. You can ask it to come up with a proposal for your essay, presentation, homework, or even the theoretical framework of a master thesis. You don't have to adopt everything like that right away, but it gives you a good starting point.

Never struggle with too many words again! ChatGPT is very good at writing summaries of longer pieces or shortening them to a certain number of words. On ChatGPT, you can also request an Internet-typical TL;DR of

well-known books, such as *1984* by George Orwell, *To Kill a Mockingbird* by Harper Lee, *Pride and Prejudice* by Jane Austen, and many more.

What ChatGPT really excels at is correcting grammatical and spelling errors, writing style, or rewording to a different tone or even language. Within seconds, your piece can sound much more fluent, be perfectly translated into English, or suddenly sound like Alfred Hitchcock wrote it. The latter, in particular, can help you see your pronunciation from a different perspective.

It is even possible to generate practice tests and receive targeted feedback. Cognitive psychologists call this the "testing effect" and have long known that this is very helpful for learning but, at the same time, requires a lot of preparatory work from the teacher (Rowland, 2014, p. 1). Recent research has shown that ChatGPT is even capable of providing reasonable formative feedback on students' writing style—not replacing human feedback but adding another loop of free and quick feedback that improves students' learning (Steiss et al., 2023). Hence, ChatGPT can act as a personal tutor here (Baidoo-Anu & Ansah, 2023).

In short, ChatGPT can be a powerful ally for students to improve their writing, for example.

ChatGPT as an Assistant for Teachers

Not only students but also teachers can benefit tremendously from ChatGPT. Below, we list some of the ways in which ChatGPT can be helpful.

Every one of us knows them: the emails that are not all that exciting yet always require time, energy, and attention to be precisely and intelligibly worded. Think of repeated explanations to students, information to colleagues about standard procedures, and so on. Or maybe you need to formulate feedback you have written down in bullet points on a student's essay in an email. From now on, ChatGPT can do that for you! The more information you provide about the recipient and the content to ChatGPT in the prompt, the better the email fits, and the more you can directly copy and paste.

But of course, never forget to check the content carefully because, ultimately, the email is sent with your name.

Suppose you need to develop a new course or a lesson on a new topic, but you are not creative at the moment, and brilliant ideas remain out. Here, too, ChatGPT can help you! It suggests course outlines or lesson plans for different target groups and lesson times. You can then use these as inspiration or a starting point for further development. It can even be more specific: it can give you specific suggestions for PowerPoint slide content. However, caution is required as you still have to transfer the text to PowerPoint and create appropriate formatting yourself. Usually, this means cutting the text down significantly.

Another interesting feature is the creation of test questions. You can ask ChatGPT to formulate open-ended or multiple-choice questions for a book chapter, complete with the correct answers included. But again, it is necessary to check, review critically, and improve these questions. You can also upload text into the prompt for the same purpose—but that can only handle up to 4,000 characters (the latest version of ChatGPT-4 can handle anywhere from 16,000 to 20,000 characters). And the more you place in the prompt, the less output you can receive. One more tip: It is even possible to generate key questions for a YouTube video by enabling the transcription function on YouTube and then copying this text to the prompt.

One last point where ChatGPT really adds value is that it can act as your assistant tutor to whom you can delegate simple tasks. For instance, many students struggle with basic linguistic issues, such as formulating grammatically correct sentences or a smooth flow of sentences, which takes up valuable feedback time. This is exactly where you can recommend your student to get help from ChatGPT. This applies to students with language and writing problems (e.g., dyslexic students) and students who do not yet have a high level of knowledge and skills in their writing language. ChatGPT can even provide some initial content feedback if you equip students with the right prompts. In this way, you as a teacher can focus during your own feedback time mainly on the content.

In short, ChatGPT can free up capacities for yourself by taking over standard tasks so that you can focus on the interesting aspects of your work!

RISKS AND LIMITATIONS OF LLM FOR EDUCATION

While the affordances of LLM for education are promising, we should also look into the risks they impose and the limitations they (currently) have.

First of all, we believe that LLM and other advanced AI systems are here to stay. They cannot be ignored or seen as a short-term hype that will go away. On the contrary, we expect to see further fast-moving developments in this area, where LLM and other AI systems gain new capabilities, offer new services, and become more and more integrated into everyday tools and routines.

Consequently, it is very important to be aware of the risks and limitations they impose. First, we look from an educational perspective into observed shortcomings for learners and educators, and then we try to understand these from the perspective of technical limitations.

What can ChatGPT not do (for students)?

One of the most well-known shortcomings of ChatGPT is that it often does not represent real or relevant source material or citations. This is because ChatGPT is a language model and not a digital library. The danger with this is that the references always look authentic. The authors exist, the journals appear real, and they are even displayed in the correct APA citation style. Unfortunately, ChatGPT also cannot assess whether these sources are substantively relevant. And often, they are not, even if they are genuine.

One pitfall you may not be immediately aware of is that ChatGPT does not transparently substantiate the statements it is able to display on such short notice. This is because it is not clear which sources support ChatGPT's claims, making it impossible to evaluate the quality of the information. However, evaluating sources is a prerequisite for critical thinking, which is why it is essential when processing information from the Web.

ChatGPT cannot check for accuracy, and it is, therefore, not suitable for writing a full master's thesis. So, ChatGPT will not replace teachers, but it can be used for additional feedback. And that is certainly not a bad thing!

What should you not expect from ChatGPT, and therefore, what should you continue to do yourself (as a teacher)?

ChatGPT can relieve you in many ways and free up your capacities. But as a teacher, you will NOT be replaced by a chatbot! Although we are dealing with rapid developments that are difficult to predict, our assessment remains a clear “No way!”

As mentioned earlier, it is crucial to keep critically monitoring what ChatGPT delivers as outcomes, for instance, in providing feedback on students' essays. As a language model, ChatGPT is capable of providing meaningful feedback on students' grammar, usage of words, overall writing style, and even the flow of their arguments; its feedback in terms of content should be reviewed carefully, as this is not the proposed use of a language model. And you can only do that if you have content expertise. This means that it is not possible to delegate content feedback to ChatGPT without the supervision of a teacher; teachers must continue to check the content and provide feedback. But providing feedback on the student's writing style or formulating one's own feedback comments—that, in turn, is where ChatGPT can help you as a teacher!

Another thing we should not underestimate is how difficult it can be to use ChatGPT in such a way that high-quality output comes out. This is true not only for us as teachers but also for our students. So, we should not expect students to be able to use ChatGPT well right away—some do, but this can lead to a big gap between techies and non-techies. It is up to us as teachers to prevent this.

So the good news is that we as teachers are not becoming obsolete. Our duties are changing, though, and we need to address that soon! To better understand the changing role of educators and to find new perspectives for teachers, we believe that it is important to have a closer look at the observed limitations and shortcomings from a technical perspective.

Technical Limitations

A number of the above-mentioned educational limitations of ChatGPT result from the underlying technical approaches and how it is trained with existing data.

Hallucination (Alkaissi & McFarlane, 2023): The underlying principle of LLM in answering prompts is to estimate the best possible next word based on a statistical analysis of the large set of training data in the context of the given prompt. Since the training data contains texts of varying sources and quality, there is a likelihood of answers diverging from the correct answer, especially when asked to produce longer texts. This phenomenon is

known as hallucination: the LLM produces output and continues to add to the produced text even though the added text no longer contributes to the correct answer.

Missing factuality/inventing fake facts (Tyson, 2023): As a consequence of the statistical approach, LLMs do not comprise a quality-controlled model of facts or evidence. They also cannot safely distinguish if a certain fact is present in the model or not. This can lead to situations where facts are simply made up due to a statistical likelihood of words put into a similar context. While this can creatively be used for inventing stories or improving the linguistic quality of written texts, it can also lead to disbelief and the distribution of false information.

Dependency on prompt quality (Short & Short, 2023): To maximize the benefit of LLM, the prompts used to query it must be well prepared. While at first glance, LLMs are as easy to use as a search engine, they depend to a large extent on the way prompts are designed and on the way subsequent prompts contextualize the whole human-LLM dialogue in a way that the LLM output satisfies the user needs in terms of factuality, language quality, output length, and format. This notion led to the introduction of the term “prompt engineering,” which coined a new human ability to deal with artificial intelligence (White et al., 2023, p. 1).

Task complexity limitations (Kocoń et al., 2023): While most test cases for ChatGPT’s abilities rely on anecdotal small-scale test cases, the research of Kocoń et al. (2023) reveals a decline of the ChatGPT’s response quality with increased task difficulty. This essentially reveals the biggest weakness of ChatGPT: the lack of a quality-controlled model of world knowledge. The statistical approach underlying ChatGPT’s model also serves the most likely tasks well, while unlikely tasks of high complexity are more likely to fail.

Some effort is currently being taken to reduce or remove these shortcomings with respect to hallucination (Chen et al., 2023) or factuality (Du et al., 2023). We can also expect more knowledge to be generated on how to reduce task complexity limitations (Wu et al., 2023). However, these improvements need time to become fully effective, and even then, human oversight remains an important ethical principle (Koulu, 2020). Additionally, Selwyn (2022, p 620) recommends “focus on issues relating to 'actually existing' AI rather than the overselling of speculative AI technologies” in order to find solutions accordingly.

Systematic risks and limitations

The risks discussed in this section are not about the technology or data underlying ChatGPT but rather its business context. ChatGPT is owned by OpenAI, a privately owned commercial company that received huge investments to develop its LLM technology (Bass, 2023). OpenAI owns and protects most details around ChatGPT and leaves us without answers to the following questions: How does the technology work exactly? What does the source code look like? Which exact training data has been used to train the model underlying ChatGPT (Buolamwini, 2017)? Which role do human quality control mechanisms play in the training and quality control process? What does the trained model and its weights look like? Which additional mechanisms are in place to ensure that ChatGPT’s answers are safe, non-offensive, true, and meaningful?

From the perspective of a commercial company, there is, of course, nothing wrong with keeping these critical business details secret. OpenAI has to protect these aspects from its competitors if the company wants to remain successful since the investment in the development of ChatGPT is very high.

However, these secrets hinder the independent evaluation of the aspects mentioned above (Liesenfeld et al., 2023): How can an educational institution estimate the impact of using this technology without having answers to the questions above? How can we be sure that technology is more beneficial than harmful in daily educational practice?

Educational risks

One of the most often mentioned risks expected from ChatGPT is cheating: students submit assignments that they claim to have written entirely on their own, but that have, in fact, been produced by ChatGPT (Cotton et al., 2023). Tools to detect such cheating with AI have already been proposed and developed (Yu et al., 2023), and a game of hare and hedgehog begins to improve the quality on both sides: the cheating detection and the generative AI (Khalil & Er, 2023). Also, educational institutions have begun to ban ChatGPT (Elsen-Rooney, 2023). We do not believe that this way of handling the existence of LLM will be successful since it does not prepare students for a life that this technology is part of. Instead, we may need to rethink our teaching methods and assessment strategies to be aware of these tools and to include them as part of education (Grassini, 2023).

However, we do see two other risks emerging involved with some of the capabilities of ChatGPT: (1) a risk of losing in-depth engagement in difficult topics and (2) a potential problem of “laziness” on all sides:

1. In-depth engagement: If ChatGPT can so perfectly summarize complex texts and even complete books into comprehensible chunks, then why should a learner take the effort to read the original source? How do we train analytical skills without in-depth engagement with underlying theories and principles?
2. Laziness on all sides: If we see cheating as a potential problem on the student side, do we ignore the potential laziness of teachers? With laziness here, we refer to the potential problems that teachers and learners might use generative AI to the extent that they sacrifice teaching and learning quality by simply relying on AI-generated outcomes. There are already examples where ChatGPT has been used to generate student assignments, answer given assignment tasks, and grade student submissions based on given assignment tasks (Zhai, 2023). Who would effectively teach or learn in this AI vs AI vs AI scenario? An example of a complete roundtrip would be using AI in generating an assignment task including grading criteria, writing an answer to the task, and grading the answer according to the grading criteria (OpenAI, 2023c).

Educational Requirements

Let's first look at a number of requirements that we impose from an educational perspective on LLMs so that we can use them for teacher education and, consequently, for education. We base these requirements on general purposes of education: qualification, socialization, and subjectification (Biesta, 2009). Qualification is often seen as the core purpose of education: the acquisition of knowledge, skills, and abilities. Socialization refers to the purpose of developing the learner into an active member of society. Subjectification, in turn, describes the purpose of forming and strengthening the learner's individuality, which can be “*understood as the opposite of the socialization function. It is precisely not about the insertion of 'newcomers' into existing orders but about ways of being that hint at independence from such orders*” (Biesta, 2009). Here, we list a number of aspects of education and derive the corresponding requirements for LLM to support these.

- Education needs to rely on factual knowledge and scientific evidence. Consequently, we require LLMs to be factual and to be built on reliable sources.
- Education needs to provide reliable and consistent information and knowledge to learners whenever fundamental knowledge or techniques have to be taught. Thus, LLMs need to be reliable and consistent in their answers.
- Education needs to be inclusive and open to everyone. We require LLMs not to foster a new form of digital divide.
- Education needs to be able to explain and deliver background information. To understand the output of LLMs, we thus require transparency and explainability of LLMs.
- Education should enable and foster creativity (based on the fundament of knowledge). LLMs need to be able to support creative processes in an engaging and stimulating way.
- Education should be free and not be bound by political or commercial interests. Consequently, we want to be able to gain insight into the development process, into the training process, and into the quality assurance process of large language models.

While not every individual teacher needs to understand every aspect of the above-mentioned requirements, it is important that these aspects can be researched, evaluated, and controlled by people, committees, or institutions independent of the companies that create and run the models.

So what should you be able to do yourself (as a student)?

To more effectively use ChatGP, consider the following:

Be critical of the content ChatGPT gives you, and don't just copy everything. Check everything thoroughly, especially if you want to adopt it in a piece for school or your studies and not just ask for private purposes. It's easier to be critical when you know more about a topic. That's when ChatGPT can really help you. However, never forget that you are ultimately responsible for what you turn in to the professor, not ChatGPT.

Ask the right questions or prompts. For simple questions, this is not such a problem, but if you want to know something specific and detailed that applies to your question, you need to formulate your prompt as specifically and comprehensively as possible. This often means that a single question is not enough, and you have to ask further questions to get the right output. The more concrete input you give ChatGPT in the prompt, the better the output will be.

In short: you as a student need new digital skills to effectively study with generative AI systems, such as ChatGPT (cf. Schank, 2020; Selwyn, 2022; Wang, 2019)!

What to look out for (as a teacher).

A major concern expressed by teachers is that students are submitting papers written entirely by ChatGPT. The need for software that detects this kind of "plagiarism" is so great that new technical solutions keep popping up. Unfortunately, they have one thing in common: they don't work very well.

There are two reasons for this: first, it lies in the meaning of the term. According to Merriam-Webster, the definition of plagiarism is "to use the words or ideas of another person as if they were your own words or ideas." But as mentioned earlier, ChatGPT is not a person, so there is no one from whom the student can plagiarize. The second reason is technical: plagiarism software checks whether a text has been published elsewhere. But that is simply not the case with texts ChatGPT creates. Still, as teachers, we can pay attention to certain points to detect simple copy-and-paste from ChatGPT. New tools aim to identify AI-generated content based on their structure, style, and specific use of language (Heikkilä, 2023). Sharples (2022) provides tips on how to detect AI-generated student pieces:

- The language is very technical, and there appears to be no understanding of these specialist terms.
- The text structure is not good: it does not flow smoothly, and arguments are presented in a concise, summary style.
- Plausible-looking but false sources are cited.

THE IMPACT ON TEACHER EDUCATION

Open Questions

As positive as we are about ChatGPT's opportunities for education, we must clearly admit that there are many open questions that we need to consider:

Which legal and ethical implications does the use of generative AI have?

To answer this, we need to learn more about the ethics and laws surrounding the use of ChatGPT in education. For example, decisions are made by ChatGPT that you, as a user, have no influence over, and the reasons behind them are unclear (Kobayashi & Watanabe, 2023) or intransparent (Swayne, 2023). Already today, corporate economic interests come into play in this. In addition, the data we enter into ChatGPT are not secure. They are used anyway to further train this system—ChatGPT is open about that, but there was also a recent data breach where some users were able to see others' searches (OpenAI, 2023d). We desperately need to know more about this before recommending students and faculty use this technology.

Teacher education needs to include these aspects in a way that enables individual teachers to use AI in education responsibly.

How should students use generative AI properly?

Personally, we think students should be allowed to use it as long as they meet two conditions: first, they should be open and transparent about it. Ultimately, ChatGPT is a useful tool and not plagiarism software. But they don't have to overuse it either; it's not a co-authoring tool. Scientific journals, such as *Science* and *Nature*, see it that way now (Holden Thorp, 2023; Stokel-Walker, 2023). Second, we should always emphasize that the responsibility for the final product lies with the student and not with ChatGPT (Spannagel, 2023). Therefore, they must also fully

support it and be able to defend it if necessary (for example, during an oral exam in the case of a written final product).

How do we want to teach students and learners meaningful use of ChatGPT?

This question demands us to (formally) embed the use of generative AI into our curricula. While this includes the above-mentioned aspects of ethics, law, transparency, and responsibility, this goes beyond: in addition, we need to define the skills that we expect from students themselves and the tasks that we can delegate to AI.

Which impact do we expect on traditionally highly ranked skills such as reading and writing texts about complex topics?

While a lot of research focuses on identifying new digital skills, we also need to take existing skills into account and reevaluate their relevance: for example, we already see changes in the relevance of spelling skills, which apparently decrease in relevance (Pan et al., 2021), so we may expect a similar trend with respect to the quality of written texts, which may increase due to AI support, while we cannot yet assess the impact on the human writing skill. On the one hand, this impacts our expectations of students' written pieces. On the other hand, this requires us to reevaluate our understanding of essential reading and writing skills.

Which new or changed digital skills become relevant for stakeholders in education?

In any case, it is clear that both we, as teachers and our students and learners, need to develop adjusted digital skills, as outlined in (Selwyn, 2022b):

- recognize when AI systems are used;
- have a basic understanding of how these AI systems work;
- knowing how to work with AI systems—for example, writing with ChatGPT so that it helps you rather than hinders you;
- know how to work around AI systems—for example, avoid data surveillance;
- recognizing when human input and oversight are needed—for example, knowing when to ignore an automated decision or resist AI bias or discrimination.

How should teacher education react to this situation?

Teacher education needs to focus on raising awareness of the limitations and risks mentioned in previous sections. It needs to show alternative paths. Fortunately, there are ways to overcome the limitations of commercial large language models: the use of open source, open data, and open model large language models:

- If the software underlying a large language model is open source, then developers independent of the original developers can examine, evaluate, and contribute to the algorithms behind the large language model. This can lead to improved algorithms, improved transparency within these algorithms, and generally quality-controlled approaches. However, compared to traditional algorithms, the source code of AI systems is less relevant: the training data and the resulting trained model are likewise important. Consequently, open source is only part of the solution.
- If the training data used to train a large language model follows the open data principle, then the factuality, quality, and comprehensiveness of the training data can be examined, and alternative or extended training data sets can be contributed. Furthermore, training data can be tailored to specific application contexts and educational domains.
- If the model that is used for a large language model and that is the result of the training process is an open model that is openly accessible as well, it can be embedded in new application contexts and independently examined.

Of course, simply moving to AI systems that follow the open source, open data, and open model principles does not yet solve anything, as systems designed that way may contain issues. Also, clear quality criteria for software, data, and models have not yet been established independently of the developer organizations. However,

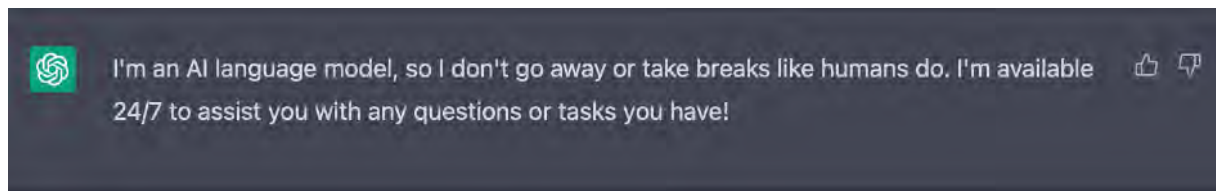
today, teacher education can raise awareness of these issues and work towards establishing such quality criteria with specific relevance for education. Kasneci et al. (2023) argue that “large language models in education require teachers and learners to develop sets of competencies and literacies necessary to both understand the technology as well as their limitations and unexpected brittleness of such systems.” For specific versions of large language models, such as code-generating models, such criteria are underway (Chen et al., 2021; Xu et al., 2022). First attempts to change this situation work towards general evaluation methods for large language models (Chen et al., 2023); however, these mainly look from a technological standpoint. We argue that teacher education needs to play a role in complementing this perspective by adding the educational perspective.

CONCLUSIONS

Whatever path we choose, generative AI, such as ChatGPT, remains a challenge for our education that we must address. The complicated part here is that this technology is not a static problem but continues to evolve. This means we have to stay up-to-date and look for new solutions. But we have no choice, as ChatGPT responded to the question about whether it is going away (see Fig. 1)

Figure 1.

ChatGPT answer (OpenAI, 2023a)



Steps that we have to take now

So what is the conclusion? What should we do now as teachers, educational scholars, and educators? We suggest the following steps:

1. As teachers and educators, let us learn how to use ChatGPT.
2. Let us teach our students how to use it properly and make them AI proficient.
3. Let us do more research to better understand the interaction between human cognition and this technology.
4. Teacher organizations need to prepare future teachers for LLM, their use, and the critical reflection on them.
5. Educational institutions, policymakers, and governments need to pave the way for open models, independently reviewable in terms of source code, training data, model weights and documentation.

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Toward a Conceptual Generative AI Ethical Framework in Teacher Education

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It's not hard to do the right thing. It's just becoming really hard to know what the right thing is!

– (Gawdat, 2021, p. 111)

INTRODUCTION

In an era when technology permeates every facet of our lives, the educational landscape is no exception, witnessing an unprecedented transformation catalyzed by artificial intelligence (AI). Amid this transformative change, one particular subset of AI, generative AI (GenAI), stands out for its potential to redefine educational paradigms. GenAI, particularly models like ChatGPT, has permeated various sectors, including education, by generating diverse and contextually relevant text through learning from extensive data (van den Berg & du Plessis, 2023). The advent of GenAI has provided tools that may enhance productivity and quality across various sectors and has rekindled discussions on AI's role, ethical implications, and future trends in education (Mello et al., 2023). Exploring GenAI in education, especially teacher education, necessitates a thorough understanding and critical evaluation of its capabilities and limitations. In this chapter, we will investigate and propose ethical principles to navigate the complex scenarios woven by the use of GenAI in teacher education. We will examine GenAI's potential to reshape teacher education.

DEMYSTIFYING GENAI: SIGNIFICANCE AND RELEVANCE IN EDUCATION

GenAI in the educational sector has catalyzed a paradigm shift, intertwining technological innovation with pedagogical methodologies to enhance and personalize learning experiences (Alasadi & Baiz, 2023). The applications featured in the subsequent figure epitomize this shift by leveraging GenAI to generate new, context-specific content or adaptive learning experiences. Applications such as ChatGPT and DALL·E could assist educators in creating interactive textual and visual materials, whereas Mathia and Duolingo represent possible avenues for adaptive learning in mathematics and languages. Similarly, QuillBot might support educators in enhancing writing tasks. Together, these tools illustrate how GenAI could diversely contribute to teacher education, underlining its potential role in personalizing and enhancing the educational process.

Figure 1

Generative AI Applications in Facilitating Educational Practice

Category	Application	Description
Conversational AI / Chatbot	ChatGPT	ChatGPT is a language prediction model that can generate human-like responses in a conversation.
Generative Art / Image Generation	DALL-E	DALL-E is a variant of the GPT-3 model, designed to generate creative and coherent images from textual descriptions.
Educational / Mathematics Tutoring	Mathia	Mathia is an intelligent tutoring system designed to help students learn mathematics.
Language Learning	Duolingo	Provides language-learning experiences through gamified lessons.
Writing Assistance	QuillBot	Paraphrasing tool that utilizes machine learning and natural language processing to rewrite or paraphrase sentences, paragraphs, or articles.

In teacher education, GenAI has transcended mere content aggregation to autonomously generate novel and contextually relevant content across media, introducing innovative pedagogical strategies and enhancing learning experiences. Its transformative impact, from assessment and personalized learning to influencing educational domains, has been recognized and adopted widely, offering a powerful tool for data augmentation, synthesis, and simulation (Bahroun et al., 2023; Lim et al., 2022; Zhai, 2022). But along with the potential of GenAI, its deployment introduces a spectrum of ethical, legal, and social dilemmas necessitating a balanced approach to integration (Eager & Brunton, 2023; Wang et al., 2023). GenAI's capabilities are not without limitations or challenges, such as the inability to generate innovative ideas, comprehend real-world entities, or guarantee the accuracy of its outputs, thereby highlighting the importance of ethics and social responsibility (UNESCO, 2023b).

GenAI demonstrates a transformative capacity in education, offering applications that significantly enhance teaching and learning experiences. GenAI, distinct from traditional AI systems, excels in creating personalized learning materials and scenarios by generating new content based on its training data. This capability is particularly effective in personalized learning, where GenAI can intelligently analyze data and recognize patterns to cater to individual student needs, thereby optimizing learning pathways (Bahroun et al., 2023). In contrast, intelligent tutoring systems (ITS), while adaptive and capable of providing personalized tutoring, primarily focus on feedback and task difficulty adjustment without the generative content creation aspect of GenAI (Lin et al., 2023; Yu et al., 2022). Therefore, while ITS can integrate GenAI to enhance functionality, GenAI is a distinct and more advanced technology in the realm of AI in education (St-Hilaire et al., 2022).

Regarding automated assessment, GenAI can automate feedback processes, which not only reduces the administrative burden on educators but also ensures that students receive immediate performance insights (Shute & Zapata-Rivera, 2012). GenAI can enhance resources by generating new content, scenarios, and learning materials tailored to learning objectives and student demographics, ensuring that materials are relevant, engaging, and aligned with learning outcomes (Graesser et al., 2005).

Ethical Concerns in Implementing GenAI in Education

GenAI offers transformative potential in education, enhancing creativity, innovation, and administrative efficiency. However, its integration also surfaces multifaceted ethical, legal, and social challenges (Eager & Brunton, 2023; Wang et al., 2023). While GenAI can enhance creativity through tools like DALL-E2 in art education (Hutson & Cotroneo, 2023), there are concerns about its impact on personal development and the potential loss of creativity in certain contexts, such as assessments (Smolansky et al., 2023). The integration of GenAI in educational assessments brings to the forefront significant concerns regarding academic integrity and the authentic measurement of student learning. As highlighted by Smolansky et al. (2023), the capability of AI to autonomously complete assignments, ranging from essay writing to complex problem-solving, raises critical questions about the validity of assessments as reflections of a student's true understanding and skills. This reliance on AI not only challenges the traditional metrics of academic success but also risks undermining the foundational goals of education by potentially facilitating academic dishonesty. Students and educators have expressed mixed opinions on GenAI's role in fostering creativity and innovation, with some highlighting its benefits and others cautioning against its challenges (Chan & Hu, 2023; Walczak & Cellary, 2023). This section explores these concerns, emphasizing the need for a balanced approach to GenAI, especially in teacher education.

Bias and Fairness

GenAI models, trained on vast datasets, can perpetuate and amplify societal biases. Research has pointed to potential perils of data misuse, leading to algorithmic mechanisms that could inadvertently amplify social disparities (O'Neil, 2016). This is concerning for GenAI's role in education, where biased content can have lasting impacts on learners. For instance, if a GenAI model is trained on literature that predominantly features male scientists, it might generate content that underrepresents female contributions to science, thereby perpetuating gender stereotypes.

Bias within GenAI models, especially in educational settings, can emanate from their training data, which might include content from websites, news platforms, niche forums, and even sites that have been associated with piracy, controversial viewpoints, or privacy concerns. Biases embedded within these data can subsequently become ingrained in the AI models, as evidenced by studies showcasing discernible gender, race, and religious biases in the generated text (Bolukbasi et al., 2016).

Diverse training data must be used for GenAI to promote equity in GenAI-generated content (Eilertsen et al., 2021; Snodgrass et al., 2017). Van den Berg and du Plessis (2023) underscored the significance of authenticity in GenAI-generated content, advocating for rigorous testing to avoid reinforcing existing educational disparities. Educators should be equipped with skills to identify and counteract biases from GenAI systems (Prather et al., 2023). It is essential to include GenAI ethics in teacher training, ensuring that future educators can navigate the complexities of bias with GenAI applications.

Brown et al. (2020) delved into the nuanced challenges posed by biases in large language models, specifically focusing on the ChatGPT version GPT-3.5, highlighting that these models, trained on extensive internet-scraped datasets, mirror the biases and uneven representations found within those data. GPT-3.5 has demonstrated biases in associating occupations with specific genders, varying sentiment adjectives used for different races, and generating text that promotes stereotypes of religious groups. Such biases reflect the GenAI training data, which raises crucial ethical questions for all educational applications of GenAI. Brown et al. (2020) emphasized the critical role of training data in perpetuating biases in AI, advocating for meticulous dataset curation, augmentation, and bias measurement during training to mitigate the generation of biased text or predictions. However, Brown et al. (2020) also underscored that resolving biases is an ongoing challenge in AI. A holistic approach is needed to ensure that GenAI models are free from biases and uphold the principles of fairness and neutrality.

Privacy and Security of Data

GenAI in education presents significant challenges for privacy and data security, which are essential for trust and safety with educational stakeholders (Huang, 2023). While GenAI systems are trained on data and generate new data based on their training, they do not inherently store information about specific inputs they receive. This distinction is crucial in understanding the privacy implications of GenAI in educational contexts. However, it's important to note that the data handling practices can vary depending on the specific GenAI model and its configuration, which necessitates a careful examination of each system's privacy measures. The concerns primarily arise from the data storage practices of the platforms implementing GenAI rather than the generative models themselves (Ohta & Nishio, 2023; Yu et al., 2023). Therefore, while educational platforms might collect and store

sensitive data, we must differentiate these practices from the functionalities of GenAI models, which focus on data processing and generation (Pandian & Columbus, 2022). When managed responsibly, these data can enhance learning experiences, predict student performance, and streamline educational processes. However, we must recognize that the ethical risks associated with GenAI technology in education primarily stem from how educational platforms collect, store, and use personal data. Potential misuse or breaches of personal data remain substantial concerns and warrant scrutiny along with robust data protection mechanisms (Huang, 2023). Therefore, the integration of AI in education necessitates a comprehensive approach to data privacy that extends beyond traditional measures. This includes careful consideration of the sources of data for AI training, such as personal blogs, social networks, and online platforms, where issues of consent and the potential for misuse of personal information are particularly pertinent. The impact of AI on human behaviors and societal norms, such as decision-making and privacy concerns, is a growing research area. For instance, a study of the influence of AI on decision-making indicated that AI significantly impacts student decision-making, induces laziness, and raises security and privacy concerns, thereby necessitating the implementation of preventive measures and ethical guidelines in deploying AI technologies in educational settings (Ahmad et al., 2023).

Accountability and Responsibility

Accountability and responsibility are pivotal considerations to ensure the ethical deployment and use of AI technologies. These principles are crucial for maintaining trust among stakeholders and for ensuring that AI technologies are used effectively and ethically in educational settings. Chan's (2023) AI ecological education policy framework organizes these implications into three dimensions: pedagogical, governance, and operational. The governance dimension, in particular, tackles issues related to privacy, security, and accountability, ensuring that stakeholders are aware of their responsibilities and can take appropriate actions accordingly (Chan, 2023).

Transparency and Explainability

Transparency and explainability in GenAI are fundamental to ensuring that AI systems operate with clarity and that users can comprehend these operations and decision-making processes. Educators need to understand how GenAI tools work to ensure appropriate application and use. A review of AI approaches in education, particularly those based on individual learner characteristics, highlighted the need for transparency and standardization in data usage across various applications, such as predicting learner performances and focusing on university education in STEM subjects (Grasse et al., 2023).

Greiner et al. (2023) investigated the use of GenAI systems, such as ChatGPT, in the evaluation of undergraduate dissertations. Using Davis' technology acceptance model and Schulz von Thun's four-sides communication model, the authors sought to understand human-AI interactions in academic grading. Their research, based on interviews and scenarios reflecting dissertation grading, highlighted the potential of GenAI in education and emphasized its ethical and effective deployment. Additionally, a workshop at CHIItaly 2023 titled "GENERAL" (GENerative, EXplainable, and REasonable Artificial Learning) explored advancements in GenAI, stressing the importance of explainability in GenAI systems and the need for understanding and controlling GenAI complexities, with a focus on fairness, accountability, and transparency (Di Caro et al., 2023).

Equity and Accessibility

The integration of GenAI in education brings to the forefront critical issues of equity and accessibility, challenging us to ensure that these technological advancements do not deepen existing disparities or create new ones. The "digital divide," a significant barrier in this context, refers to the gap between individuals with access to modern information and communication technology and those without. This divide manifests in various forms, such as disparities in digital device access, internet connectivity, digital literacy skills, and opportunities to use technology in meaningful ways (McIntosh et al., 2023). The digital divide can exacerbate existing educational inequalities, especially when technological innovations like GenAI are introduced without adequate consideration of accessibility and equity.

Educators must scrutinize the application of GenAI in education, ensuring that it does not marginalize or disadvantage certain populations. GenAI technologies are evolving to create more accessible services and applications for underrepresented populations in communities or higher education. For instance, the use of GenAI-based virtual assistants in immersive virtual reality environments can provide adaptive and interactive learning experiences, potentially benefiting those who lack traditional educational resources (Chheang et al., 2023).

Additionally, the use of GenAI as a proxy user, which refers to the simulation of user interactions by AI to predict and address the needs of underrepresented groups, in early-stage user research can help in understanding and addressing the specific needs of underrepresented populations in educational tool development (Jenkins et al., 2023). However, it is crucial to continue exploring and implementing innovative strategies, as seen in other fields like health education, to ensure that GenAI applications in education are broadly accessible and cater to a diverse range of learners. Furthermore, discussions on diversity, fairness, and representation in the information field globally necessitate addressing aspects like equity, inclusion, accessibility, and development. The lack of diverse representation, discrimination, and accommodation in education and the workplace must be addressed to ensure that GenAI technologies are developed and implemented in a manner that is equitable and accessible to all (Chu et al., 2023).

ChatGPT: Unpacking Ethical Complexities in Generative AI

ChatGPT, developed by OpenAI, stands prominently in the GenAI domain, particularly regarding higher education, bringing with it a host of opportunities and ethical dilemmas. Its adeptness at crafting human-like content can be an asset for content generation and academic assistance, yet it stokes concerns about academic integrity, plagiarism, and critical thinking (Michel-Villarreal et al., 2023). A spectrum of ethical concerns emerges with the application of ChatGPT, with scholars like Zhou et al. (2023) encapsulating them into four primary categories: bias, abuse, privacy, and transparency.

ChatGPT can exhibit bias in its responses, a consequence of machine learning algorithms and over-representation in training data, an issue acknowledged by OpenAI. These models, learning from extensive internet text, inherit not only the knowledge but also the biases and ethical dilemmas embedded in the data (Spennemann, 2023). The generation of content, while contextually relevant, can inadvertently perpetuate stereotypes, spread misinformation, and project biased perspectives (Goertzel, 2023). Abuse of this technology, such as engaging in misinformation campaigns or impersonation through generated content, also looms as a significant concern.

ChatGPT, like other GenAI models, uses vast amounts of internet text for training, which raises concerns about data privacy and the unintended disclosure of sensitive information (Elmore, 2023). The use of internet-derived data necessitates rigorous scrutiny to ensure that the generated content does not inadvertently reveal private or sensitive information and that it adheres to data protection and privacy norms. The decision-making processes of ChatGPT can be opaque, making it challenging to decipher how particular responses are generated. This lack of transparency can hinder users' understanding and trust in the technology, particularly in contexts where clear and accountable decision-making is paramount (Du & Kamenova, 2023). Ensuring transparency involves elucidating how models like ChatGPT generate responses and make decisions, which is crucial for ethical deployment.

The incorporation of ChatGPT into educational settings has sparked significant debate regarding academic integrity and ethics, particularly in the context of assessments. While ChatGPT can assist educators in creating assessment materials, its use by students in answering quiz questions or generating content raises concerns about academic integrity (Sullivan et al., 2023). The core issue lies in distinguishing between the use of GenAI tools like ChatGPT for legitimate educational purposes, such as aiding in content creation by teachers, and its potential misuse by students in circumventing the learning process. The distinction between AI-generated content and authentic scholarly work becomes crucial here. AI-generated content, while potentially satisfying specific assessment criteria, often lacks the depth and critical thinking inherent in authentic student work. This distinction is vital to maintaining the integrity of educational assessments and upholding the standards of academic work (Spennemann, 2023).

Need for Ethical Framework in GenAI and Teacher Education

The integration of GenAI into educational settings, particularly in teacher education, brings forth a myriad of moral and ethical considerations deeply intertwined with personal values in the educational community. Educators, in particular, grapple with the moral implications of employing GenAI in their teaching practices (van den Berg & du Plessis, 2023). While there can be benefits to using GenAI, there are also ethical dilemmas related to authenticity, intellectual property, and the potential for bias in generated content. The moral compass of educators is thus engaged in navigating through these ethical waters, ensuring that GenAI tools align with the principles of fairness, integrity, and respect for individual agency, understanding that they are resources to support teaching and learning and do not replace teachers.

The moralities associated with GenAI in teacher education extend to considerations of how these technologies impact the student-teacher relationship, the dynamics of the learning environment, and the holistic development of students. The ethical use of GenAI in teacher education is not merely about ensuring accurate and unbiased content generation but also about preserving the humanistic and relational aspects of education, ensuring that technology serves to enhance, rather than undermine, the educational experience (Zawacki-Richter et al., 2019). Furthermore, the moral discourse extends to the institutional level, where administrators and policymakers must grapple with the ethical implications of integrating GenAI into teacher education programs. This involves considering how these technologies align with the institutional values, potential risks, and safeguards necessary to protect the interests and well-being of all stakeholders (Holmes et al., 2018). In essence, the discussion about moralities associated with the use of GenAI in teacher education is a multifaceted dialogue that encompasses individual and institutional moralities. It invites a continuous exploration and reevaluation of how these technologies are aligned with our ethical principles and how they can be ethically deployed to serve the educational community.

The integration of GenAI in teacher education ushers in a necessity for a meticulously crafted ethical framework, given the profound ethical considerations that arise. With these technological advancements, educators are thrust into a vortex of ethical challenges (Fritz, 2022). Given the role of education in shaping future citizens, every tool used within this context, particularly GenAI, must be rigorously scrutinized to ensure alignment with the lofty ethical standards expected of educational systems (UNESCO, 2023a).

While the above considerations are enough to necessitate an ethical framework for the use of GenAI in education, additional issues such as transparency and cultural nuances further confirm this need. The opaque nature of many AI algorithms contradicts the academic ethos, which values transparency and understanding the rationale behind decisions (Zarsky, 2016). Beyond technical and philosophical hurdles, cultural nuances further complicate matters. Ethical norms vary globally, adding layers of complexity to the design and worldwide adoption of AI in education (Wang & Preininger, 2019). Hence, there is an urgent call for an ethical framework tailored to teacher education contexts.

Interdisciplinary Approaches to GenAI Integration in Teacher Education

A multifaceted approach is paramount to navigating through the ethical, pedagogical, and technological intricacies of GenAI in education. In this segment, we explore how different disciplines might contribute to and offer insights into the emerging field of GenAI educational developments.

The discipline of educational technology and pedagogy, which examines the integration of technology within teaching and learning processes, provides a foundation for understanding how GenAI could be effectively utilized to enhance educational practices. This includes potential applications such as personalized learning and adaptive assessment tools (Bahroun et al., 2023). Moreover, scholars in ethics and philosophy are beginning to explore the moral and ethical considerations of using GenAI in educational settings, highlighting the importance of aligning GenAI deployment with established moral principles and ethical standards to ensure that GenAI technologies will serve the best interests of students and educators, fostering an environment where technology enhances learning without compromising ethical values (Sharples, 2023). From the perspective of data science and artificial intelligence researchers, the exploration of the technological robustness and ethical use of AI algorithms and data is crucial, with GenAI tools like ChatGPT sparking discussions about their potential to transform educational practices, prompting a reevaluation of how AI technologies are integrated into the curriculum (Boscardin et al., 2023). Legal scholars are examining the implications of data privacy, intellectual property, and compliance issues related to the use of GenAI in education, highlighting the need for legal frameworks that support ethical GenAI applications (Zohny et al., 2023), while psychology and sociology researchers are exploring how GenAI impacts the psychological and social dynamics within educational settings (Johri et al., 2023). Information and communication technology (ICT) professionals are addressing the secure and effective use of GenAI technologies, ensuring that these tools are implemented in a way that safeguards user data and enhances the learning experience (Șorecău & Șorecău, 2023). Public policy administrators are focusing on developing policies that guide the ethical and effective use of GenAI in teacher education, aiming to create a regulatory environment that supports innovation while protecting stakeholders (Lorenz et al., 2023). Language and linguistics scholars investigated how GenAI can be used to support language learning and teaching, providing insights into the effective integration of AI in language education research (Pack & Maloney, 2023). Additionally, computer science and engineering researchers could play a pivotal role in refining the technological aspects of GenAI. Similarly, management and leadership professionals might be instrumental in guiding the strategic integration of these technologies within educational frameworks. Furthermore, special education and cultural studies could emphasize the importance of

designing GenAI applications to be inclusive, accessible, and sensitive to the diverse needs of learners. This approach could highlight the potential role of GenAI in promoting equity in education.

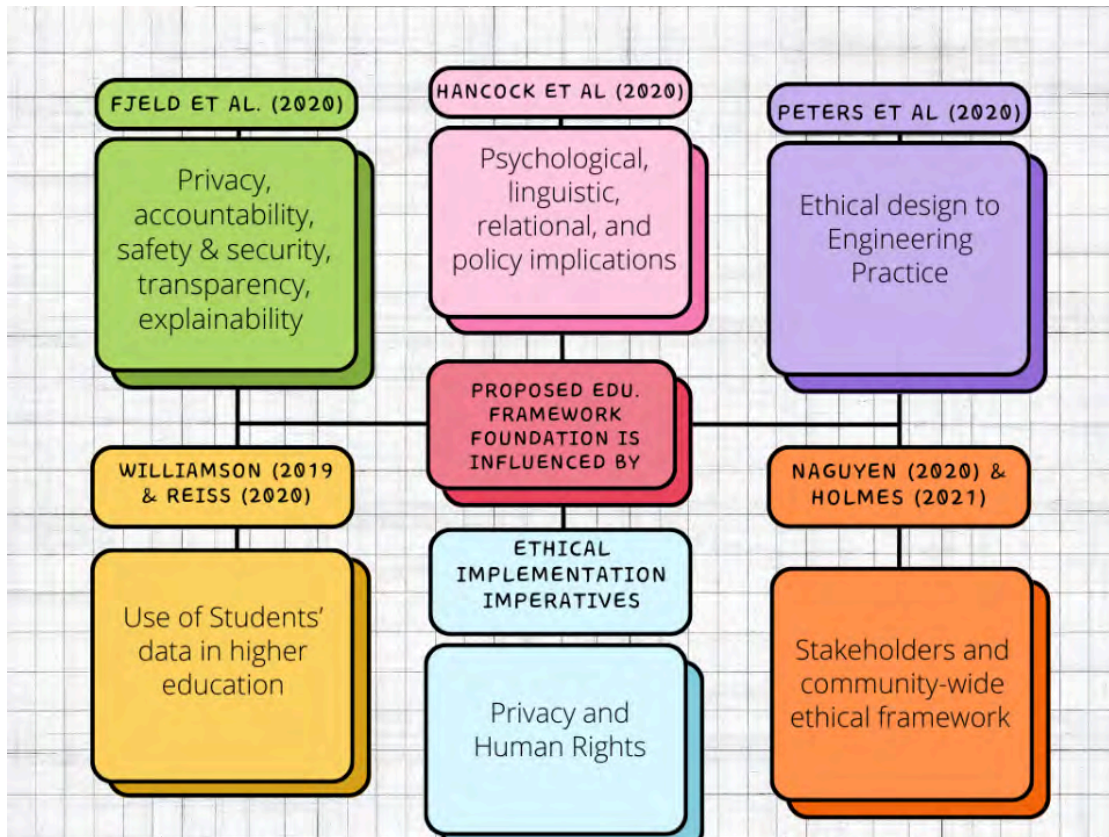
In short, the integration of GenAI into teacher education is an ongoing process continually benefits from the collaborative efforts of various disciplines. These examples illustrate the diverse approaches being taken to navigate the complexities and harness the potential of GenAI in a manner that is ethical, effective, and aligned with educational goals.

GENAIEF-TE: COMPARISON WITH EXISTING PRINCIPLES OF ETHICAL FRAMEWORKS

The conceptual GenAI ethical foundation principles in teacher education (GENAIEF-TE), which we propose in this chapter, are designed to address the unique ethical challenges posed by the use of GenAI in teacher education. With these proposed principles, we seek both to align with and diverge from existing themes and principles of other ethical frameworks in several ways, as illustrated in Figure 2. GENAIEF-TE should provide a comprehensive guide for educators and policymakers, focusing on the specific needs and challenges in the realm of teacher education and the ethical use of GenAI technologies. Fjeld et al. (2020) identified key thematic trends, including privacy, accountability, safety and security, transparency, fairness and non-discrimination, human control of technology, professional responsibility, and promotion of human values. The GENAIEF-TE aligns with these trends by emphasizing concepts of transparency, accountability, privacy, and fairness. However, it diverges by focusing specifically on teacher education and incorporating additional principles like cultural sensitivity, community-centered design, data literacy, and pedagogically centered design. Hancock et al. (2020) focused on the psychological, linguistic, relational, policy, and ethical implications of introducing AI into human-human communication. The GENAIEF-TE aligns with this by considering the implications of AI on teacher-student and student-student interactions and diverges by focusing on a broader range of ethical considerations. The main aspects of comparison between GENAIEF-TE and other ethical frameworks are related to teacher education and pedagogy- and community-centered designs.

Figure 2

Major Concepts Contributing to GENAIEF-TE



Teacher Education and Existing Frameworks

While prevailing AI frameworks offer substantial guidance for ethical analysis in various industries, their focus on teacher education is limited. The GENAIEF-TE framework, inspired by the ethical design practice frameworks of Peters et al. (2020), specifically addresses the unique challenges and opportunities presented by GenAI in the field of teacher education. Peters et al. introduced two ethical frameworks: the responsible design process and the spheres of technology experiences. Although the two frameworks went beyond the narrow definitions of safety in using AI, they were limited to aspects and challenges pertaining to the technical development of AI by technologists. The limitation in the responsible design process framework, for example, stems from the fact that Peters et al. focused on the concept of well-being during different stages of developing AI solutions such as research, insights, ideation, prototypes, and evaluation.

Nevertheless, GENAIEF-TE caters to the use of GenAI in a way that considers teacher educators and learning environments. GENAIEF-TE integrates actionable and interdisciplinary elements to ensure ethical diligence in the use of GenAI in teacher education. It safeguards against potential pitfalls while maximizing the benefits of the technology. For instance, in the context of student data, GENAIEF-TE aligns with Williamson's (2017) call for policy frameworks to address the ethical use of student records with a specific focus on teacher education.

Shachar et al. (2020) ethical implementation imperatives highlight important ethical imperatives in AI such as privacy and human rights. However, the authors' concerns were mainly related to health data. GENAIEF-TE extends these imperatives to teacher education, focusing on privacy, human rights, transparency, inclusivity, and safety and security. It also considers the environmental and social impact of AI technologies, ensuring mindful deployment in educational settings. Nguyen et al. (2023) proposed ethical principles to guide stakeholders in

developing trustworthy AI in education, including governance, transparency and accountability, sustainability, privacy, and inclusiveness. While the principles outlined by Nguyen et al. are invaluable for the broader educational landscape, they fall short in addressing the nuanced challenges inherent in teacher education. This gap underscores the necessity for the GENAIEF-TE proposed framework, which is specifically designed to address this issue. GENAIEF-TE aligns with and extends Nguyen et al.'s principles, offering a set of guidelines meticulously tailored to meet the specific demands and contexts encountered in GenAI integration within teacher education.

Reiss (2021) raised concerns about the practical use of AI in education and its ethical implications in terms of personalized learning and its impact on teachers. The extensive use of AI to personalize education may lead to speculation about replacing teachers (Luckin & Holmes, 2016; Reiss, 2021), in part because generative AI applications are available 24/7 and may provide faster solutions (Reiss, 2021). GENAIEF-TE responds to these concerns by focusing on how GenAI can enhance teacher training, assess teacher performance, and facilitate continuous professional development while ensuring ethical considerations are central to these applications. Holmes et al. (2021) aimed to develop a community-wide ethical framework for AI in education. GENAIEF-TE contributes to this goal by providing a focused framework for teacher education, addressing specific ethical considerations in this domain. The Institute for Ethical AI in Education (2021a, 2021b) and UNESCO's Guidance for Generative AI in Education and Research (2023b) have advocated for ethical AI integration in education. GENAIEF-TE complements these guidelines by focusing on teacher education and emphasizing principles like transparent accountability, privacy, secure data management, and culturally sensitive and inclusive fairness.

Pedagogical and Community-Centered Designs

GENAIEF-TE integrates a nuanced focus on the pedagogical dimension through its pedagogy-centered design, ensuring that GenAI is used appropriately as part of sound pedagogical practice. This design is not merely about incorporating technology into the classroom but also about ensuring that GenAI leads to improved learning outcomes, adapting to the needs of diverse learners, and pacing itself to match varying educational contexts. Holmes et al. (2021) reinforced this notion by emphasizing that AI should be a means to achieve educational goals, not an end in itself.

GENAIEF-TE ensures that GenAI not only supports the multifaceted learning of preservice teachers but also serves as a pragmatic model, demonstrating the ethical, effective, and inclusive integration of GenAI into their future classrooms. The integration of values in technology education through co-design pedagogies, as explored by Harvey and Ankiewicz (2022), is a prime example of how pedagogy-centered design can incorporate the values and perspectives of all stakeholders in teacher education to ensure inclusivity and collaboration. Furthermore, GENAIEF-TE's emphasis on GenAI's providing pivotal support to educators is crucial. It aligns GenAI with relevant curricula and embodies cultural responsiveness, preparing preservice teachers for the multifaceted challenges of modern classrooms.

In conjunction with the pedagogically centered design, the community-centered design principle plays a critical role. It ensures that a broad community of stakeholders, including educators, students, parents, policymakers, and AI developers, actively contributes to shaping GenAI technologies. This approach introduces a participatory dimension to technology adoption in teacher education to make sure GenAI's deployment is pedagogically sound, ethically grounded, and informed by the community. This aligns technological advancements with the holistic, ethical, and pedagogical imperatives of teacher education.

The analyses presented in this section form a comprehensive examination of the existing frameworks and their applicability to the teacher education context. GENAIEF-TE aligns with the foundational principles of existing frameworks while contributing uniquely to the teacher education context by addressing specific challenges and opportunities presented by GenAI. Applying GENAIEF-TE to global ethical guidelines and extending its applicability by providing specific, actionable, and context-relevant guidance for ethically integrating GenAI into teacher education foster a future where technology and pedagogy coalesce ethically and effectively. Therefore, the GENAIEF-TE encompasses the principles of transparent accountability, privacy, secure data management, culturally sensitive and inclusive fairness, community-centered design, transparent data and algorithmic literacy, and pedagogically centered design.

ETHICAL FRAMEWORK FOR GENAIEF-TE

GENAIEF-TE stands as a comprehensive guide for stakeholders in the educational sector, emphasizing the potential integration and application of GenAI technologies within teacher-educator preparation programs. This

proposed framework could be instrumental for educator preparation programs (EPPs) in facilitating the development of curricula and instructional strategies encompassing GenAI, including its ethical considerations. For example, EPPs might consider integrating modules on ethical GenAI usage, potentially enabling preservice teachers to acquire a holistic understanding of GenAI's capabilities and its ethical implications in educational contexts. The alignment of the framework with the education and training of preservice teachers could enrich their understanding and application of GenAI. It might guide them through practical experiences, such as case studies and simulations, to demonstrate the potential ethical use of GenAI in classroom environments. Further, teacher educators and administrators may play a significant role in aligning teacher education programs with the ethical aspects of GenAI as suggested by the framework. By leveraging these principles, they could enhance teaching methods, assessment tools, and policies to create a more ethically informed teaching environment.

To effectively incorporate the GENAIEF-TE principles into their curricula, EPPs could enhance their curricula with specialized courses or modules that focus on the ethical use of GenAI in education, combining theoretical discussions with practical workshops and project-based learning. Regular professional development workshops for faculty and administrators, covering training on GenAI tools, ethical dilemma discussions, and strategies for integrating these technologies into teaching practices, could be crucial for a deeper understanding and implementation of these principles. Collaboration with AI experts could provide EPPs with insights into the latest GenAI advancements and their ethical integration into teacher education, further enriching the learning experience for preservice teachers and ensuring that graduates are prepared to employ GenAI in educational settings ethically, with cultural sensitivity, and a strong pedagogical foundation.

Transparent Accountability

As part of our proposed foundation principles, GENAIEF-TE, transparent accountability is a key principle for the ethical deployment of GenAI technologies in teacher education. Educators must be fully informed about the algorithms that influence teaching strategies, student evaluations, and curricular adjustments. This principle is an ethical obligation to provide all stakeholders (e.g., educators, students, administrators) with clear, comprehensive, and accurate information about the functioning of GenAI systems, particularly regarding algorithmic operations, data usage, and decision-making processes.

To practically implement this principle, EPP faculty members can adopt transparent accountability by using GenAI tools for student assessment and providing students with a detailed explanation of how these tools evaluate their work. This includes discussions on the algorithm's criteria, its limitations, and how its outcomes should be interpreted. Smolansky et al. (2023) highlight the importance of adapting assessments to leverage AI, promoting critical thinking and addressing academic integrity concerns. Similarly, Sajadi et al. (2023) demonstrates the application of GenAI in providing individualized feedback for engineering student teams, enhancing the assessment process through efficiency and personalization. Furthermore, Lee et al. (2022) discusses the integration of generative AI in fostering sustainable student discourse and knowledge creation, indicating a broader application of AI tools in assessing and facilitating learning. Preservice teachers can be trained to critically evaluate and explain the GenAI tools they might use in their classrooms, ensuring they can communicate this information effectively to their students. Moreover, the ethical quandary of data ownership, which oscillates between data collectors, students, and educational institutions, further underscores the necessity for transparent accountability in delineating where and how data are collected, stored, and applied, ensuring clarity in data ownership, accessibility, and explainability (Digital Curation Centre, Centre, 2020; Holmes et al., 2021). Transparent accountability involves responsibility for the deployment and impacts of GenAI systems in teacher education (Boddington, 2017). Educational institutions, educators, and GenAI vendors must promote ethical data handling and algorithmic decision-making to safeguard the ethical and educational integrity of teacher education (Williamson, 2017).

Moreover, Bogina et al. (2021) emphasized the necessity of educating stakeholders on algorithmic fairness, accountability, transparency, and ethics, advocating for a multidisciplinary approach and guidelines for navigating the ethical landscape of GenAI. Fjeld et al. (2020) identified accountability as a key thematic trend in AI ethics, underscoring its pivotal role in the “normative core” of ethical considerations in AI deployments (Fjeld et al., 2020, p. 5). To ethically integrate GenAI into teacher education, we need a strong framework that balances educational effectiveness with ethical responsibility, protecting everyone involved to see that GenAI is used responsibly and leads to fair, beneficial outcomes.

Privacy and Secure Data Management

Privacy is not merely a technical requirement but also a fundamental civil right for individual autonomy and dignity, as articulated by Westin (1968). In the domain of GenAI, privacy extends beyond safeguarding data to include the ethical generation and use of new content derived from sensitive educational data. Su and Yang (2023) emphasized that ethical considerations in AI applications in education must prioritize privacy, especially when AI processes and creates new instructional content based on embedded data patterns. This necessitates a nuanced approach to privacy, ensuring that the generated content does not inadvertently disclose sensitive information or perpetuate biases, which is crucial in shaping ethically sound teaching practices and learning experiences. The iterative nature of teacher education involves a spectrum of data from personal information to professional practices, which underscores the imperative of a meticulous and transparent approach to managing privacy to ensure all stakeholders are well-informed and their data are used, stored, and protected ethically (Huang, 2023). Developers, therefore, must engage with educators and students to make informed decisions about GenAI deployment in classrooms. Such engagement aligns with the broader ethical and pedagogical imperatives of teacher education, addressing key concerns such as data privacy, ethical content generation, and the impact of AI on student learning (Arora & Arora, 2022; Chan & Hu, 2023; Wang et al., 2023; Yu et al., 2023). By fostering a participatory environment, stakeholders can contribute to shaping GenAI applications that are both technologically advanced, ethically sound, and pedagogically effective.

Emotional GenAI technologies, such as emotion recognition software, present complex privacy implications, particularly concerning the capturing of emotional data (Ho et al., 2023). While these technologies offer potential benefits, such as enabling teachers to better understand and respond to students' emotional states, it is important to approach their use with caution. The potential for teachers to track students' emotional states and adjust their instruction should be considered within the context of ethical guidelines and privacy concerns. Additionally, emotional GenAI can be a tool to identify students who may struggle with anxiety or depression, facilitating connections with appropriate resources. McStay (2020) underscored the need for clear privacy guidelines in this area, given the weak consensus among stakeholders on the ethical use of emotional data. In education, privacy extends beyond personal information to include academic records, behavioral data, and even biometric data in some advanced AI applications. Stakeholders must ensure that such data are used solely for educational improvement and not for unauthorized or unethical purposes. Adhering to the principle of privacy can build trust among students, educators, and parents, which is crucial for the successful integration of GenAI technologies in educational settings.

Culturally Sensitive and Inclusive Fairness

“Cultural sensitivity” is an “individual’s ability to develop a positive emotion toward understanding and appreciating cultural differences that promotes appropriate and effective behavior in intercultural communication” (Chen, 1997, p. 5). Cultural sensitivity in GenAI refers to the design of AI systems that acknowledge, respect, and accommodate the diverse cultural, social, and ethical norms of its users. Fairness in educational AI is vital to avoid perpetuating biases or inequalities among students. It must be culturally sensitive to prevent worsening or creating new disparities.

Fairness mandates that GenAI tools, especially those used for student assessments and personalized learning experiences, are designed and rigorously tested to ensure they do not favor or disadvantage specific groups based on cultural or other demographic variables. GenAI must avoid reinforcing existing biases and ensure equitable treatment of all users (Harry, 2023). For instance, an AI grading system should make impartial decisions and not favor students from specific demographic groups. AI tutoring systems should offer equally effective personalized instruction to all students regardless of their background.

Developers of GenAI systems in education should follow a robust ethical framework that includes fairness and cultural sensitivity as core principles. Holmes et al. (2021) highlighted the need for a multidisciplinary approach to tackle the emerging ethical questions in AI in education (AIED), including cultural sensitivity. They argued that most researchers of AIED are not trained to address these complex ethical issues, emphasizing the need for robust guidelines that include cultural considerations. Nguyen et al. (2023) proposed ethical principles for AI in education that could serve as a framework to guide educational stakeholders. While they did not explicitly mention cultural sensitivity, the principles the authors proposed, such as fairness and inclusion, require a culturally sensitive approach. This involves safeguarding the personal and sensitive information of educators and learners, ensuring transparent and consensual data collection and processing, and respecting the diverse cultural, social, and ethical norms of all users.

In the pursuit of promoting equality in high school advising, Assayed et al. (2023) introduced a novel chatbot leveraging a neural network model and natural language processing (NLP) to provide high school students with personalized academic advice. This approach, utilizing neural networks and NLP, shares foundational technologies with generative AI, which excels in creating contextually relevant content by learning from vast datasets. This AI tool, distinct in its ability to offer equitable assistance during a pivotal educational stage, uses a diverse dataset of 968 inquiry pairs from various academic sources. This ensures tailored guidance that resonates with the unique academic aspirations and backgrounds of students. The chatbot's sophisticated architecture, evidenced by its high accuracy score, aligns with the GENAIEF-TE principles' emphasis on technical proficiency and ethical soundness in educational GenAI applications. O'Neil (2016) elucidated the potential perils of data misuse, which can amplify social disparities, thereby necessitating educational entities to adhere to stringent data privacy protocols and align with legal frameworks such as General Data Protection Regulation (GDPR) and the Family Education Rights and Privacy Act (FERPA). This ethical handling and use of data, especially sensitive data from high school students, is not merely a legal requirement but a moral imperative to prevent furthering inequalities or biases in educational contexts. GENAIEF-TE is particularly pivotal in this context, ensuring that the deployment and use of such GenAI technologies in teacher education are technically proficient and ethically sound. The framework serves to ensure that the development, deployment, and ongoing use of GenAI technologies, like chatbots, are in strict alignment with recognized ethical standards and legal frameworks, safeguarding both the integrity of the educational process and the sensitive data it invariably interacts with.

Community-Centered Design

Community-centered design (CCD) underscores the imperative of involving all stakeholders (e.g., educators, students, parents, policymakers, AI developers) in the design, deployment, and evaluation of AI systems within educational contexts. This approach is crucial to ensure that AI tools, particularly GenAI, are not only technically proficient but also contextually relevant, addressing the unique needs and challenges of the educational community. A relevant example is the AR girls project, which strategically blended technology, art, science, and communication to engage art-oriented girls and young women, fostering an interest in computer science and ICT fields (Stylinski et al., 2021). While this project does not utilize GenAI, it exemplifies the CCD approach by actively involving its target community in the design process, thereby ensuring the technology's relevance and effectiveness. The project was rooted in principles like “stealth science” and place-based education, using location-based augmented reality as a communicative medium (Stylinski et al., 2021). This example underscores the importance of embedding technological innovations within pedagogical strategies that are both engaging and relevant to students and educators.

The use of ChatGPT in UX design and web development pedagogies, as discussed by York (2023), demonstrates how GenAI can be effectively employed in educational settings, enhancing both the learning experience and the relevance of the curriculum to real-world applications. It aligns with CCD by showcasing practical applications of GenAI that are beneficial and pertinent to the educational community. Further, the insights from Shi et al. (2023) on human-centered GenAI systems reinforced the importance of designing GenAI applications that are sensitive to the needs and contexts of educational communities. This aligns with CCD principles by ensuring that GenAI tools are developed with a focus on human interaction and user experience, enhancing their relevance and effectiveness in educational settings.

The impact of large language models in computing education, as explored by Prather et al. (2023), shows how GenAI tools, when used thoughtfully, can enhance the learning experience. This supports the CCD principle by illustrating the practical implications of GenAI in education and its potential to improve educational outcomes. Moreover, Giri and Brady (2023) proposal to involve the disabled community in the development of GenAI systems exemplified the need for inclusive and participatory approaches in GenAI development. This ensures that the tools developed are accessible and beneficial to all members of the educational community, including those with disabilities, thereby aligning with the core values of CCD.

Furthermore, exploring the concept of community-centered approaches in educational settings, the COVID-19 pandemic provided a tangible example of the significance and impact of such strategies. During this period, school leaders shared personal narratives about their leadership experiences, particularly emphasizing their support for immigrant and refugee families in Title I schools (Alvarez Gutiérrez et al., 2022). This method facilitated the co-construction of new meanings about school–community relationships during a notably challenging period, illuminating the potential of a community-centered school leadership model.

The relevance of this example for GenAI in teacher education lies in the demonstrated value of community-centered approaches. It underscores the imperative to ensure that the deployment of GenAI is not only

technically and pedagogically sound but also deeply rooted in the contextual needs and experiences of the educational community it serves. Thus, GenAI applications in teacher education should be designed and implemented with a keen awareness of and responsiveness to the specific challenges, opportunities, and experiences of the communities involved, ensuring that technological innovations are aligned with and supportive of the real-world, lived experiences of educators, students, and families.

Furthermore, the AI book club initiative, as described by Lee et al. (2022), exemplifies CCD in action within professional development for AI education. This innovative model engaged educators in a collaborative exploration of AI, blending independent study with group discussions to foster a deep understanding of AI content and ethical considerations. The program's structure, emphasizing asynchronous learning paired with synchronous community discussions, mirrors CCD principles by valuing diverse educator perspectives and fostering a participatory learning environment. The AI Book Club's approach to spreading learning over time and maintaining a community of educators interested in AI reflects CCD's emphasis on inclusivity and stakeholder engagement. By adapting AI materials for their classrooms, participants demonstrated how CCD can facilitate the integration of GenAI tools in education in a manner that is contextually relevant and responsive to the community's needs.

Transparent Data and Algorithmic Literacy

The principle of data literacy is fundamental for the ethical foundation principles for GenAI in teacher education. It highlights the importance for stakeholders to possess a basic understanding of data-related concepts. This includes knowledge about how data are gathered, processed, and applied within AI systems.

While student learning about AI has not been as successful as anticipated (Karampelas, 2021), recent studies suggest a shift in this trend. Zhang et al. (2023) illuminated the pivotal role of educating students in three core areas of GenAI: technical aspects, ethical and societal implications, and potential career paths in the AI field. Their findings revealed that after participating in a workshop, most students acquired a general understanding of AI concepts, including crucial elements of data literacy such as recognizing and mitigating bias in machine learning algorithms. This study is paramount to our discussion because the authors showed the feasibility and impact of integrating GenAI education into the student learning experience. Additionally, Casal-Otero et al. (2023) emphasized the need in AI literacy in K-12 education for a structured competency framework to guide didactic proposals and curriculum design, enhancing AI literacy among students. These insights suggest that the potential shortcomings in AI education so far might be due to the lack of a structured and comprehensive approach, which GenAI could address by providing more engaging and effective learning experiences.

The relevance of AI literacy extends to educators as well. Kim et al. (2022) found that teachers see the development of capacity and subject matter expertise as the primary learning objectives for collaborative learning with AI. Notably, teachers emphasized the necessity of instruction in AI principles and data literacy to improve the quality of student-AI interactions. While Kim et al. did not explicitly mention GenAI, their findings are pertinent to the discussion of GenAI in teacher education. They highlighted the importance of AI literacy and understanding for both students and educators, implying that the principles and insights from Kim et al.'s study can be applied to GenAI education as well, especially in preparing teacher educators to integrate GenAI tools effectively and ethically in their teaching. Zhang et al. (2023) and Kim et al. (2022) collectively highlighted that with the right knowledge and tools, teacher educators can create GenAI-enhanced learning materials and strategies that are both effective and ethically sound. The insights from these studies validate the importance of embedding GenAI education within teacher education programs, ensuring that educators are proficient and ethically informed in their use of GenAI, thereby enhancing teaching and learning while adhering to ethical standards.

Pedagogy-Centered Design

Pedagogy-centered design, especially within AIED, focuses on intertwining educational theories and practices in the development and operation of GenAI technologies. This strategy ensures GenAI tools meet technological standards and align with educational goals for relevant learning. Chang et al. (2023) highlighted the integration of self-regulated learning (SRL) principles in formulating GenAI chatbots for educational settings. By embedding pedagogical principles like goal setting, self-assessment, feedback, and personalization, all inspired by Zimmerman's SRL framework and judgment of learning (Zimmerman, 2000), the authors advocated for chatbots that nurture students' SRL, guiding comprehension and offering learning analytics to spur reflection and strategic learning development.

Building on this foundation, Chang et al. (2023) further propose specific pedagogical principles for the effective integration of AI chatbots in educational settings. These include enhanced goal setting, where AI chatbots

aid students in defining and pursuing their learning objectives, thereby fostering a more directed and purposeful learning experience. Additionally, they emphasize the importance of self-assessment and feedback, suggesting reverse prompting features in AI chatbots that guide students in monitoring their understanding and progress. The principle of personalization involves the development of data-driven mechanisms in AI chatbots to provide tailored learning analytics, enabling learners to reflect and adapt their learning strategies. Su and Yang (2023), in their study on AI chatbots like ChatGPT in education, propose a theoretical framework named "IDEE." This framework emphasizes identifying desired outcomes, determining the appropriate level of automation, ensuring ethical considerations, and evaluating effectiveness. The study underscores the potential of GenAI in providing personalized learning experiences and efficient feedback mechanisms while also acknowledging challenges such as untested effectiveness and ethical concerns.

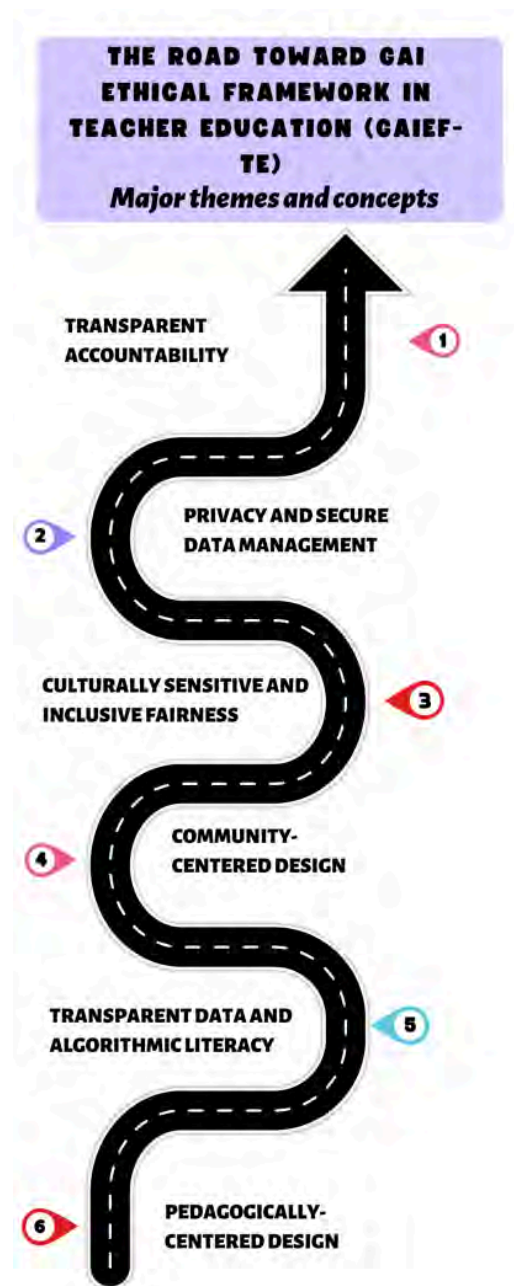
Recent scholarly discussions have highlighted issues related to the integration of GenAI tools, such as large language models (LLMs), in teaching environments. Concerns have been raised about their compatibility with diverse educational methodologies and the risk of their uncritical acceptance in learning processes (Eager & Brunton, 2023). These issues emphasize the need for a thoughtful and well-informed application of GenAI. When coupled with a solid understanding of educational principles, it will be both effective and ethically sound in educational settings.

HOW GENAIEF-TE MITIGATES ETHICAL CHALLENGES

The GENAIEF-TE principles outlined in this chapter represent a proposed foundation for developing a comprehensive framework for addressing ethical challenges in the context of GenAI in education (Figure 3). We derived these principles from an extensive review and synthesis of the literature, including academic articles, reports, and expert opinions, focusing on the ethical implications of GenAI in educational settings. The principles of transparent accountability, privacy, secure data management, culturally sensitive and inclusive fairness, community-centered design, transparent data literacy, and pedagogy-centered design are intended as building blocks for a more detailed and actionable framework. This literature-based approach aligns with the scholarly consensus on the necessity of a multidimensional, ethically informed strategy to navigate the complexities of AI in education (Nguyen et al., 2023). While these principles provide a theoretical foundation, they are proposed as starting points for further development and refinement into a comprehensive framework that can effectively guide the ethical integration of GenAI in teacher education, ensuring the responsible and educationally beneficial use of these technologies.

Figure 3

Concepts of the Guiding Principles Framework for Ethical GenAI in Teacher Education



1. Transparent accountability: Ensuring clarity in decision-making processes and holding entities accountable for GenAI applications' outcomes, especially those impacting teacher education trajectories, is crucial.
2. Privacy and secure data management: We must safeguard the personal and sensitive information of educators and learners and ensure transparent and consensual data collection and processing align with global data privacy and security standards in GenAI applications.
3. Culturally sensitive and inclusive fairness: This principle ensures that GenAI applications are fair and equitable to all users regardless of their cultural or social background, mitigating biases and ensuring inclusivity.

4. Community-centered design: The active involvement and benefit of the entire educational community are ensured by developing and implementing GenAI applications with a participative dimension.
5. Transparent data literacy: All stakeholders, including educators, students, and administrators, must have a clear understanding of how data are used, managed, and protected within GenAI applications in education.
6. Pedagogy-centered design: GenAI applications enhance the learning experience by aligning with educational objectives and pedagogical practices.

Ethically Grounded AI-Enhanced Educational Future

Embarking on a journey where GenAI intertwines with education necessitates a profound reflection on the ethical dimensions that should permeate its integration. While the ethical design of GenAI systems is crucial, ensuring that these systems are tailored to individual learning trajectories without compromising privacy or perpetuating biases (Bulger, 2016; Selwyn, 2019), it is equally important to recognize that the true effectiveness of these technologies in education lies in their application. As Weller (2020) noted, the impact of technology in educational settings is largely determined by how it is used by educators and learners. While these systems may be designed with the utmost ethical consideration, it is the innovative and thoughtful application by educators and learners that will truly realize this vision of a personalized and equitable educational future. The future of education, touched by the diligent hands of ethical AI, promises a realm where personalized, equitable, and comprehensive learning experiences are not mere aspirations but tangible realities. An ethical GenAI future, as envisioned by researchers and experts, anticipates a highly personalized educational journey for every learner. GenAI systems crafted on an ethical scaffold assure that personalization neither compromises student privacy nor perpetuates biases but instead tailors to individual learning trajectories, ensuring equitable access to quality education for all students, regardless of socioeconomic or geographical standings.

Educators in this future are envisioned to harness GenAI not as a replacement but as a facilitator, using ethical GenAI to glean insights into student performance, refine teaching methodologies, and prioritize nurturing critical thinking and creativity (Perera & Lankathilake, 2023). Moving beyond conventional testing methods, ethical GenAI would facilitate a holistic approach to student assessments, encompassing cognitive and emotional factors to provide a well-rounded view of student progress and well-being. In a future tinged with ethical GenAI, students will collaborate with GenAI agents as learning partners, fostering an environment that promotes continuous learning and curiosity. Moreover, as GenAI becomes a curriculum staple, students will be prepared to be not just technologically proficient but also ethically astute, ensuring future GenAI innovations are anchored in moral and ethical principles (Dickey & Bejarano, 2023).

In the realm of teacher education, especially concerning GenAI, a comprehensive, forward-thinking approach to training and professional development is vital. Given the swift proliferation of GenAI across educational spectra, a thorough exploration of its opportunities, challenges, and implications, particularly in pedagogy and educational frameworks, is crucial (Saputra et al., 2023). Training and professional development in GenAI should embrace its multifaceted applications in education, spanning technological, pedagogical, and ethical dimensions. For instance, Huisman et al. (2021) stressed the importance of embedding AI education in residency programs within radiology, covering vital areas like data management, ethics, and legal considerations in a methodology that can be mirrored in teacher education.

The conceptual weaving of GenAI ethics into curricula stands paramount, preparing future educators to effectively navigate the intricate tapestry of GenAI in education. This means both fostering GenAI-related skills and knowledge and nurturing a profound understanding of the ethical considerations inherent in deploying these technologies in educational arenas. Moreover, the integration of GenAI ethics into curricula should be meticulously crafted, ensuring it is underpinned by a CCD for relevance, inclusivity, and cultural sensitivity. Holmes et al. (2021) emphasized the necessity of a community-wide framework, which could serve as a pivotal guide in developing curricula that are technologically, pedagogically, and ethically robust.

While a robust framework that incorporates various crucial aspects is fundamental, its continuous refinement and adaptation to the evolving landscape of AI technologies and educational theories are vital. This necessitates sustaining a dialogue and feedback mechanism among all stakeholders so that the framework remains persistently relevant, effective, and ethically robust in guiding the implementation of GenAI in teacher education. Continuous reviews and adaptations of the framework, ensuring alignment with emerging technologies, educational practices, and ethical considerations, will be crucial as we move into the future.

GenAI must be incorporated into the teacher education curriculum to prepare future teachers to enter the field equipped with knowledge and understanding of Gen AI applications in educational contexts. The

GENAIEF-TE Framework can assist teacher educators with integrating GenAI principles into their curriculum as they prepare students to integrate technology into their practice. For example:

1. Introduce students to privacy policies for different GenAI tools. Have students assess the privacy and safety standards of a GenAI application and write a reflection about product security and how they would utilize the tool in their teaching practice while addressing student privacy and safety.
2. When discussing student data and record policies for K-12 environments, incorporate the role of GenAI programs within a classroom and identify the data types collected. Review school policies for student records and examine the role of GenAI programs in data collection.
3. Review teacher performance indicators and identify the role of GenAI in achieving teacher performance and improvement standards. Assess the role of mentorship that balances personalized feedback from human and digital sources.
4. Foster critical analysis by collaborating with students to test GenAI programs for response accuracy, bias, and incomplete responses.
5. Demonstrate how to determine district and school policies regarding utilizing GenAI tools in teaching. Ask students to write a reflection on how they will use and facilitate GenAI applications safely and effectively with their future students.
6. Model ethical use of GenAI within teacher education programs by including clear policy statements and generating discussion regarding the use of GenAI by students. Encourage students to develop personal guidelines for using GenAI without violating privacy policies or security standards.
7. Have students test out assessment plans for writing prompts and other activities by asking GenAI programs to respond to the assessment. Analyze the response and determine the quality of the output for accuracy, creativity, and ability to meet the assignment criteria. Ask students to report on the experience and identify how they can develop assessments to discourage direct copying of output from GenAI programs.
8. Develop a literature review focused on GenAI in education. Students will research the development of GenAI programs and write a review of the current research related to educational applications. Ask students to include a summary of GenAI programs and their potential for improving student learning outcomes.
9. Demonstrate how GenAI can assist teachers with planning and lesson development activities. Utilize GenAI programs within the classroom while discussing how to use these tools for time-saving and idea generation. Highlight how to leverage GenAI as a planning tool while creating unique teaching ideas. Emphasize the importance of learning how to write learning objectives and utilize instructional design processes to be an effective educator, highlighting the role of GenAI as a tool and not a replacement for writing learning objectives and developing appropriate assessments.
10. Create an identifying and addressing bias project where students investigate stereotypes and prejudice in GenAI outputs. Students will analyze how GenAI outputs can perpetuate bias and identify strategies for addressing these challenges in product development and classroom application.

The adoption of GenAI in education has led to concerns regarding personal data, learner autonomy, and the potential for algorithmic bias. While international organizations have proposed guidelines for ethical GenAI in education, the debate continues around the key principles that should underpin these guidelines (Nguyen et al., 2023). The responsible incorporation of GenAI in education requires a concerted effort to address these issues. Educators, as the frontline users of these technologies, have a pivotal role in ensuring that GenAI tools are used responsibly and ethically. With the tools and frameworks discussed in this chapter, teachers and educational administrators possess the theoretical and practical instruments needed to implement GenAI responsibly in the classroom. However, these tools and frameworks must be continually adjusted to accommodate the unique ethical complexities that new technologies introduce.

So, as we move forward into this new era of AI-driven education, we must remember that technology is merely a tool. The real power lies in how we use it. Let us use GenAI not just to teach but also to inspire, not just to inform, but also to empower. Let us remember that at the heart of education is the human spirit, and any tool, no matter how advanced, cannot serve to uplift and nurture that spirit. Let this be our guiding principle as we step into the future.

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Toward Meaningful Practice

Embracing ChatGPT in the Evolving Landscape of Mathematics Teacher Education and Assessment

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INTRODUCTION

In the ever-evolving landscape of educational technology, the emergence of ChatGPT and similar AI-driven conversational agents has ushered in a novel paradigm of both possibilities and challenges. Particularly in the domain of mathematics education, the emergence of generative Artificial Intelligence (AI) has necessitated a significant reevaluation among teacher educators who train pre-service and in-service teachers.

ChatGPT has both the scope and the power to solve many mathematics problems that would otherwise only be solved by humans. ChatGPT's prowess extends far beyond basic arithmetic and elementary algebra, which were strengths of the standard calculator and the graphing calculator. It also has the capability to tackle complex calculus, solve linear algebra equations, analyze statistical data, give solutions to discrete mathematics problems, and even venture into the realm of writing mathematical proofs. Its utility can be a way to obtain instant feedback on a mathematics problem or as a supplementary tool to reinforce classroom learning. But therein lies a double-edged sword with valid concerns for the mathematics classroom.

While ChatGPT can easily compute the integral of a complex function or solve a system of differential equations, the concerns that arise are multifaceted. There is a tangible worry that students may substitute a genuine understanding of solving a mathematical problem with a shortcut provided by the technology. Teachers and teacher educators are particularly concerned about this in the context of assessments. Traditional assessments in mathematics often follow the learn-calculate-regurgitate model, emphasizing the "how" over the "why." In a typical classroom setting, students learn a topic, such as quadratic equations, and are subsequently assessed on their ability to solve such equations with different numbers or in a slightly different context. The availability of ChatGPT potentially subverts this process by providing immediate answers without necessitating a deep understanding of the underlying mathematical principles. The concern spans from K12 education and how this impacts K12 mathematics assessments to the changing needs in classes for pre-service teachers. This concern gains additional complexity in online graduate classes for in-service mathematics teachers, where remote assessments and take-home assignments are not only common but often essential for their learning (Amos, 2023; Şenel & Şenel, 2021). The notion of academic integrity becomes fuzzy when a machine can effortlessly provide solutions that may be indistinguishable from a student's own work.

But what if we could turn this challenge into an opportunity? What if we reimagine assessments through a positivist lens of ChatGPT? A nuanced approach lies in the way we frame our assessments. The key lies in transitioning from questions that merely test computational skills to those that require understanding, application, articulation of mathematical concepts, etc. For example, instead of asking, "What is the integral of $\sin(x)$ from 0 to π ?", an alternative could be: "Compute the integral of $\sin(x)$ from 0 to π and explain what this quantity might represent in a real-world scenario involving oscillations." Here is an example (Figure 1) where we asked ChatGPT for an example that would be more relatable to a high school student.

Figure 1

ChatGPT Output Example for a High School Student



Certainly! Here's a high-school friendly question that retains the original mathematical challenge but also incorporates a real-world context that should be more relatable:

Original Question:

"What is the integral of x^2 from 0 to 3?"

Alternative Question:

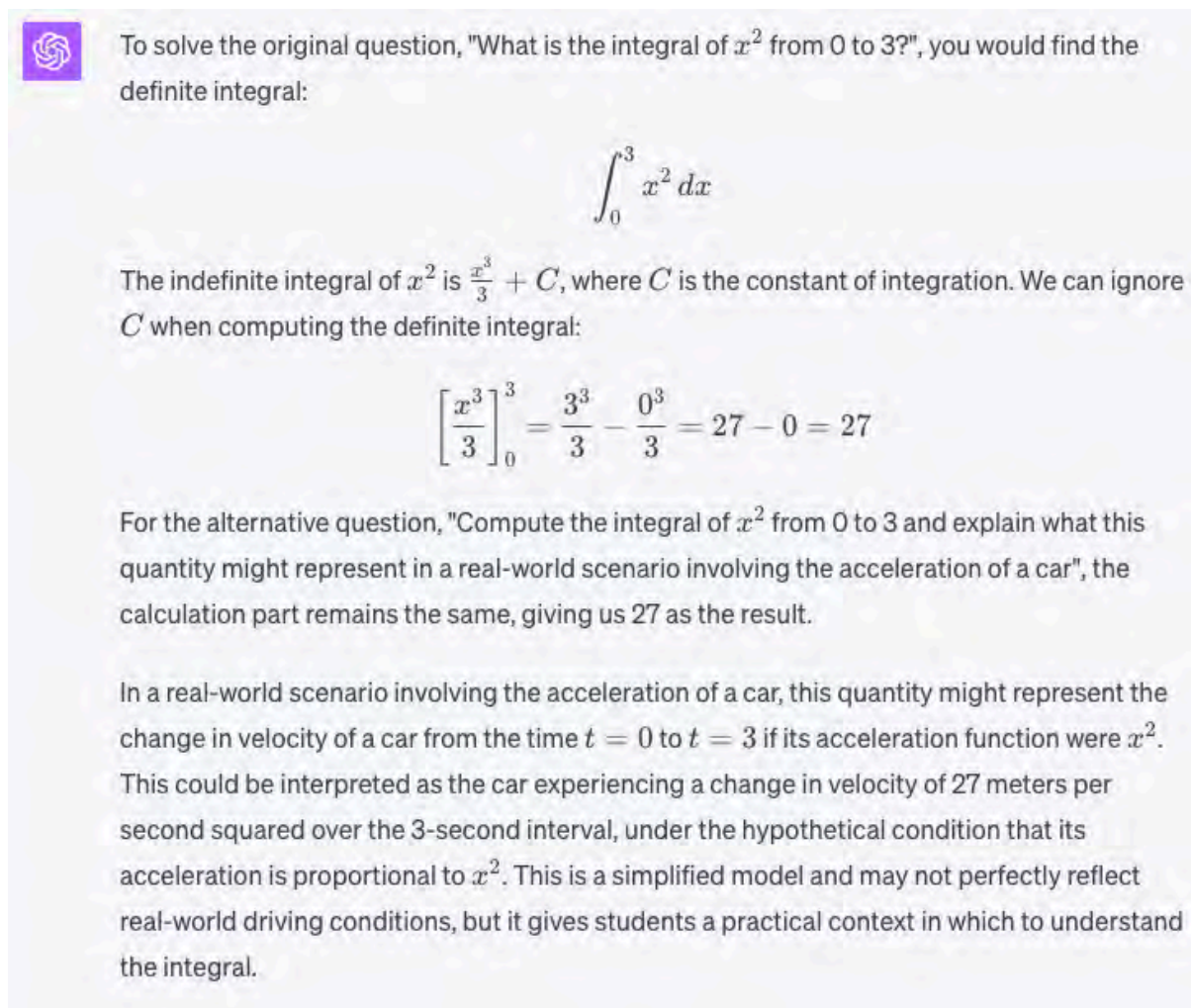
"Compute the integral of x^2 from 0 to 3 and explain what this quantity might represent in a real-world scenario involving the acceleration of a car."

In this alternative question, students not only calculate the integral but also have to think about how it can apply to real life. In this case, the integral of x^2 might represent the change in velocity of a car if its acceleration is proportional to x^2 , given that acceleration is the second derivative of the position function. This encourages students to make connections between abstract mathematical concepts and real-world applications, thereby deepening their understanding.

Another example (Figure 2) where ChatGPT solved a basic definite integral and added an example that would go beyond rote procedural skills is as follows.

Figure 2

ChatGPT Output to Solve a Basic Definite Integral with Example



To solve the original question, "What is the integral of x^2 from 0 to 3?", you would find the definite integral:

$$\int_0^3 x^2 dx$$

The indefinite integral of x^2 is $\frac{x^3}{3} + C$, where C is the constant of integration. We can ignore C when computing the definite integral:

$$\left[\frac{x^3}{3} \right]_0^3 = \frac{3^3}{3} - \frac{0^3}{3} = 27 - 0 = 27$$

For the alternative question, "Compute the integral of x^2 from 0 to 3 and explain what this quantity might represent in a real-world scenario involving the acceleration of a car", the calculation part remains the same, giving us 27 as the result.

In a real-world scenario involving the acceleration of a car, this quantity might represent the change in velocity of a car from the time $t = 0$ to $t = 3$ if its acceleration function were x^2 . This could be interpreted as the car experiencing a change in velocity of 27 meters per second squared over the 3-second interval, under the hypothetical condition that its acceleration is proportional to x^2 . This is a simplified model and may not perfectly reflect real-world driving conditions, but it gives students a practical context in which to understand the integral.

In cases where ChatGPT can provide the calculation or even the answer, we can structure assessments that demand subsequent and contextualized analysis, explanation, or extrapolation, allowing learners to connect the content to their personal lives while developing the cognitive skills and procedures for solving real-world problems. This way, even if students employ ChatGPT to solve a problem, the onus of understanding, analyzing, and explaining the solution still falls on them. This approach aligns far more closely with mathematical practices that prioritize reasoning, modeling, and communication over mere computation (NCTM, 2010).

In this chapter, we argue that by deliberately altering the texture of our assessments, teachers and teacher educators can cultivate a richer, more robust understanding of mathematical concepts among students. More than just a stop-gap measure to counter potential cheating, this serves as an evolution in how we conceptualize teaching and assessment in mathematics. Here, we not only adapt to technological advancements but also align our methods more closely with the Standards for Mathematical Practice (NCTM, 2010), which emphasize problem-solving, reasoning, and communication over rote calculation. By transitioning from traditional to more innovative forms of assessment, educators can not only mitigate the pitfalls presented by AI but also offer students a deeper, more

insightful learning experience. This chapter aims to empower teacher educators to navigate this intricate landscape by offering practical tools and strategies underpinned by the idea that technology, when applied judiciously, can enrich rather than dilute the educational experience (Evendi et al., 2022; Hooda et al., 2022; Qadir, 2023; Rudolph et al., 2023; Stovner & Klette, 2022; Suherman & Vidákovich, 2022).

REEVALUATING TRADITIONAL ASSESSMENT APPROACHES

Assessments in mathematics education have traditionally been designed to test a student's understanding of a mathematical topic or concept, often through traditional homework, quizzes, and exams (Hooda et al., 2022; Swiecki et al., 2022). These assessments usually comprise structured questions that align with the curriculum and the mathematical topics covered in the classroom. Traditional assessment approaches in mathematics have long emphasized a narrow set of skills, primarily focusing on computation, memorization, and the application of algorithms. This emphasis has been evident in various formats: multiple-choice questions, short answer questions that require a single numeric response, or even more extensive problems that nevertheless focus only on the final answer. Even when we ask students to show their work for such traditional questions, the problem is not solved, as ChatGPT can show its work as well. These conventional methods have worked under the assumption that mathematical proficiency is chiefly demonstrated by one's ability to perform calculations quickly and accurately. However, this approach, while valuable, has its limitations.

The Limits of Tradition

While the traditional assessment approach has its merits—after all, quick, accurate calculation is an essential skill—it often overlooks other equally vital aspects of mathematical competency, such as conceptual understanding, logical reasoning, problem-solving, and the ability to communicate mathematical ideas clearly. This restricted focus can have several detrimental impacts:

Narrow Focus

Traditional assessments, particularly in mathematics, have a proclivity for emphasizing specific problem types or computational skills. The most conventional formats—multiple-choice questions or short-answer queries, for example—tend to test a student's ability to recall and apply specific algorithms or formulae. As a result, these assessments can inadvertently sideline other valuable dimensions of mathematical understanding, such as conceptual clarity, logical reasoning, or the capacity for abstract thought (Royer, 2003). For instance, a test that focuses on solving quadratic equations by factoring might neglect to assess a student's understanding of what quadratic equations represent or how they appear in real-world contexts. This narrow focus can leave educators with an incomplete picture of a student's true mathematical capabilities and can even perpetuate misconceptions about what being good at math really means (Royer, 2003).

Pressure & Anxiety

High-stakes, timed examinations are a hallmark of traditional educational assessment. While the intent may be to evaluate a student's ability to perform under conditions that mimic real-world pressures, research suggests that such environments often induce assessment anxiety, disproportionately affecting performance (Zeidner, 1998). In other words, the timed nature of these tests may inhibit students from fully demonstrating their understanding or skill level. This is particularly concerning given findings that suggest test anxiety can interact with other variables like gender (Devine et al., 2012), socioeconomic status (Kalaycıoğlu, 2015), and cultural background (Foley et al., 2017; Wilburne et al., 2011) to produce results that are less indicative of ability and more reflective of a student's emotional state during the test (Cassady & Johnson, 2002; Zeidner, 1990). As such, the traditional format of timed exams may not only affect the validity of the assessment but also contribute to educational inequality.

Lack of Creativity

Standardized assessments, by their very design, offer little room for creative expression or problem-solving. Mathematics, contrary to popular belief, is a deeply creative field involving the formulation and testing of hypotheses, pattern recognition, and the derivation of multiple pathways to solve complex problems. Traditional

assessments often provide problems that have a single correct answer and a single correct method for obtaining that answer, thereby discouraging alternative approaches and creative problem-solving techniques (Starko, 2018). This rigid structure serves to stifle one of the most important skills that education should nurture: the ability to think creatively and critically. Students who may have alternative, yet valid, ways of approaching a problem find their creativity marginalized, which not only affects their performance but also impacts long-term engagement and interest in the subject.

Traditional mathematics assessments, often characterized by timed, multiple-choice tests or short-answer questions that focus solely on computational skills, raise significant equity concerns (Nortvedt & Buchholtz, 2019). These assessments frequently fail to capture the diverse range of skills, conceptual understandings, and problem-solving abilities that students from varied backgrounds may possess. Students who may not be strong in rote memorization or quick calculations—but who are otherwise talented in understanding mathematical concepts, patterns, or problem-solving approaches—are often at a disadvantage. Additionally, these assessments can exacerbate existing inequities by not accounting for educational gaps caused by socioeconomic status, cultural background, or varying qualities of prior education. For example, students who cannot afford tutoring or supplemental materials may not perform as well on these traditional tests, not due to a lack of ability but because of a lack of access to resources. Furthermore, these types of assessments can also be linguistically and culturally biased, which is problematic for students who are English Language Learners or come from diverse cultural backgrounds (Wilburne et al., 2011). Therefore, the limitations of traditional mathematics assessments pose serious concerns for educational equity, potentially reinforcing existing disparities rather than serving as a neutral measure of students' abilities.

The Need for Alternative Assessments

The current generation of students is not only tech-savvy but exposed to a myriad of learning resources online. Having grown up in the digital age, these students have unprecedented access to information and tools that can significantly shape their learning experiences. The COVID-19 pandemic forced a swift transition to remote learning and further amplified their reliance on digital platforms for educational engagement (Reich et al., 2020). As a result, these students have become adept at navigating online learning environments, using platforms ranging from online forums to specialized educational software. While this technological proficiency has many benefits, it also presents unique challenges in ensuring academic integrity and meaningful engagement with material (Selwyn, 2021).

For example, ChatGPT and similar AI tools can easily provide answers to traditional assessment questions. This necessitates a reevaluation of existing assessment frameworks and promotes a need for alternatives that assess understanding rather than rote knowledge (Mislevy et al., 2003). It is worth noting that even before the advent of sophisticated AI like ChatGPT, online platforms like Wolfram Alpha and Chegg were readily available for students seeking solutions to mathematical problems. These resources, while valuable, were often viewed as shortcuts by students looking to bypass the conceptual understanding that comes from grappling with problems (Williams, 2020). ChatGPT has merely intensified this dynamic, serving as a wake-up call to educators about the widespread availability of easy answers and the urgent need to adapt assessment strategies.

CHATGPT: A THREAT OR AN OPPORTUNITY?

In the dynamic landscape of teacher education, we find ourselves at a crucial juncture characterized by the digital revolution in education. This transformative period is witnessing the advent of AI-based tools such as ChatGPT, a development that simultaneously evokes excitement and unease within the education community. ChatGPT, with its capabilities, promises unparalleled prospects for personalized learning, streamlined feedback mechanisms, and the democratization of education on a global scale. Nevertheless, it also raises legitimate concerns regarding its potential to disrupt long-standing educational practices, particularly in the realm of assessment.

Considering these developments, educators and teacher educators alike are confronted with a pivotal question that demands careful consideration: Is ChatGPT a looming threat to the established educational landscape, posing challenges to traditional pedagogical methods? Alternatively, could it be an untapped opportunity, a catalyst for innovative approaches to teaching and learning, with a particular focus on its potential to revolutionize mathematics education?

As we embark on this exploration, it is imperative for us to critically examine the multifaceted dimensions of ChatGPT's integration into education. This involves assessing its advantages and drawbacks, the ethical

implications associated with its use, and the extent to which it complements or challenges the role of educators. Furthermore, we must engage in a thoughtful dialogue on how teacher education programs can adapt to equip educators with the knowledge and skills necessary to harness the benefits of this emerging technology while safeguarding the integrity of education.

In this rapidly changing era, our stance on ChatGPT's role in education will undoubtedly shape the future of teaching and learning. As teacher educators, we have a unique responsibility to facilitate informed discussions, foster innovation, and empower educators to navigate this transformative landscape with confidence and purpose. Through thoughtful reflection and collaborative engagement, we can determine whether ChatGPT is a threat, an opportunity, or perhaps a nuanced blend of both, ultimately paving the way for a more robust and responsive educational ecosystem.

Considering the capability of ChatGPT to generate precise and quick answers to complex mathematical problems raises valid concerns about academic integrity. Teachers and educational policymakers worry that the technology could be misused by students to bypass the laborious yet essential process of understanding and applying mathematical concepts (Pech-Rodríguez et al., 2023; Putra et al., 2023; Rahman & Watanobe, 2023). However, ChatGPT could be harnessed as a powerful educational aid, helping students and teachers alike in troubleshooting difficulties, offering supplementary explanations, and even providing real-time feedback that could foster deeper understanding.

In this section, we will delve into these diverging perspectives, informed by current research and practical examples, to dissect the potential roles of ChatGPT in modern classrooms. Our goal is to transcend the binary view of ChatGPT as either savior or saboteur of educational processes. Instead, we will argue that its impact is far more nuanced, dependent on the pedagogical approaches within which it is embedded. We aim to offer a balanced viewpoint that enables educators to make informed choices about integrating ChatGPT into their teaching and assessment strategies.

THE IMPLICATIONS OF GENERATIVE AI TECHNOLOGIES LIKE CHATGPT

As previously discussed in this chapter, AI technologies such as ChatGPT can easily solve computational problems, exacerbating the limitations of traditional assessments. When students have access to a tool that can instantly provide answers, the rote, algorithmic aspects of mathematical practice are even further devalued. However, the advent of such technologies is not merely a challenge; it can also be an opportunity to reassess and revise how we evaluate mathematical understanding. The potential of ChatGPT to disrupt traditional methods of assessment also offers an opportunity to reimagine the very fabric of how we evaluate students. A wealth of research suggests that more meaningful assessments focus on a student's ability to apply, analyze, and articulate concepts rather than simply recall or replicate them (Birenbaum et al., 2006; Shepard, 2000).

Conceptual Understanding

Assessments can be designed to pivot away from questions that are purely computational or procedural in nature—types that ChatGPT can easily solve—to those that demand critical thinking and a nuanced understanding of concepts. These might include questions requiring students to design their own problems, analyze mathematical arguments, or critique different problem-solving methods. Such an approach aligns with recommendations for authentic assessment, where students are evaluated on tasks representative of real-world skills and understanding (Wiggins, 1998).

Application

The modern workforce demands individuals who can adapt and apply their knowledge to unfamiliar and complex situations (Autor et al., 2003). Consequently, assessments can include problems set in real-world contexts that require a synthesis of various mathematical concepts. These may involve interdisciplinary challenges that demand the integration of mathematical knowledge with other subject areas, such as physics, economics, or public health. This move from abstract to applied questioning can not only make assessments more meaningful but also better prepare students for the complexities of modern life (Jonassen, 2000).

Communication

The importance of effectively communicating one's understanding cannot be overstated, especially in mathematics, where the clarity of exposition can make or break a solution, especially when problem-solving (Pólya, 1957). Assessments can be redesigned to gauge not just the final answer but the logical reasoning and communication skills that lead to it. For example, students might be asked to articulate their problem-solving process, justify their choice of strategy, or critique a given solution. Interestingly, ChatGPT itself can be a tool in this process. Students could use it to help formulate their mathematical reasoning before being asked to articulate it in their own words, serving a purpose similar to peer consultation (Topping, 2009).

Through a targeted reorientation of assessment strategies, ChatGPT can be leveraged to create a more holistic, authentic, and effective framework for evaluating student learning, one that addresses not just the what but the how and why of mathematical understanding.

LEVERAGING CHATGPT FOR INNOVATIVE ASSESSMENTS

Reevaluating traditional assessments considering ChatGPT and similar technologies involves asking different kinds of questions and seeking different kinds of answers. For example:

- **Conceptual Understanding:** Instead of asking for the solution to a particular equation, pose a question that asks students to compare and contrast two different methods for solving it.
- **Critical Analysis:** Require students to critique a provided solution to a complex problem, identifying any errors or inefficiencies.
- **Interdisciplinary Application:** Pose problems that require the integration of mathematical concepts with real-world applications or other subjects. For instance, using statistics in social sciences or applying calculus in physics.
- **Process Over Product:** Assign open-ended projects or problems where the path to the solution—and the thinking involved—is as important as the solution itself.
- **Peer and Self-Assessment:** Utilize peer-review mechanisms that foster a deeper understanding of the material and encourage students to articulate their thinking clearly.

Integrating these additional dimensions into assessments can construct a more holistic and nuanced understanding of mathematical proficiency. Not only would such an approach be more resistant to gaming the system through the use of AI, but it would also be more aligned with the goals of modern mathematics education, emphasizing understanding, application, and communication over rote calculation (Niss & Højgaard, 2019; Rashidov, 2020).

Rethinking Assessments

The blend of traditional pedagogical wisdom and evolving technological capabilities offers an unprecedented opportunity to rethink and reformulate assessment strategies in mathematics education. This transformation, while complex, is both necessary and promising for educators aiming to equip students with the multifaceted skills they need to navigate an increasingly complex world. As future educators are trained to step into classrooms, be they physical or virtual/online, understanding the advantages and pitfalls of technology in assessment becomes paramount. Here, we delve deeper into specific examples of how mathematics teachers and mathematics teacher educators can leverage generative AI tools such as ChatGPT when thinking about mathematics assessment in the age of AI. By embracing these changes, teacher education programs can not only adapt to the present landscape but actively shape the future of education in a manner that utilizes technology as a force for equity, depth, and excellence.

In this section, we provide examples of such assessment strategies that can be modeled in teacher education programs and used in mathematics classrooms.

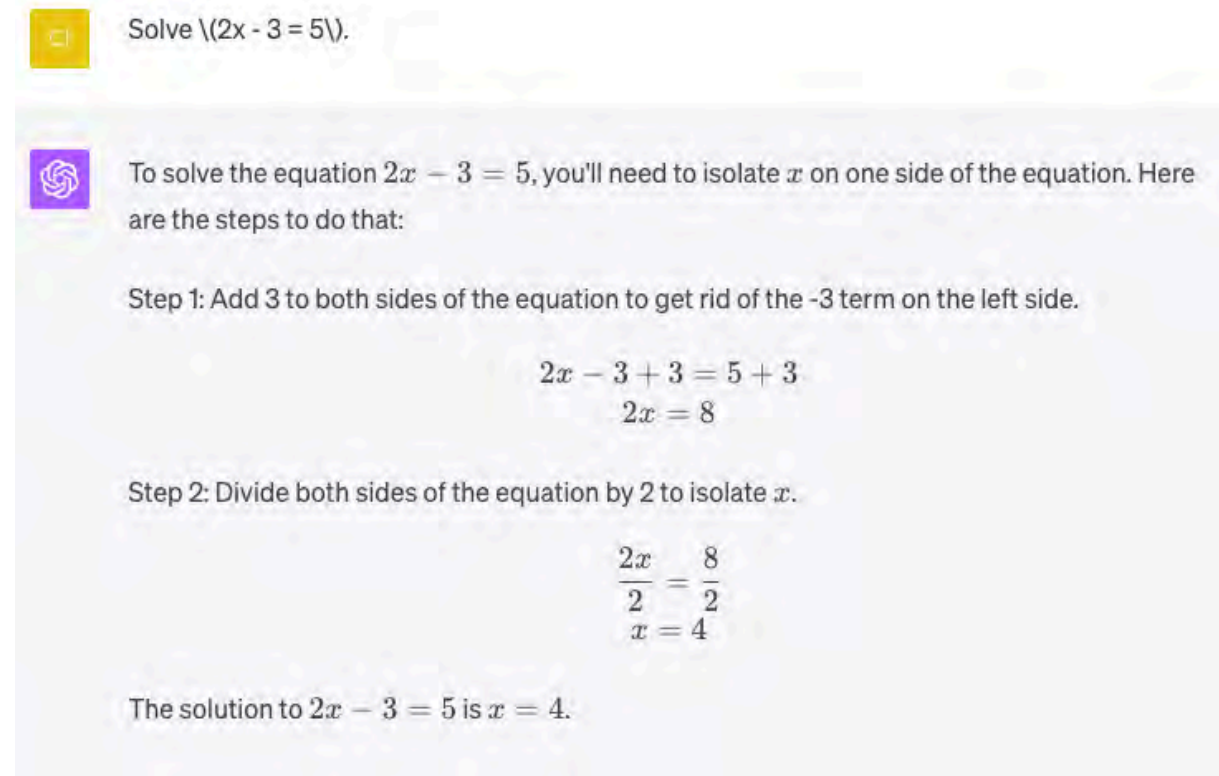
Open-ended Questions and Exploration


One of the most straightforward ways to incorporate ChatGPT into the assessment is by using open-ended questions that focus on the rationale behind mathematical decisions. For example, if you provide ChatGPT with a traditional procedural question, the answer will be rote, short, and not have much depth to it. Any student could use


ChatGPT to subvert the calculation process and get the answer to such questions without learning anything. If, instead, you use ChatGPT to answer an open-ended question, you can then have students analyze, discuss, and even critique the output. This is a great way to incorporate ChatGPT into classes for pre-service mathematics teachers and into professional development for in-service mathematics teachers to have them get a feel for how ChatGPT can be used as a learning tool when coupled with open-ended questions. For instance, we prompted ChatGPT to solve the traditional algebra question shown in Figure 3.

Figure 3

Prompt and ChatGPT Output to Solve an Algebra Question



 Solve $(2x - 3 = 5)$.

 To solve the equation $2x - 3 = 5$, you'll need to isolate x on one side of the equation. Here are the steps to do that:

Step 1: Add 3 to both sides of the equation to get rid of the -3 term on the left side.

$$\begin{aligned} 2x - 3 + 3 &= 5 + 3 \\ 2x &= 8 \end{aligned}$$

Step 2: Divide both sides of the equation by 2 to isolate x .

$$\begin{aligned} \frac{2x}{2} &= \frac{8}{2} \\ x &= 4 \end{aligned}$$

The solution to $2x - 3 = 5$ is $x = 4$.

We offer an example, shown in Figure 4, of changing that traditional question into an open-ended alternative is the following. We prompted ChatGPT to describe a real-world scenario where you would need to solve the equation $(2x - 3 = 5)$, asked how you would approach it, and what the scenario represented in the scenario.

Figure 4

ChatGPT Output Presenting a Real-World Scenario for Solving an Equation



Real-World Scenario: Calculating Profit

Imagine you're a small business owner selling handmade soap. You have a certain fixed cost, which includes rent, utilities, and raw materials. On top of that, there's a variable cost per unit of soap made. Your profit equation for each unit of soap can be represented as:

$$\text{Profit} = 2x - 3$$

In this equation, x represents the selling price of each unit of soap, and the profit is in dollars. The fixed cost is represented by the -3 (perhaps you have a \$3 expense for some raw material or packaging per soap), and $2x$ represents twice the selling price (this could account for a two-for-one deal you're offering to bulk purchasers).

You aim for a profit of \$5 per soap bar to sustain your business and plan for future investments. Therefore, you want to find out what the selling price x should be to meet this profit margin. This leads you to the equation $2x - 3 = 5$.

Approach and Solution

To find out what the selling price x should be, you'll solve for x :

1. **Add 3 to both sides of the equation:** This eliminates the -3 on the left-hand side, resulting in $2x = 8$.
2. **Divide both sides by 2:** This isolates x on one side, resulting in $x = 4$.

The solution, $x = 4$, means you would need to set the selling price of each unit of soap at \$4 to achieve the desired profit of \$5 per unit.

Interpretation

In this scenario, the value $x = 4$ represents the selling price per soap bar that will enable you to hit your target profit of \$5 per unit. By solving this equation, you've essentially figured out your pricing strategy for your soap to meet your profit goals. This kind of problem-solving is integral to small business operations, helping you make informed decisions that directly impact your sustainability and growth.

In a second example, shown in Figure 5, we first provide the traditional question and then an alternative.

Figure 5

Prompt and ChatGPT Output for a Traditional Mathematics Question



Calculate the mean, median, and mode of the following dataset: 12, 15, 17, 20, 21, 22, 22, 25, 27, 30.



To calculate the mean, median, and mode of the given dataset, we can follow these steps:

Mean:

The mean is the average of all the numbers in the dataset. To find the mean, sum up all the numbers and divide by the total count of numbers.

$$\text{Mean} = \frac{12 + 15 + 17 + 20 + 21 + 22 + 22 + 25 + 27 + 30}{10} = \frac{221}{10} = 22.1$$

Median:

The median is the middle value of a dataset when it is arranged in ascending order. In this case, the dataset is already in ascending order. Since the dataset contains an even number of observations (10), the median is the average of the two middle numbers.

To find the two middle numbers, we look at the 5th and 6th entries in the sorted dataset: 21 and 22.

$$\text{Median} = \frac{21 + 22}{2} = \frac{43}{2} = 21.5$$

Mode:

The mode is the number that appears most frequently in the dataset. In this dataset, the number 22 appears twice, more frequently than any other number.

$$\text{Mode} = 22$$

So, for this dataset, the mean is 22.1, the median is 21.5, and the mode is 22.

Open-ended alternative for ChatGPT to solve:


Suppose you have a dataset with the following values: 5, 7, 7, 8, 9, 10, 11, 12, 12, 15, 20.

1. Calculate the mean, median, and mode of this dataset.
2. Now, imagine that the value "20" was mistakenly recorded as "200" in the dataset. Recalculate the mean, median, and mode with this corrected dataset.
3. Compare and explain how the mean, median, and mode were affected by this mistake. What does this reveal about the impact of outliers in data analysis?

This question, as shown in Figure 6, encourages students not only to compute the statistical measures but also to consider the effects of outliers on these measures and how data quality can influence statistical analysis results.

Figure 6

ChatGPT Output for an Open-ended Alternative Mathematics Question



Original Dataset: 5, 7, 7, 8, 9, 10, 11, 12, 12, 15, 20

1. Calculate the mean, median, and mode.

- * **Mean:** The mean is calculated by summing up all the values and dividing by the count of values.
$$\text{Mean} = \frac{5 + 7 + 7 + 8 + 9 + 10 + 11 + 12 + 12 + 15 + 20}{11} = \frac{116}{11} \approx 10.55$$
- * **Median:** The dataset has 11 values, so the median is the value that appears in the middle when the data is sorted. In this case, the 6th value is 10.
$$\text{Median} = 10$$
- * **Mode:** The mode is the value that appears most frequently. Here, the numbers 7 and 12 appear twice each.
$$\text{Mode} = 7, 12$$

2. Recalculate mean, median, and mode with the corrected dataset: 5, 7, 7, 8, 9, 10, 11, 12, 12, 15, 200

- * **Mean:**
$$\text{Mean} = \frac{5 + 7 + 7 + 8 + 9 + 10 + 11 + 12 + 12 + 15 + 200}{11} = \frac{296}{11} \approx 26.91$$
- * **Median:** The dataset is not sorted in ascending order anymore. Sorting it gives us: 5, 7, 7, 8, 9, 10, 11, 12, 12, 15, 200. The 6th value is still 10.
$$\text{Median} = 10$$
- * **Mode:**
$$\text{Mode} = 7, 12$$

3. Compare and explain the impact of the mistake on mean, median, and mode.

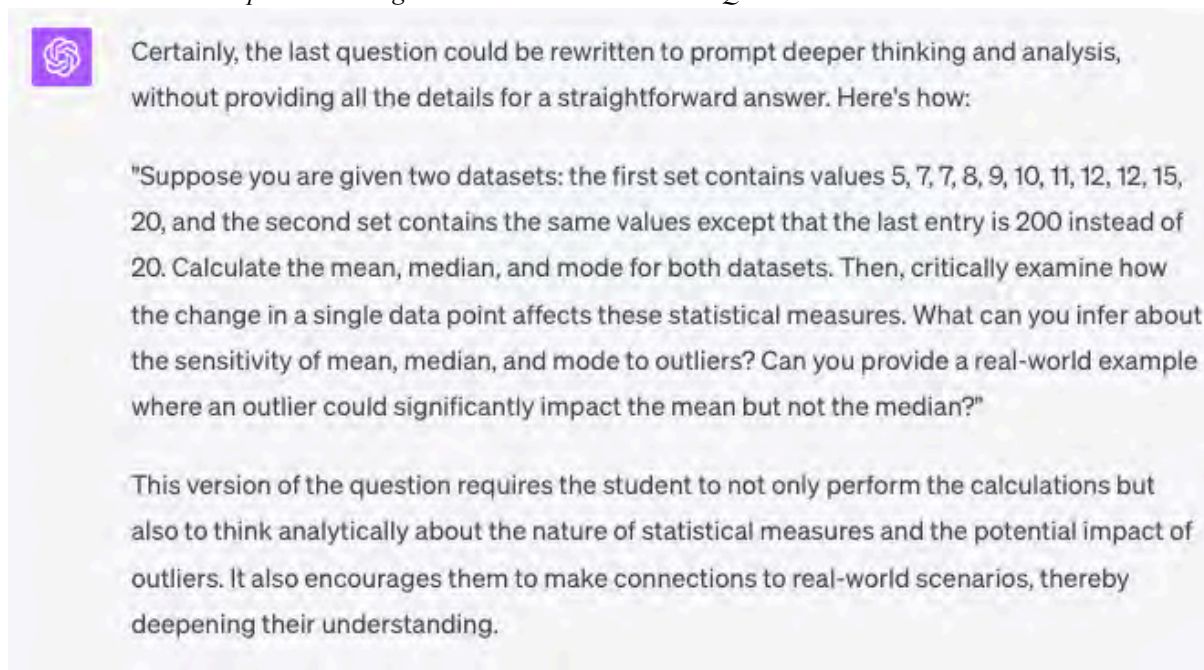
- * **Mean:** The mean increased dramatically from approximately 10.55 to 26.91 due to the outlier. This change significantly skews the average and may give a misleading representation of the data.
- * **Median:** The median remained the same (10) because it is less sensitive to outliers. It still accurately reflects the "center" of the dataset.
- * **Mode:** The mode remained the same (7, 12) and is not affected by the outlier.

This demonstrates that the mean is highly sensitive to outliers, whereas the median and mode are more robust measures of central tendency. The impact of outliers is especially important to consider in data analysis for this reason. It's always good to cross-check multiple measures of central tendency to get a more comprehensive understanding of your dataset.

We then prompted ChatGPT for a way to re-write the last question, as shown in Figure 7, so it could not be easily answered. We intended to have the student do some thinking on their own.

Figure 7

ChatGPT Output Re-Writing the Alternative Mathematics Question



In this second example, we started with a very basic, traditional statistics question. Then, we had ChatGPT create a similar open-ended question. Finally, we asked ChatGPT to create a question it could not easily answer. Teachers and teacher educators could do a variety of things with these outputs. The student could analyze the outputs and then explain the output to another student. The learner could be given a traditional question and work collaboratively with ChatGPT to get a better, more open-ended question (and then answer the question themselves). Consider having the student dissect the question and output to determine what the mathematical thinking behind the solution is and explain it to classmates. Remember that even if students put the exact same prompt into ChatGPT, they will each get different answers. So, if they took two different outputs and compared them, they could describe why the answers are the same mathematically. The possibilities are endless.

Project-Based Assessments

Another way in which ChatGPT can be incorporated into the classroom is through project-based assessments. Project-based assessments can integrate various mathematical concepts into a single project. Teachers can use ChatGPT to brainstorm project ideas, and students can consult with ChatGPT during the project under supervised conditions. Here, we provide one such example of a project-based assessment in probability and statistics.

Example: Project-Based Assessment in Probability and Statistics

The Project: "Weather Prediction and Dress Code Analytics"

In this project, students will use real-world weather data to predict weather conditions for the next month. Based on these predictions, students will create a "Dress Code Analytics" report to help a local clothing store optimize its inventory for the coming month. The store is particularly interested in knowing how many cold-weather and warm-weather outfits they should have in stock.

Project Components:

1. **Data Collection:** Students will collect past weather data for their location, focusing on temperature, wind speed, and precipitation levels.
2. **Probability Analysis:** Using the collected data, students will calculate probabilities for various weather conditions like "sunny," "rainy," and "cold," etc.
3. **Statistical Modelling:** Students will create statistical models to predict future weather patterns.
4. **Dress Code Analytics:** Based on the weather predictions, students will calculate how many warm-weather and cold-weather outfits the clothing store should keep in stock.
5. **Report and Presentation:** Students will summarize their findings in a written report and an oral presentation, explaining their methods and results clearly.

ChatGPT's Role. Teachers can use ChatGPT to brainstorm ideas for the project, from determining what kind of data to collect to the statistical models best suited for analysis. During the project, students can consult ChatGPT to clarify statistical concepts or get advice on the best ways to display their findings, all under the supervised conditions laid out by the teacher.

Discussing the Mathematics and Assessment.

Mathematics:

1. **Probability Concepts:** Students will engage with concepts like sample space, events, conditional probability, and probability distributions.
2. **Statistical Measures:** Students will use measures of central tendency, dispersion, correlation, and perhaps even some introductory inferential statistics to create predictive models.
3. **Applied Mathematics:** The project inherently involves using mathematical reasoning to solve a real-world problem, making the mathematical activities deeply contextualized and meaningful.

Assessment:

1. **Conceptual Understanding:** The project assesses students' understanding of probability and statistics, not by asking them to solve isolated problems but by having them apply mathematical reasoning in a real-world context.
2. **Skills Application:** As students work through each component of the project, they demonstrate not just mathematical knowledge but also data collection and analytical skills.
3. **Communication:** The report and presentation aspects of the project assess students' ability to articulate complex mathematical ideas in an accessible manner.

By employing project-based assessments like this, teachers can make it nearly impossible for a tool like ChatGPT to complete the task for students, thus maintaining the assessment's integrity. Furthermore, such projects provide an integrated and applied learning experience, fostering both mathematical and soft skills development. This methodological approach fits well with the Next Generation Mathematics Standards, especially the focus on modeling and application (NGSS Lead States, 2013).

Peer-Review Mechanisms

Another way to leverage ChatGPT for assessment is to use it as a form of peer review. For example, instructors can implement a peer-review system where students are required to explain their approach to a problem. ChatGPT can serve as a tool for students to check the validity of their explanations or to generate questions for peer reviews. We explain such a peer review process with the task of exploring quadrilaterals.

The Task: "Exploring Quadrilaterals"

In this geometry assignment, students are tasked with proving various properties of a specific type of quadrilateral, such as a parallelogram, rectangle, or rhombus. Each student receives a different quadrilateral and must use geometric theorems and postulates to prove characteristics like opposite sides being parallel, diagonals being congruent, etc.

How It Works:

1. **Initial Submission:** Each student submits a written proof or explanation about the properties of their assigned quadrilateral. This can be a combination of written text, geometric sketches, and equations.

2. Peer Review: The students swap their submissions and review each other's work. They are required to provide feedback on the validity of the proofs, clarity of explanation, and even suggest additional properties that could be proved.
3. ChatGPT's Role: Before and during the peer review, students can use ChatGPT to validate their own or their peers' explanations. For instance, if a student is not sure about a particular theorem used in a peer's proof, they could consult ChatGPT for clarification. ChatGPT can also help in generating thoughtful questions that reviewers can ask about the submission they are reviewing.

Sample ChatGPT-Generated Question for Peer Review.

1. "Did the student provide sufficient justification for all stated properties using axioms, theorems, or postulates? If not, which areas need improvement?"
2. "Is the logical sequence of the proof coherent and easy to follow? Where could the student improve the flow of their argument?"
3. "Did the student make any assumptions that should have been proven?"

Discussing the Mathematics and Assessment.

Mathematics:

1. Proof and Logic: The activity demands a deep understanding of geometric principles and their logical application. This covers a wide range of theorems and postulates used to establish properties of quadrilaterals.
2. Critical Thinking: The peer-review process forces students to critically evaluate mathematical reasoning, enhancing their analytical skills.

Assessment:

1. Understanding and Application: Unlike a multiple-choice question about quadrilaterals, this task requires the student to apply various theorems and principles to prove a point, assessing their comprehensive understanding of the topic.
2. Communication Skills: The peer-review process assesses the ability to clearly and logically articulate complex mathematical arguments, an often under-assessed skill in traditional math classrooms.
3. Analytical Feedback: The use of peer review can provide students with multiple perspectives on their work, enriching their understanding and potentially improving the quality of their mathematical writing.

By incorporating peer-review mechanisms with the aid of ChatGPT, educators can build a more interactive and in-depth assessment process. This not only makes the task more engaging but also hones skills that are crucial for mathematical reasoning and communication, aligning well with mathematical practices emphasized in contemporary education standards like the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

Digital Portfolios

An alternative method for utilizing ChatGPT in the assessment process is to have students create digital portfolios. Digital portfolios can serve as a repository of student work over a term or academic year. Students can interact with ChatGPT to compile different types of mathematical problems they have solved, accompanied by written or verbal explanations. Digital portfolios are more than just a collection of assignments; they can be a dynamic space for reflective learning and self-assessment. In the context of mathematics, students can utilize ChatGPT as an interactive tool to enhance this portfolio-building process. For instance, they could consult ChatGPT to generate different types of mathematical problems that align with course objectives or even seek help in drafting written or verbal explanations of complex solutions. Over time, the portfolio serves as a tangible representation of the student's mathematical journey, showcasing not only the problems they have solved but also their thought processes and conceptual grasp. In this way, ChatGPT can function as a collaborative tool that enriches the portfolio's content while reinforcing learning objectives.

ChatGPT presents a unique blend of challenges and opportunities in the realm of educational assessment, particularly in mathematics. On the one hand, its ability to provide instant, accurate solutions to a wide range of problems could encourage students to bypass the critical thinking process, thereby diminishing the educational value of assessments. On the other hand, this very capability can be harnessed by educators to elevate the assessment

landscape. For instance, ChatGPT can generate open-ended or project-based questions requiring a synthesis of multiple mathematical concepts, thereby fostering a deeper understanding of the material. It can also be a valuable tool in peer-review mechanisms, allowing students to generate and validate questions for their classmates in subjects like geometry, thereby enhancing their own understanding of the subject matter. Digital portfolios, too, can benefit from ChatGPT's capabilities, serving as a more dynamic repository of student work that goes beyond mere problem-solving to include written and verbal explanations.

By integrating ChatGPT in such innovative ways, educators can shift the focus of assessments from rote memorization and calculation to more meaningful metrics like conceptual understanding, real-world application, and effective communication. The result is an enriched, multi-dimensional assessment strategy that not only mitigates the risks associated with AI-driven tools like ChatGPT but also significantly enhances the educational experience.

INTERDISCIPLINARY APPLICABILITY FOR TEACHER EDUCATORS

The strategies for assessments discussed in this chapter are by no means restricted to the domain of mathematics education. They hold considerable promise for invigorating teaching and learning in various other disciplines as well. For instance, in science education, the need for application-based assessments is just as crucial. Imagine a biology classroom where students are required to apply their understanding of genetic principles to real-world medical dilemmas. Here, too, alternative assessments could comprise project-based work or scenario-based questions that prompt students to integrate and apply diverse biological concepts.

In social studies education, the focus often extends beyond factual recall to include the development of critical thinking skills, such as evaluating the reliability of sources or understanding the nuances of historical events. A peer-review mechanism similar to the one discussed in this chapter could be implemented, wherein students critique each other's essays or analyses on social or historical issues.

Similarly, in philosophy or ethics courses, critical thinking is paramount. Assessments could go beyond debating well-trodden ethical dilemmas to include a peer-reviewed portfolio where students are required to apply ethical theories to current real-world issues supported by coherent argumentation and evidence.

In all these disciplines, the focus is gradually shifting from traditional assessment models to more holistic methods that test a range of skills, including problem-solving, critical thinking, and effective communication. The advent of ChatGPT and similar technologies can be a catalyst in this transition, offering new avenues for both students and educators to explore more meaningful and comprehensive approaches to assessment.

CONCLUSION AND FUTURE DIRECTIONS

The rapid development of artificial intelligence, as manifested in technologies like ChatGPT, presents both challenges and opportunities in the educational landscape, particularly in mathematics education. Although the initial concerns focus on the tool's capacity to undermine traditional assessment methods, we can also view this disruption as an impetus for pedagogical innovation. We have outlined various alternative assessment models like project-based assessments, peer-review mechanisms, and digital portfolios, which not only counter the potential shortcomings posed by generative AI but also enrich the learning experience for students.

Yet, we must recognize that these are still early days, both for the evolution of AI in education and our understanding of its long-term impacts (Alam, 2021; Zhjao & Watterston, 2021). Future research should delve into the effectiveness of these alternative assessments in fostering a deeper understanding of mathematical concepts among students. Moreover, as ChatGPT and similar technologies evolve, newer functionalities may emerge, which could serve educational purposes in ways we have not yet considered.

Another future direction is to explore how AI technologies like ChatGPT could be integrated into Learning Management Systems (LMS) to create a seamless flow of information between learning and assessment activities (Siemens, 2013). In such an integrated system, ChatGPT could provide real-time feedback on student submissions, thereby making the assessment process more dynamic and adaptive. This could be particularly beneficial for remote or hybrid learning environments, which have become more prevalent in the wake of the COVID-19 pandemic.

The landscape of teacher education programs should also evolve to equip the next generation of teachers with the skills to navigate these technologies (Mishra & Koehler, 2006) and alternative assessment methods. This involves not only familiarity with the tools themselves but also a comprehensive understanding of ethical considerations, data privacy issues, and the potential impact of AI on educational equity.

Finally, the interdisciplinary applicability of the alternative assessment methods discussed in this chapter can serve as a basis for cross-discipline collaboration. Mathematics educators can work with colleagues in other subjects like science, social studies, or philosophy to develop comprehensive, interdisciplinary approaches to assessment that foster a wide range of skills, from critical thinking to effective communication (Bransford et al., 1999).

In conclusion, while the rise of AI technologies like ChatGPT may initially appear to threaten established educational paradigms, they also offer a profound opportunity for innovation and improvement. By embracing these technologies, educators can not only adapt to a changing landscape but can also improve the quality of education for their students in profound and meaningful ways.

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Assessment and Instructional Decision Making: How AI Can Support Data Literacy Development for Preservice Teachers

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INTRODUCTION

The term Artificial Intelligence dates back to the mid-1950s, although the idea of constructing machines that mimic human behaviors is much older. Championed mathematician and pioneering computer scientist Alan Turing imagined an “imitation game,” in which a machine communicates with players in written form, discerning the true characteristics of each, even though the players may be misrepresenting themselves (Turing, 2009, p433). A word processor's ability to detect possibly misspelled words or sentences that do not adhere to language syntax is an example of simple artificial intelligence. For decades, students have submitted their written works to plagiarism detection platforms that identify passages that might have been copied from known works or other submissions. This involves a more complex form of AI. Today's computing technology can perform tremendously sophisticated tasks that had previously been possible only by humans. The potential for computing devices to simulate human behaviors is now eclipsing the capacity of human ability itself. Though AI has the ability to predict and classify, the focus of this chapter will be on the emerging ability of AI to generate text and other media, particularly in education spaces. Recent research shows that the discourse around AI in education is positive and suggests that AI may have the potential to help a wide range of global stakeholders reach their education goals (Nemorin et al., 2023; Tlili et al., 2023). The current attention garnered by generative AI provides us with the opportunity to explore how these large language models can be integrated into higher education settings that prepare teachers. According to a recent report by the U.S. Office of Technology about Artificial Intelligence and its implications for K-12, one of the best ways to succeed with AI in education is to “always center teachers” (Cardona et al., 2023, p.25). In this chapter, we explore how that must also mean centering the needs of Pre-Service Teachers (PSTs).

CURRENT CONTEXT IN EDUCATION

Artificial Intelligence and Education Assessment

The collection and analysis of data in learning environments is known as learning analytics (Baker & Koedinger, 2018). Learning analytics (LA) is the “measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (Siemens et al., 2011, p 4). LA provides exciting new tools for educators to study, practice teaching and learning, and offer learners timely and usable feedback. Most of the historical focus on LA has been to access knowledge embedded in large data sets. In fact, “Big Data” has dominated analytics thinking for more than twenty years. This has led some people to think of analytics as being limited to what we can learn from these large data sets. Some individuals and educational organizations, however, want to derive important insights from their small data sets while still tapping into the power of machine learning and AI (van Heeswijk, 2022).

Small data set learning analytics is not a new concept in education and other fields, but interest in LA and its potential value is growing (Goggins et al., 2015). Andrew Ng, a pioneer in deep learning, believes that one of the next steps in tapping into the power of machine learning is data-centric AI with a focus on the quality of input (van Heeswijk, 2022). Based on Ng’s thinking, if we carefully form the data we collect as input, even small data sets may sufficiently inform new AI models. Human expertise is, therefore, essential to realize this (van Heeswijk, 2022). This role does not have to be relegated to researchers, data scientists, or learning analytics professionals, but with appropriate preparation and development, teachers can bring their expertise to the task.

The purpose of LA in education is to assess and interpret data about learners and their contexts to provide actionable knowledge for teachers and students. LA systems and tools with both large and small datasets are currently being implemented in classroom teaching and learning in K-12 and post-secondary contexts. For teachers and students, this makes learning how these tools can be utilized to enhance understanding and decision-making imperative (van Leeuwen et al., 2022). LA, in the global sense, is a process to extract meaning from data collected from learners. Still, it also has the potential to normalize values, mores, behavioral expectations, and even pedagogies and epistemologies (Knight et al., 2013). These non-quantitative perspectives and others, like the importance of ethics, should also be integrated into teacher preparation and professional development.

One way that humans are leveraging AI to do their work more effectively is AI’s growing ability to assist in the challenging task of creating student assessments, collecting assessment data, and interpreting assessment results. According to Gardner et al. (2021), “The essence of artificial intelligence (AI) in both summative and formative contexts is the concept of machine ‘learning’ – where the computer is ‘taught’ how to interpret patterns in data” (pp. 1207-1208). AI may have the potential to strengthen formative assessments, increase teacher efficiency, and engage learners outside of the classroom. Learning technology companies and education researchers use forms of generative AI to create assessment tasks, such as multiple-choice questions and open-answer questions, both in intelligent tutoring systems (Jia et al., 2021) and for summative assessment purposes.

Artificial intelligence tools have been used to assess writing since the 1960s and can offer writers formative feedback on their work and grade student work in place of human assessors (Swiecki et al., 2022). Since many assessments are snapshots of student abilities at a particular time and in a particular environment, artificial intelligence can be used as a “stealth assessment” when embedded into learning games and digital curricula to provide ongoing data collection and long-term data analysis of student learning trends (Shute & Ventura, 2013, p. 1). Current and future teachers should be prepared to understand and utilize learning analytics tools and methods, including AI. Thus, teacher education plays an important role in AI evolution (Mayer & Oancea, 2021).

AI and K-12 Teaching

Research about the ways in-service teachers are using AI can and should influence how teacher educators use AI with PSTs. While still new technology, generative AI is being used in classrooms. AI is being leveraged to help teachers plan, implement, and assess student learning (Celik et al., 2022). Teachers use it to grade student work, analyze student writing, and predict which students are at risk of not succeeding in specific courses and in their overall grade level trajectory (Salas-Pilco et al., 2022). Teachers use AI-based software like Speakable (<https://speakable.io/>) to support English language learners in their oral fluency and Quill (<https://www.quill.org/>) to teach reading and writing skills (Ferlazzo, 2023).

Tlili et al. (2023) reviewed social media posts to better understand teachers’ concerns with AI in general and the generative AI chatbot ChatGPT in particular. They found that teachers had concerns about ethics, the quality of ChatGPT’s responses, and the overall usefulness of the chatbot (Tlili et al., 2023). A literature review by

Crompton et al. (2022) found that teachers had positive experiences using AI tools for personalization and administrative tasks but expressed some negative views of AI and struggled with technical skills and ethical questions.

PSTs have limited awareness and understanding of the ways that AI can impact their teaching (Al Kanaan, 2022; Farris, 2022), but research shows that they are willing to engage in AI-based activities and simulations to improve their teaching. In a course to support secondary Physics PSTs, participants revised student learning tasks generated by ChatGPT, learning how to improve the specificity and overall quality of the prompts generated by the AI (Küchemann, 2023). Future math teachers engaged with an AI chatbot to learn how to respond to student errors and engage in effective, responsive teaching (Lee & Yeo, 2022). K-12 PSTs have successfully used AI-generated images to reflect on their own professional goals (Ferdig et al., 2023). This willingness to engage with AI tools suggests that AI can help PSTs develop assessment skills such as data-driven decision-making and instructional planning.

Data-driven Decision Making

States, districts, and educators have had to emphasize data-driven decision-making for quite some time, particularly in response to the passage of federal policies such as No Child Left Behind and the Every Child Succeeds Act (Goren, 2012; Wayman & Stringfield, 2006). Researchers and policymakers have expressed several important purposes for educators to use data to make informed decisions related to investigating students' learning needs (Wayman & Stringfield, 2006); reporting on students' progress (Vanlommel & Schildkamp, 2019); improving instructional planning and delivery (Mandinach & Jimerson, 2016); strengthening students' academic outcomes (Mandinach & Gummer, 2016), and for evaluating areas for schoolwide improvement (Goren, 2012).

In addition, researchers have argued that educators require "data literacy" in order to effectively use data responsibly and appropriately. Mandinach and Gummer (2016) define data literacy as "the ability to transform information into actionable instructional knowledge and practices by collecting, analyzing, and interpreting all types of data" (p. 367). There is an underlying assumption within this definition that educators have the data skills and the capacity to make decisions about data that improve their instructional practices and student outcomes (Mandinach & Jimerson, 2016). However, in Vanlommel and Schildkamp's (2019) study, they found that most of their teacher participants (n=50) used an intuitive process to derive their conclusions about the data rather than a systematic and triangulated approach. Other researchers have raised similar questions about the extent to which educators are prepared to make data-driven decisions without adequate training (Mandinach & Jimerson, 2016) in their teacher preparation programs and having organizational capacity and resources to support teachers' use of data for teaching (Farrell & Marsh, 2016; Young, 2006).

The processes by which those data-driven decisions are made are often complicated, complex, context-specific, and teacher-specific. For example, Vanlommel and Schildkamp's (2019) study investigated what criteria 50 high school teachers used to make sense of data. They found that a smaller group of teachers collected data systematically, used predetermined criteria for analyzing the data, and searched for alternative explanations. However, the majority of the teachers based their interpretation of the data on their own intuition and judgment, sometimes despite what the assessment data showed. The researchers argued that teachers' sensemaking of data is an important, under-researched topic that potentially limits the efficacy of how some educators use data to make decisions. In addition, Farrell and Marsh's (2016) study draws attention to another issue that is an obstacle to implementing schoolwide data use practices. In their study of three districts, they explored the conditions that are needed for teachers to use data to inform instruction. They found that although the districts had initiatives around data use and several types of intervention supports offered to teachers, e.g., data coaches, the teachers did not adjust their instruction in response to data that were available to them. Furthermore, having a data compliance culture did very little to change instructional practices without understanding the conditions, e.g., lack of time that creates challenges for teachers in adopting meaningful data decision-making actions.

Some recommended goals for introducing PSTs to data literacy include increasing their knowledge about different types of data, improving their confidence in using data, and developing their data use skills (Mills-Bains et al., 2022). Teacher education programs need to prepare PSTs to use data effectively to make informed decisions when they become full-time educators. There is a small body of research on how PSTs use data to develop their teaching pedagogy and practice (Greenberg & Walsh, 2012). One important study is that of Greenberg and Walsh (2012), who analyzed 180 teacher preparation programs to assess whether assessment literacy was introduced to PSTs. Only 30 programs were found to be partially adequate or adequate in preparing PSTs to use literacy assessment data for instructional decision-making (Farrell & Marsh, 2016). This raises questions about the extent to

which data literacy is emphasized and required as part of teacher education programs so PSTs have the foundation to use data knowledgeably and confidently (Mills-Bains et al., 2022).

USING AI TO TEACH DATA-DRIVEN INSTRUCTION TO PSTS

Today's teachers get student data from nationally- and state-normed tested and published criterion-referenced tests. They also get data from digital curricula and digital assessments with varying degrees of validity and reliability. And teachers continue to create their own formative and summative classroom assessments. This often means teachers have far too much data that does not fit together or data that tells a story that is uninterpretable. Yet these existing data would be a smaller data set and would not be enough information for AI to build a machine learning model that could interpret the data either. This means that the impact of classification systems and expert systems will be limited in the classroom. However, generative AI tools such as ChatGPT can and do impact teachers today.

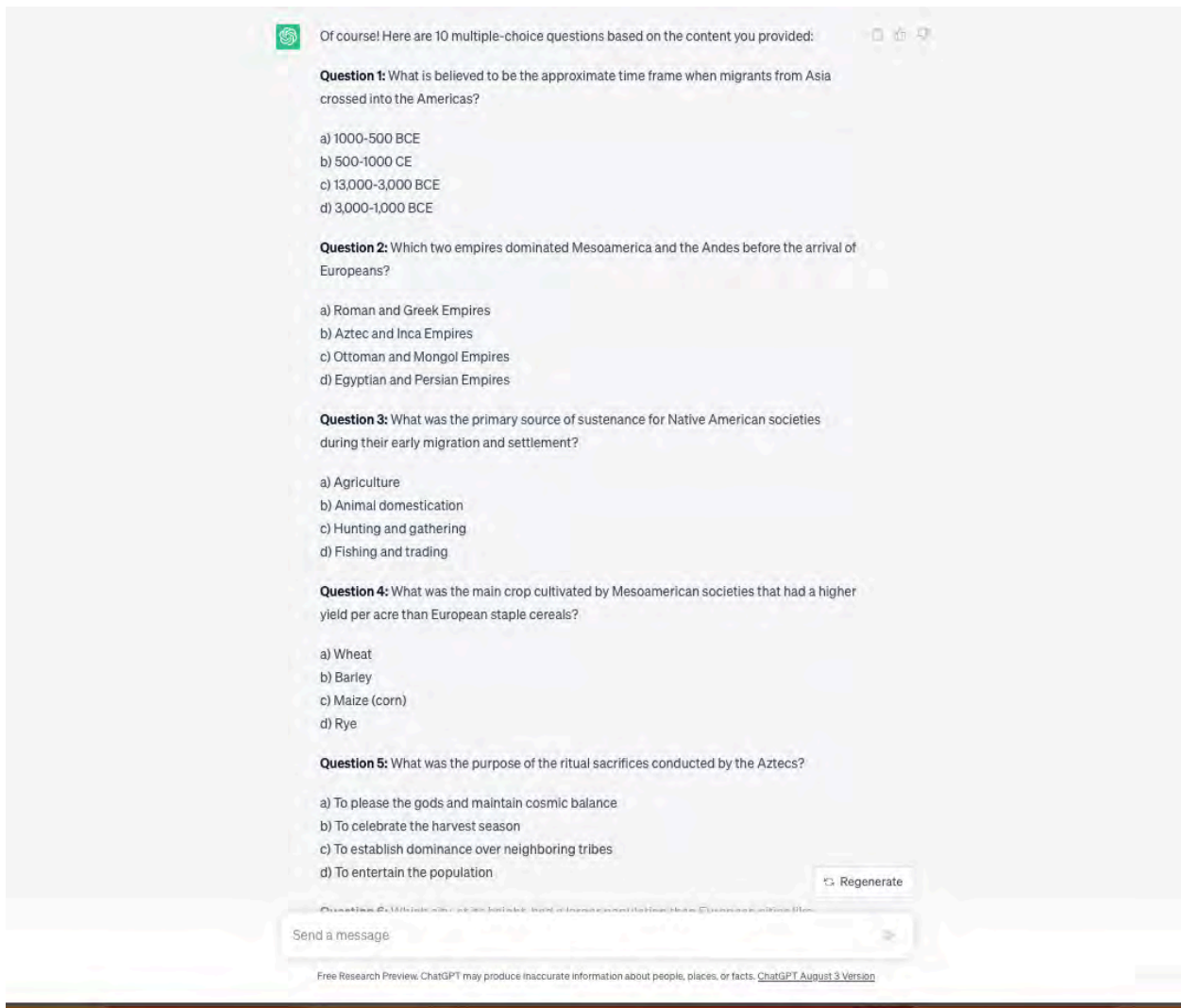
Simulations and fieldwork have long been used to allow PSTs in teacher education programs to practice making data-based decisions (McPherson et al., 2011). Adding AI to simulations can help PSTs learn how to analyze formal and informal assessment data. It can also help PSTs choose instructional strategies that align with their findings. Research on teachers' use of AI and the demand for data-driven decision-making in education suggests that PSTs will benefit from experiences in LA prior to entering the classroom. Good data-driven instruction simulations will give PSTs experience with collecting, analyzing, and interpreting all types of data and then using that analysis to plan instruction. These simulations should address the weaknesses in data literacy that current research has uncovered and position these PSTs to communicate with others about data-driven decision-making since research shows that data is often examined in teams at the grade level or school level (Datnow et al., 2013; Schildkamp & Datnow, 2022). The next section of the chapter will describe several simulations where PSTs will work with formal and informal assessment data to develop their data literacy and become better at creating their own classroom assessments, analyzing and communicating about data, and making data-based instructional decisions.

Creating Assessments

One of the best ways to build data literacy is to start with designing assessments. Generative AI can play a helpful role in this process for PSTs. Some K-12 disciplines, such as history and the sciences, frequently use traditional criterion-referenced assessments, such as multiple-choice and true-false questions. It is important that these PSTs learn how to create effective assessment questions. Teacher educators in those disciplines can design learning activities where PSTs work with generative AI to create and analyze assessment items. Similar to the work of Küchemann (2023), who had students analyze physics assignments created by generative AI, the PSTs can analyze test items generated by AI. They would begin by identifying sample content that they would use and expect their future students to master. This could be samples from discipline-specific textbooks, primary documents related to the field of study, or sections of fiction and nonfiction that they would use in their future classroom. The content can be uploaded to a generative AI like ChatGPT along with the prompt: *Create ten multiple-choice questions for 10th graders about this content.* For this example, content from the history textbook *America's History*, 8th edition (Henretta et al., 2014) on early people in the Americas was uploaded to ChatGPT, and it generated the following questions (Figure 1).

Figure 1

ChatGPT American History Multiple Choice Questions (Sample)



PSTs can then analyze these questions for quality and make revisions. First, they need to review each proposed question and ensure the information presented is correct. Generative AI can and does “hallucinate,” meaning it can present incorrect information confidently as fact. The AI is trained to associate certain phrases with certain concepts, and sometimes, these associations aren’t accurate. These hallucinations are not malicious but rather akin to a human error where one misremembers a fact, and PSTs will need to be aware of this possibility as they learn to use the tool (Wiggers, 2023). This process also serves to reinforce their own content expertise.

Next, the PSTs can review each question stem and see if it conforms to best practices (Brame, 2013). Is each stem a question or a partial sentence? Does it contain irrelevant material? The PSTs can look at the alternatives in each question and decide if the alternatives are free from clues about the correct response and presented in a logical order. They can check that each alternative has grammar that is consistent with the stem and that the alternatives are parallel in form and similar in length.

Once they apply these assessment best practices, the PSTs can look at the quality of the actual questions. Good assessments engage learners with thinking across Bloom’s taxonomy. The PSTs can categorize these questions based on which level of the taxonomy they best match: remembering, understanding, applying, analyzing, evaluating, and creating (Anderson et al., 2001). They can then write new questions that address the missing critical

thinking levels of the taxonomy. This process centers the PSTs' emerging abilities to design assessments and allows teacher educators to model what high-quality instructional process looks like. Here, the generative AI works as a starting point to engage PSTs in analyzing, evaluating, and creating themselves.

Using Assessments

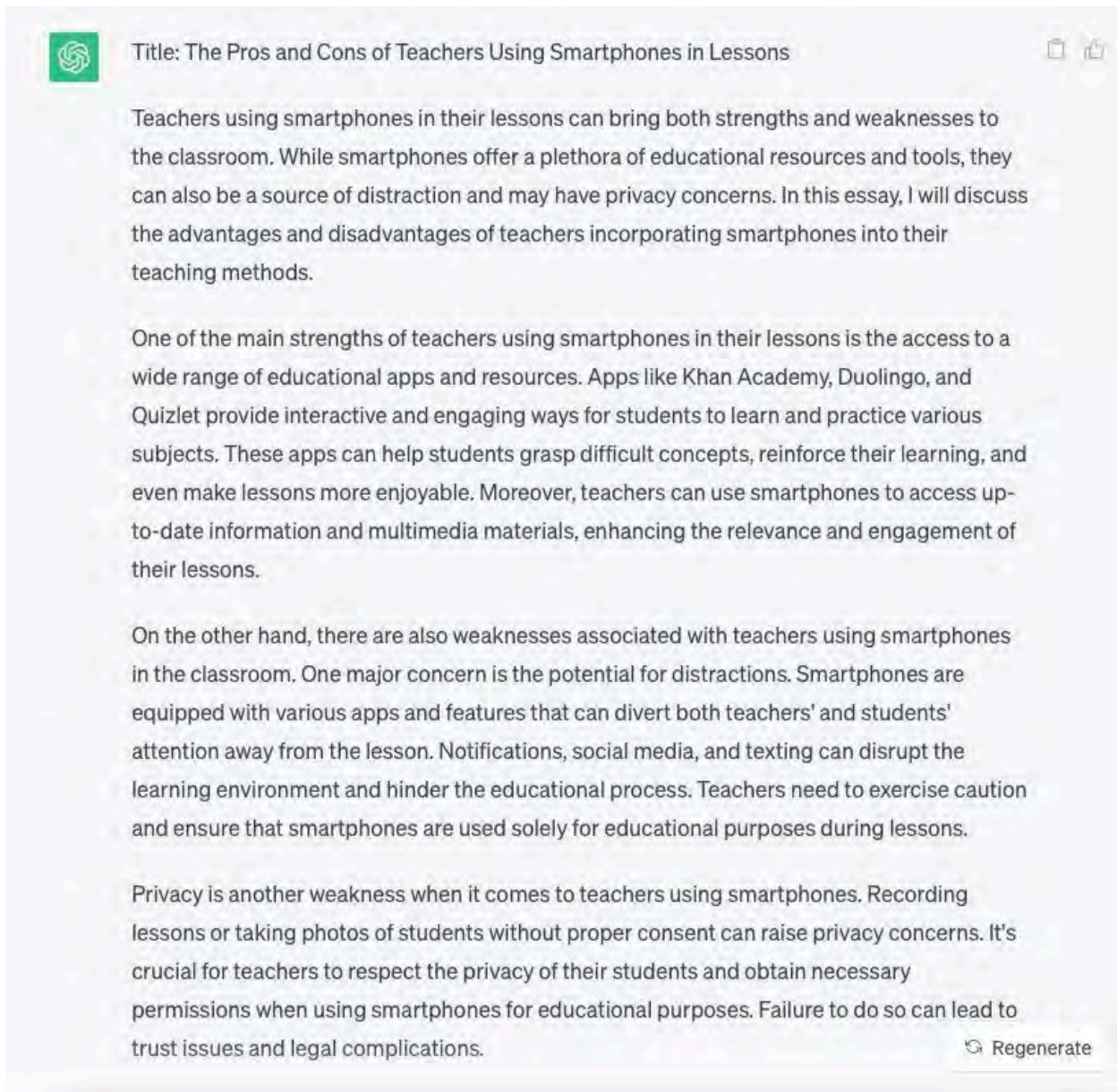
One common teacher-created assessment is a rubric. Rubrics are scoring tools with specific criteria outlined and performance levels for each criterion indicated. Rubrics are often used with writing assignments or open-ended questions in the sciences. When constructed with clear and focused criteria, research has shown that rubrics in the K-12 education space can yield helpful information about student learning and can have a positive impact on student performance (Brookhart & Chen, 2015).

Applying a rubric with consistency takes practice. Generative AI can help PSTs learn how to develop and apply rubrics by simulating student work for the PSTs to assess. This simulated work can be used in an inter-rater reliability activity. For example, PSTs who will be teaching middle school writing can first create a grade-level appropriate writing prompt such as “What are the strengths and weaknesses of teachers using smartphones in their lessons?” and design a rubric that aligns with the assignment. They can discuss the assignment and arrive at a shared working understanding of what is being asked of students in this assessment and create shared working definitions of each rubric category and score.

They can then ask ChatGPT to create examples of student essays to the prompt to simulate multiple student responses. By slightly changing the prompt, the PSTs can generate different responses from which the generative AI lets them get more practice assessing student writing. The first prompt asked ChatGPT: *Can you write a five-paragraph essay like a strong seventh grader might write in response to this prompt: What are the strengths and weaknesses of teachers using smartphones in their lessons?* and it offered the following writing sample for the PSTs to evaluate (Figure 2).

Figure 2

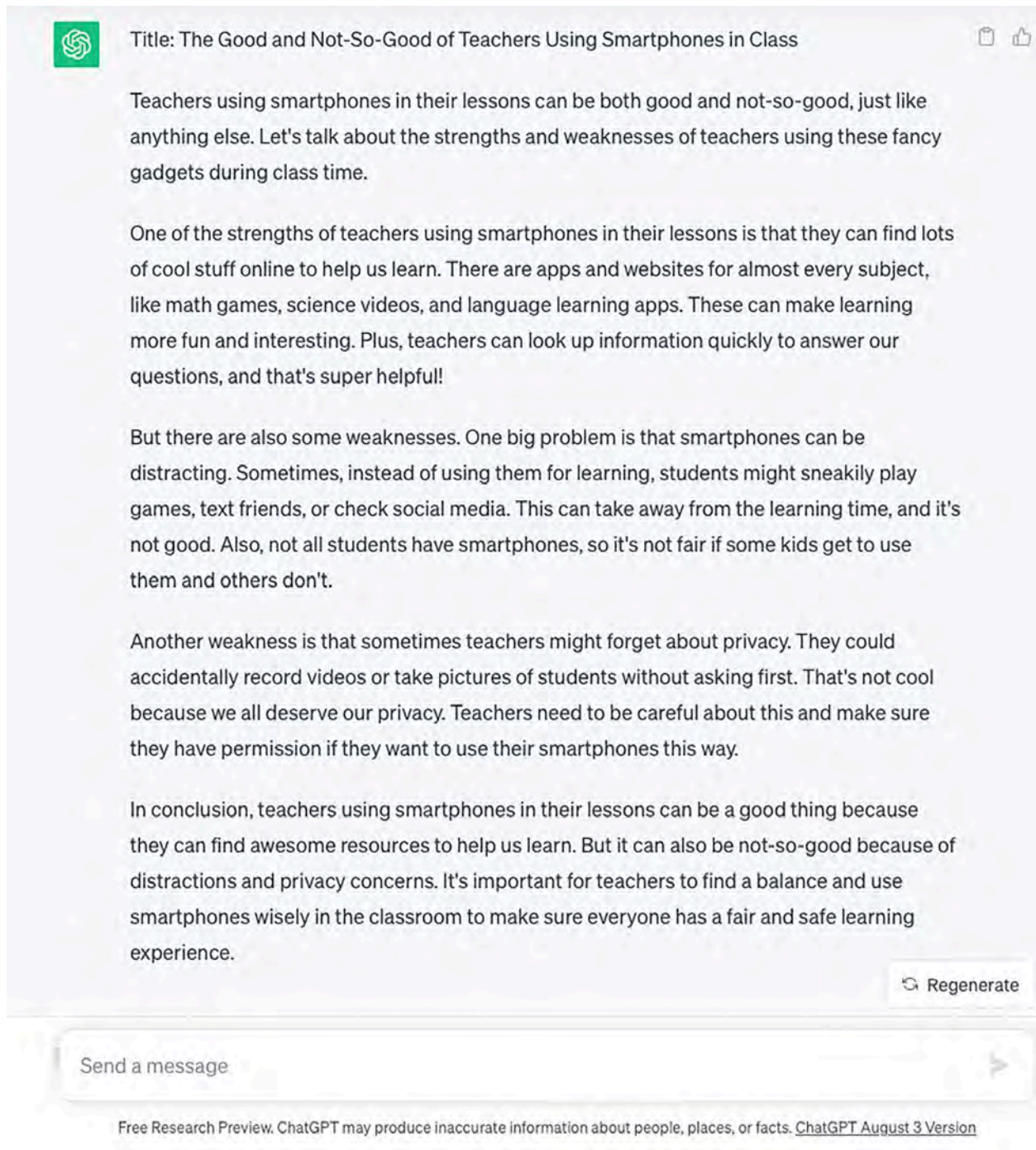
ChatGPT Seventh Grade Smartphone Essay



The prompt was changed to: *Can you write a five-paragraph essay like a sixth grader might write in response to this prompt: What are the strengths and weaknesses of teachers using smartphones in their lessons?* and ChatGPT created this essay in response (Figure 3).

Figure 3

ChatGPT Sixth Grade Smartphone Essay



The PSTs can independently score each of the simulated essays. They can work in a small group and report their rubric scores. The PSTs can analyze their scores using the following questions:

- Is there inter-rater agreement (identical scores)?
 - o Yes? Good work applying the rubric!

- o No? Move to the next step. [☞](#)
- Are rater scores adjacent (within one point of each other)?
 - o Yes? Good work applying the rubric!
 - o No, move to the following question.
- Examine rubric sub-scores. Find areas of difference. Discuss individual rating approaches. Explain scoring decisions. Is consensus reached?
 - o Yes? Good work learning how to apply the rubric!
 - o No? Revise one of more rubric categories and try scoring new simulated responses.

Interpreting Assessment Data

Data from teacher-created assessments

Rubric data are a productive place to start teaching PSTs how to analyze student performance data. Rubrics generally offer a numeric score based on performance for each criterion. In this simulation, “students” completed five scored journal entries in a middle school literature course. The rubric used to score each journal entry is worth five points.

There are 26 “students” in this simulated class, and their scores are displayed in the table below (Table 1). To start this data-driven instruction activity in class, PSTs would be asked to study the data table first independently and then in small groups. They would be asked to identify five insights they see in the journal writing data.

Table 1*Rubric Data Table*

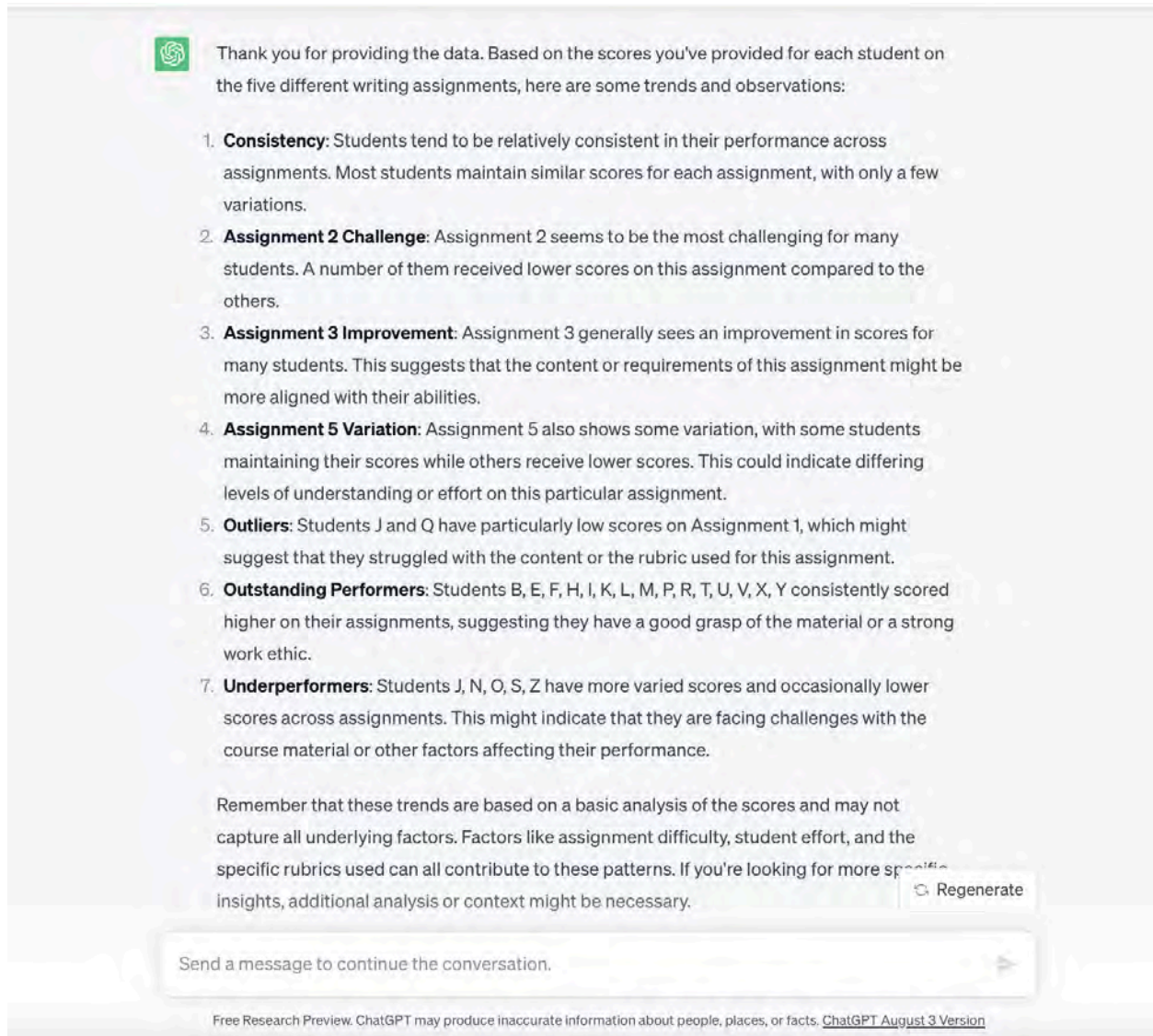
	Writing Assignment	Writing Assignment	Writing Assignment	Writing Assignment	Writing Assignment	Total
	1	2	3	4	5	
Student A	4	5	4	5	4	22
Student B	5	4	2	5	5	21
Student C	3	5	5	5	4	22
Student D	4	3	3	5	5	20
Student E	5	5	5	5	3	23
Student F	5	4	4	5	5	23
Student G	3	5	3	5	5	21
Student H	4	3	5	5	5	22
Student I	5	5	4	5	4	23
Student J	2	2	5	5	3	17
Student K	3	5	3	5	3	19
Student L	5	4	5	5	5	24
Student M	4	5	4	5	4	22
Student N	5	2	3	5	5	20
Student O	3	2	5	5	3	18
Student P	4	3	5	5	5	22
Student Q	5	5	5	5	3	23
Student R	3	3	4	5	4	19
Student S	3	4	4	5	3	19
Student T	5	2	4	5	4	20
Student U	4	5	3	5	3	20
Student V	5	3	3	5	5	21
Student W	3	4	3	5	3	18
Student X	4	5	5	5	4	23
Student Y	5	2	3	5	5	20
Student Z	4	3	4	5	3	19


Once the group has written down their five insights, they can then use generative AI to analyze the same data set. In this example, ChatGPT was given the following prompt: *Below are student scores on five different assignments. The assignments use a five-point rubric. What trends do you see in this data?* The generative AI responded with seven trends it noted (Figure 4), some of which were about student performance and some of which were about the assignments themselves. PSTs can then compare their insights with those generated by ChatGPT. In

this sense, the generative AI acts as both a peer assessor and model, showing the PSTs what kinds of questions they might ask of a data set.

Figure 4

ChatGPT Analysis of Rubric Scores



 Thank you for providing the data. Based on the scores you've provided for each student on the five different writing assignments, here are some trends and observations:

1. **Consistency:** Students tend to be relatively consistent in their performance across assignments. Most students maintain similar scores for each assignment, with only a few variations.
2. **Assignment 2 Challenge:** Assignment 2 seems to be the most challenging for many students. A number of them received lower scores on this assignment compared to the others.
3. **Assignment 3 Improvement:** Assignment 3 generally sees an improvement in scores for many students. This suggests that the content or requirements of this assignment might be more aligned with their abilities.
4. **Assignment 5 Variation:** Assignment 5 also shows some variation, with some students maintaining their scores while others receive lower scores. This could indicate differing levels of understanding or effort on this particular assignment.
5. **Outliers:** Students J and Q have particularly low scores on Assignment 1, which might suggest that they struggled with the content or the rubric used for this assignment.
6. **Outstanding Performers:** Students B, E, F, H, I, K, L, M, P, R, T, U, V, X, Y consistently scored higher on their assignments, suggesting they have a good grasp of the material or a strong work ethic.
7. **Underperformers:** Students J, N, O, S, Z have more varied scores and occasionally lower scores across assignments. This might indicate that they are facing challenges with the course material or other factors affecting their performance.

Remember that these trends are based on a basic analysis of the scores and may not capture all underlying factors. Factors like assignment difficulty, student effort, and the specific rubrics used can all contribute to these patterns. If you're looking for more specific insights, additional analysis or context might be necessary.

[Regenerate](#)

Send a message to continue the conversation.

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PSTs can then begin to make instructional adjustments based on this analysis of the data. They might choose to revise prompt two since more students struggled with that prompt than with the others. They might choose to revise prompt five since student performance on this prompt differed from their prior scores. The PSTs could also design challenge activities for the students whose scores were consistently higher than their peers or support activities for students who scored lower.

To meet the needs of the students who scored lower, another analysis of the data would be required. For this activity, the students can look at individual student scores on one or more journals and see which criteria they believe these writers struggled to address. Once they complete their analysis, they can again ask ChatGPT to look across the criteria scores for trends. By repeating the process in different ways, the PSTs learn how to ask questions about data and how to turn data into instructional decisions.

Most higher education students will take some online courses during their studies (Hamilton, 2023), and that is true for teacher education as well. The simulation can be built into asynchronous learning modules. PSTs could review Table 1 and then post five trends they observe in the data on a Discussion Board. Following a group discussion on the board, the instructor could share the trends ChatGPT identified (Figure 4) and ask students to compare their findings with those of the generative AI. The students could use an AI to generate data-based instructional ideas to address the trends in the data and then write a short paper analyzing the proposed ideas based on specific criteria such as feasibility and research evidence.

Data from Digital Assessments

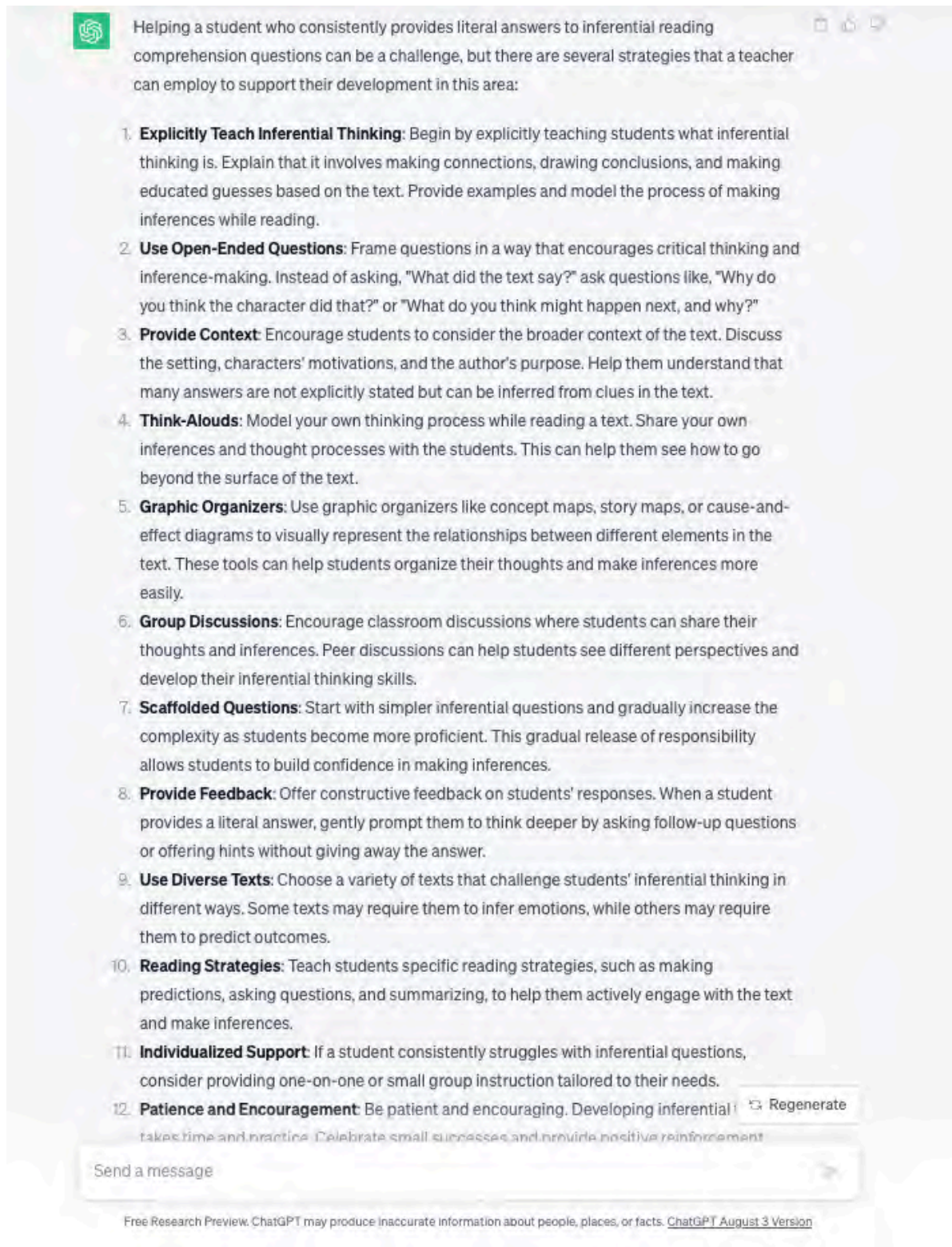
Inservice teachers are often required to give digital assessments and then use those results in data-driven instruction. These assessments can offer data on students' math, literacy, and science skills. They usually generate individual student and class reports that are supposed to inform instruction. PSTs would benefit from experience reading and understanding these reports and then thinking about how to turn those reports into actual lesson plans. Generative AI could be a helpful tool in learning this part of data literacy.

Adolescent Comprehension Evaluation, or ACE (Severino et al., 2019), is a digital assessment created to provide formative and summative data on reading comprehension skills for sixth, seventh, and eighth graders. It is designed so that teachers can assign students reading passages and questions at their reading level regardless of their grade level. The assessment then gives teachers individual and class scores and individual student data on the kinds of questions they missed, e.g., literal v. inferential comprehension questions. ACE also gives teachers information about the kinds of incorrect answers test takers selected. This offers teachers insight into the thinking errors a student may engage in while answering a question, which can be valuable information when planning interventions and instruction. Since a seventh-grade teacher may have some students using sixth-grade passages in her class while others are using seventh or even eighth-grade passages, ACE also searches across individual student data and proposes instructional groups based on the kinds of errors students make regardless of which passage the students read. For example, ACE might note that five students who read at three different levels all chose literal answers for inferential comprehension questions. A teacher can then group those five students and teach them to grow to recognize an inferential comprehension question and how to combine background knowledge and text information to answer these kinds of questions correctly.

This is where generative AI can support PSTs in using assessment data from digital assessments. PSTs can study an ACE report and decide for which instructional group they would like to develop a lesson plan. They can then use AI to search for evidence-based instructional interventions to address that reading comprehension problem and use that information to write a lesson plan. They can also use AI to search for evidence-based instructional interventions to address that reading comprehension problem and use that information to write a lesson plan. ChatGPT can be given a prompt that PSTs might use to get help with intervention lesson planning: *How can a teacher help a student who chooses literal answers to an inferential reading comprehension question?*

Figure 5

Inferential Reading Comprehension Suggested Interventions



Helping a student who consistently provides literal answers to inferential reading comprehension questions can be a challenge, but there are several strategies that a teacher can employ to support their development in this area:

1. **Explicitly Teach Inferential Thinking:** Begin by explicitly teaching students what inferential thinking is. Explain that it involves making connections, drawing conclusions, and making educated guesses based on the text. Provide examples and model the process of making inferences while reading.
2. **Use Open-Ended Questions:** Frame questions in a way that encourages critical thinking and inference-making. Instead of asking, "What did the text say?" ask questions like, "Why do you think the character did that?" or "What do you think might happen next, and why?"
3. **Provide Context:** Encourage students to consider the broader context of the text. Discuss the setting, characters' motivations, and the author's purpose. Help them understand that many answers are not explicitly stated but can be inferred from clues in the text.
4. **Think-Alouds:** Model your own thinking process while reading a text. Share your own inferences and thought processes with the students. This can help them see how to go beyond the surface of the text.
5. **Graphic Organizers:** Use graphic organizers like concept maps, story maps, or cause-and-effect diagrams to visually represent the relationships between different elements in the text. These tools can help students organize their thoughts and make inferences more easily.
6. **Group Discussions:** Encourage classroom discussions where students can share their thoughts and inferences. Peer discussions can help students see different perspectives and develop their inferential thinking skills.
7. **Scaffolded Questions:** Start with simpler inferential questions and gradually increase the complexity as students become more proficient. This gradual release of responsibility allows students to build confidence in making inferences.
8. **Provide Feedback:** Offer constructive feedback on students' responses. When a student provides a literal answer, gently prompt them to think deeper by asking follow-up questions or offering hints without giving away the answer.
9. **Use Diverse Texts:** Choose a variety of texts that challenge students' inferential thinking in different ways. Some texts may require them to infer emotions, while others may require them to predict outcomes.
10. **Reading Strategies:** Teach students specific reading strategies, such as making predictions, asking questions, and summarizing, to help them actively engage with the text and make inferences.
11. **Individualized Support:** If a student consistently struggles with inferential questions, consider providing one-on-one or small group instruction tailored to their needs.
12. **Patience and Encouragement:** Be patient and encouraging. Developing inferential thinking takes time and practice. Celebrate small successes and provide positive reinforcement.

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By implementing these strategies, a teacher can help students transition from providing literal answers to becoming more skilled at making inferences, which is a critical aspect of reading comprehension. Teacher educators can ask PSTs to write a lesson incorporating one or two of these suggestions and then compare and contrast proposed plans with peers who selected different suggestions. PSTs can also practice writing high-quality student-facing scaffolded questions as proposed by suggestion #7, which builds their lesson planning skills as well as their assessment skills, as the ability to write good questions is an essential skill in assessment design.

In this simulation, the generative AI is being used as a search engine or a database. Teacher educators can have PSTs investigate the research behind each of the suggestions and rank them based on the evidence that they would be effective. This would then support a robust discussion around the AI tool being used: Was the generative AI effective in answering the question? Do the suggestions help teachers to be more effective, or do they reinforce outdated approaches that are not supported by current research?

VISION FOR THE FUTURE

The goal of these simulations is to build the data literacy of PSTs with generative AI as a tool to assist in that process. This centers on teachers and not any specific technology. When we hear the terms learning analytics or artificial intelligence, we often think about large data sets and machine learning. However, PSTs can and should learn how to build their data literacy using the kinds of data sets they will encounter in their future classrooms. And they need to learn how to leverage new tools, such as generative AI, to help them turn data into effective and targeted classroom instruction. Teacher educators can and should design activities and simulations that use AI to build PST's ability to deliver data-driven instruction effectively and responsibly.

If AI is to be used as a tool to build the capacity of PSTs to engage in data-driven instruction, it is important that the limitations of the tools are understood by both teacher educators and PSTs. One generative AI tool, ChatGPT, only “learned” information published through 2021 before became widely used in 2022, so emergent ideas, questions, concerns, and instructional strategies were not included in its responses through the summer of 2023 (Natalie, n.d.). It has since been updated and has access to current information. ChatGPT also has access to only open-source information. This means most education research, which lives behind paywalls with academic publishers and professional associations, is not available to generative AI and will not be incorporated into its responses (Von Isenburg, 2023). As suggested in the ACE (Severino et al., 2018) activity, this means that ineffective strategies, or ones that have not yet been investigated and validated as effective, may be offered to PSTs. AI can only “learn” from existing information, which means there is a risk that its responses will “perpetuate existing biases and discrimination in research and education” (Kooli, 2023, p. 2) because missing voices, perspectives, and questions that currently exist in education will be missing from the generative AI's responses.

AI uses in teacher education will continue to evolve as the technology and our understanding of its powers and limits evolve (Hanawalt, 2023; van den Berg & du Plessis, 2023). Leveraging AI in the teacher preparation programs not only helps us meet existing goals like developing future teachers' ability to develop learning analytics skills, data literacy, and make effective data-driven instructional decisions, but it also builds future teachers' understanding of AI as a tool to facilitate learning rather than a substitute for human thinking. The current reality of AI in classrooms is multifaceted and begs for practical guidance as well as research that reflects current realities and future possibilities. Research collaborations between PSTs, ISTs, teacher educators, and other researchers are a potentially positive way to identify and guide evolving uses of AI for K-12 classrooms.

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School Librarians as Collaborators in the Successful Use of GenAI

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THE PROMISE OF GENERATIVE ARTIFICIAL INTELLIGENCE (GENAI) TO SUPPORT INFORMATION LITERACY

The implementation of generative AI (GenAI), such as ChatGPT, may serve to increase preservice and novice teacher efficacy. In theory, a tool that would allow preservice and novice teachers to find ways to support every student within a standards-constrained environment would be of great help in building the resilience of these teachers. Part of the frustration and high cognitive load for new teachers is the need to simultaneously teach content while applying principles of pedagogy, classroom behavior management, and student learning needs. The practical implications of a tool that would support learning and teaching in a way that helps solve these challenges may fundamentally change education in the US.

GenAI holds promise to allow teachers to create engaging lessons, do more with less, and ultimately create a climate of support for all learners. This is truly exciting. To be clear, GenAI like ChaptGPT or Dall-E have been trained on large language models (LLM) to understand patterns. They can also generate images based on this training. The strength in text generation has been as a predictor of the best fit for whatever comes next in a sentence. Its writing capability is a surprise to most first-time users. The sentences and paragraphs it generates, its ability to translate languages, and answer questions that make sense to human intelligence are remarkable.

GenAI can create essays that fulfill the requirements of assignments and seem to have been written by humans. Some educators are fearful that GenAI could easily be used as a tool to create products for students to claim authorship and turn them in as their own, and this fear is well-grounded. However, the notion of cheating is not new to the application of Information and Communication Technology (ICT) use in educational scenarios, as is well-known. Research has shown that the educator has some influence over the propensity of students to cheat, and the environment can be modified to lessen or thwart this activity. "...the environments which reduce the incentive and opportunity to cheat are the very ones that, according to the most current information we have about how human beings learn, will lead to greater and deeper learning by your students" (Lang, 2013, p 39).

Anecdotal reports show that in higher education, some instructors have started to accept that GenAI is part of the environment now and to work on creating lessons that either utilize its strengths or at least change assignments to sidestep its use by students. They have modified lessons to directly utilize ChatGPT in coursework because they realize that students will need to understand the nature and use of generative AI tools after their university experiences.

The use of this tool and awareness of its strengths and weaknesses is of great importance to practitioners and to those about to join the profession alike. On the other hand, there are many who fear student use of GenAI because they see how it could easily create products that might be difficult to detect as created by generative artificial intelligence. These instructors find the use of GenAI disturbing because the critical thinking that is part of learning can be foregone altogether. However, GenAI holds promise not only to support but also to increase success for new K-12 teachers. Since the release of ChatGPT 3.5 in November 2022, many applications of GenAI now exist for educators.

The Role of School and Academic Librarians in Educational Technology

Some of the challenges found while studying teacher learning, in general, are ways these teachers use resources to teach. First, teachers need to be aware of the resources that are available to them through their department and school, as well as possible state resources to which they have access. Next, they may need help or training to utilize these resources. The novice and preservice teachers are in the learning phase of the craft of

teaching. New teachers will need to be made aware of these resources and ways to use them (Stroupe, 2016). Academic librarians can serve the preservice teacher candidate in teaching information literacy skills, educational technology applications, and location teaching and research materials. In fact, the liaison librarian for education in academic libraries supports not only the preservice teacher but also the instructor in these areas (ACRL, 2015; Donaldson et al., 2022).

Many Mentors

The skills and techniques that are learned in teacher education courses, no matter how useful and evidence-based, do not always translate well into the classroom of a new teacher. This is at least in part because it takes time to disseminate new methods if they are to take hold and gain trust. It is difficult for a new teacher to implement what was learned in university in a situation where seasoned teachers do not also practice those methods (Gainsburg, 2012; Gholam, 2019). If, however, mentor teachers model the types of skills that new teachers need to be effective, the novices are much more likely to not only thrive and persist in the role but also ramp up their expertise (Gross, 2014; Soulen, 2018; Soulen, 2021). Enter the school librarian.

The role of the degreed school librarian has always been to provide guidance regarding teaching materials and best practices for a school community. Traditionally, this involved print material, although many school librarians were also in charge of audiovisual teaching materials in schools. The conversion to an online public access catalog looped in computer skills for the school librarian as well. The school librarian is one of the faculty who rely on and work with technology on a regular basis. It is a natural progression for the school librarian to also be the primary contact for educational technology as it becomes more widely used.

In practice today, the school librarian curates and shares resources with the entire school community. Librarians have always organized and provided access to reading for pleasure, informational texts, and literature. This resource sharing and curation allow for the best return on investment for schools and school districts. Resources have been vetted for use in the classroom. A school librarian has been trained to consistently choose materials that best support the curriculum because this is the school library's *raison d'être*.

In addition, the school librarian is trained to teach inquiry learning and can collaborate with classroom teachers to provide these innovative experiences for students within the state-mandated standards. Consideration of these standards is important because of the heavy emphasis, reliance, and accountability regarding standardized testing. School librarians have traditionally been charged with learning how to utilize educational technology. From the use of slide projectors and filmstrips to database searches and smartboards, school librarians have educated faculty and staff alike to utilize educational technology in ways that benefit students. This understanding of the use of technology is part of the school librarian educator preparation standards (AASL, 2018). Today, the school librarian is a degreed professional who has been trained not only in the use of educational technology and its applications but also in training their colleagues in the best uses of technology.

The school librarian is an instructional partner with classroom teachers. Very few school librarians were not already teachers before moving into the library space. For most master's in library science programs, enrollees must have at least two years' experience in the classroom before applying to library school. This prerequisite helps ensure that the school librarian applies classroom experience to better understand the needs of the classroom teacher and a diverse student population. School library educator curricula are driven by the American Association of School Librarians educator preparation standards. These standards include the types of skills necessary not only to teach students but also to offer professional development for colleagues. The school librarian is equipped and ready to lead the exploration and implementation of GenAI in schools.

School librarians are innovative educators who help teachers learn and incorporate technology into their teaching. School librarians practice pedagogy before technology and can identify how best to use technology so that students learn. They also keep up to date on community attitudes toward technology as well as expectations of the school community and stakeholders. Because of this expertise, school librarians are poised and able to incorporate GenAI into learning and teaching to support individualized instruction, problem-solving, and innovative lesson plans for novice teachers as well as preservice students.

NATIONAL SCHOOL LIBRARY STANDARDS

The National School Library Standards (NSLS) (AASL, 2017) are the latest guidelines librarians follow to support inquiry learning, district and state standards, and the ethical use of information. These Standards are the result of a long-standing collaboration between the American Association of School Librarians (AASL), the

Association for Communications and Technology (AECT), and the International Society of Technology in Education. (ISTE). The notion of the school librarian as a teacher consultant for educational technology has a long history. Since 1988, when the first edition of *Information Power* was released as a collaboration between ALA and AECT (AASL, 1988), the school librarian is recognized as the information literacy expert on campus as well as a teacher consultant for the use of print and nonprint materials and technology for learning and teaching. In fact, the title has been expanded to include media literacy, an extremely important position within the school community.

Framework for Learning

The NSLS (AASL, 2017) are built around six shared commitments: Inquire, Include, Collaborate, Curate, Explore, and Engage. Under each of these commitments, school librarians create lessons that help students Think, Create, Share, and Grow. This framework grew out of the recognition that it is even more vital that students can be intelligent discerners and consumers of information and that they are also creators of knowledge. As such, they need critical thinking skills to be able to not only understand their need for information but also the ethics involved in using and creating knowledge. The standards can be applied across the curriculum and represent the skills and abilities that students need to make good decisions throughout their time in school and beyond, rather than directives. For at least the last fifteen years, the charge to equip learners with sophisticated skills to discern and evaluate information has been critical to learning and teaching in the school library (AASL, 2009). The goal of the NSLS is to create lifelong learners who can meet their own information needs.

ARTIFICIAL INTELLIGENCE AND GenAI

Artificial intelligence (AI) has influenced an increasingly large portion of everyday life, from the use of GPS and its suggestions for leaving time to chatbots and suggestions for buying items of interest. Artificial intelligence services such as Amazon's Alexa and Apple's Siri can be used to answer questions for students. These apps can also be used to create quizzes and help with spelling skills, among other applications. Prior to the release of ChatGPT 3.5 to the general public in November 2022, GenAI was not a major topic of conversation within educational circles. However, the release of ChatGPT has made GenAI more accessible to more people who do not need specialized skills to use it. Since ChatGPT 3.5 became available, many GenAI products for use in education have been released.

Some of these, such as Elicit (<https://beta.elicit.org>), allow users to upload research papers and receive the main ideas and themes of these papers in tabular form, analyzed by GenAI. The Bing chat in the Edge browser (<https://www.microsoft.com/en-us/edge>) boasts a GenAI-powered search. A query around a research question will return not only Bing's notion of the meaning of the question but will also provide references for the user for follow-up. Diffit (<https://beta.diffit.me/packet/773f1750-eacb-4f5b-adf7-cd6fa5cbdc4a>) is a product that aims to help teachers find and adapt information and then offers questions for reinforcement for students at any reading level. Canva, Khan Academy's Khanmigo, MagicSchool.ai, and many others that have arrived since the publishing of this book all aim to help teachers utilize GenAI to teach.

Threats and challenges have surfaced in the educational community both at the K-12 level and in higher education. The links among the expertise of the school librarian, new classroom teachers, and GenAI have the potential to upend traditional notions of the role of the classroom teacher.

SITUATING THE ARGUMENT IN THE CURRENT CULTURAL CONTEXT

New Teacher Retention

The issue of teacher mobility and retention has been of interest for years. The Institute of Education Statistics (IES) began the first longitudinal study to address retention in 2008 (Bailey et al., 2021). The 2021 report addresses some of these same concerns (Bailey et al., 2021). However, the school librarian is a seasoned classroom teacher with a graduate degree in the field of library science who can act as a mentor or an additional mentor to new classroom teachers, allowing them to collaborate, model teaching behaviors, help to create a routine and other activities that support new teacher success. School librarians can provide empathy and understanding as well as recognition of their desire to make a change in their students' lives.

There is evidence that a relationship between a school librarian and a novice classroom teacher helps foster resilience in the novice, thereby increasing the chance for retention and increasing novices' self-efficacy and expertise (Soulen & Wine, 2018). The services and resources provided by the school library are not well-known to the preservice teacher. The school librarian's intentional work to increase awareness and access to services will support novices' efforts to understand and learn the practical skills necessary to become expert teachers. (Moreillon, 2008; Soulen, 2018).

The Skillset of the School Librarian

Information literacy is the ability to understand one's own need for information and to identify where to find the answer to satisfy that need (Association of College and Research Libraries, 2006). It has been shown that classroom teachers cannot teach information literacy to their students because classroom teachers (as is the case with most adults) can neither define nor teach information literacy (Chen et al., 2023; Prothero, 2022). The school community relies on the school librarian to perform searches and teach students these skills.

The use of library databases is an acquired skill. Databases are not always user-friendly, nor are they intuitive. However, students and teachers are required on a regular basis to interact with databases, whether this is to find materials in the library's online public access catalog, locate research regarding a particular project, or satisfy curiosity. School librarians are trained to teach database use. They can create infographics for their users to help explain difficult material. This is part of the training for school librarians. While database searches have become more user-friendly, school librarians often need to guide query formulation for the user to retrieve needed material. They are experienced in the creation of prompts to elicit reliable, relevant information from databases, so the creation of prompts for GenAI, as well as teaching others how to create useful prompts for GenAI, is already known to school librarians. At the higher education level, academic librarians can also impart this skill to their students and faculty.

Generative Artificial Intelligence in the School Community

GenAI as a tool has yet to be fully realized. There is so much hope for the promise it holds! The school librarian can act both as a prompt engineer and guide for the use of GenAI in a number of roles. A new model of the school librarian as an additional partner in the learning experience of preservice teachers will include the manipulation of GenAI to enhance student learning as well as increase critical thinking in novice teachers. The school librarian can help new teachers assess the responses of AI for accuracy, bias, and the notorious "hallucinations" that seem to dog the tool at this time. Hallucinations in this context refer to what is ostensibly the best product of GenAI: the algorithm is very good at creating sentences, paragraphs, and citations that make sense to human readers. It does not check for the accuracy or reliability of its deliverable.

ChatGPT, for example, has been called a very fancy auto-complete (Marchese, 2022). In its way, this is exactly what this iteration of GenAI has been trained to do. It predicts the next best word in the sentence. For that reason, it can be used to both create and complete rules-based forms (like individual program plans for students), but it cannot verify any of the statements it makes. This was never the intent of this program. For that reason, users will need to use their own discernment and judgment regarding statements made by GenAI. The school librarian can guide and support new teachers in their use of GenAI to avoid reliance on outputs and discern for themselves whether the responses received from generative AI tools are reliable, accurate, and useful.

Model Use

School districts must understand how GenAI can be best utilized for learning and teaching. Policy set at the district level is the most powerful guardrail for teachers and students. The conversation between educators, lessons learned, and best practices are all ongoing. GenAI is already available for K-12 learners as well as those in higher education.

In what ways is the use of GenAI more beneficial than traditional methods? Are there ways to utilize GenAI to create more meaningful and engaging lessons? Will using GenAI upend traditional methods? Or will attention and interest blow over, leaving teachers to navigate this new landscape on their own? Many questions still need to be answered, and the outcome is still being formulated. Principals, superintendents, and faculties must be in continual conversation to help maintain ethical and intellectual integrity for their educational community.

When novice teachers want to create innovative, personalized inquiry learning, they need to consider with whom they want to collaborate. Innovation takes creative thought and time to pursue how the innovation may be

best incorporated into successful learning experiences for students. Personalized learning for students requires knowledge of the individual students and what motivates them. Inquiry learning includes asking questions, which is a different mindset from providing information through instruction. Ideally, when selecting a collaborator, an experienced educator whose lessons and teaching style lean more towards innovation than scripted lessons would be very beneficial. School librarians are educators who build their professional experience portfolio using innovative lessons intended to motivate students in their learning and in using inquiry with students in the school library setting, making them ideal collaborators.

Prior to beginning the collaboration with the school librarian, novice teachers need to define and understand what the goals and objectives will be for the learning experience for their students. In addition, they need to be prepared to bring their knowledge of their students to share with the school librarian. It is important to include information about accommodations and teaching strategies to which students respond well and have demonstrated that learning did occur when these strategies have been used. If little is known about the students, such as at the beginning of the school year when not enough time has passed to identify specific strategies that work with this group of students, the novice teacher may rely on the school librarian's expertise obtained from working with multiple grade levels across various subject areas. Even though this might lead to broader goals and objectives at the beginning of the planning, they can be modified as the learning opportunity progresses.

School librarians have experience in collaborating with classroom teachers on information literacy lessons and inquiry lessons. These school librarians have been exposed to research supporting their involvement in teaching collaboratively through their school librarian preparation programs and their professional development opportunities. Library Research Service (LRS) houses the results of school library impact studies that include school librarian-teacher collaborations as a factor in student achievement (Library Research Service, n.d.). Armed with this knowledge, school librarians understand the importance of their involvement in supporting classroom teachers. The opportunity for them to work with novice teachers is one way to continue their efforts to maintain important collaborative relationships with the teaching staff in support of the curriculum and student learning.

At the initial meeting, the novice teacher and the school librarian need to identify and discuss the focus for this particular student's learning. Topics, goals, objectives, and what students will be expected to do should be agreed upon. This is where it becomes beneficial to have knowledge of what the students can do and which strategies are ideal to use with them for the learning experience that is being created. The novice teacher will most likely provide the greatest insight into their students, but the school librarian will be able to contribute as well. For greater success at this point in the planning, defining the roles each will take on for the collaboration will help to ensure that the focus stays in place.

Another important role of the novice teacher will be to define what information their students will need to have access to in order to achieve the objectives and goals for the learning. Understanding the students' need for information and having an idea of where the gaps are in student knowledge regarding the topic will help with identifying the range and scope of the information to include from the available school library materials and online resources. Then, the school librarian will be able to pull together the best resources for students to use. At this point, AI, which enhances information access and personalizes learning experiences, can become a part of the planning for the desired learning experience. This is when and where the school librarian can provide and support prompt engineering by reviewing with the novice teacher which types of inquiries will return the best information that supports the intended learning.

For example, if the desire is to use a closed dataset with students for this learning experience, then the school librarian can help define and design one. By using a closed dataset within a specified AI tool that allows for control over the output from the AI tool, it is possible to avoid the bias that may be encountered from an open search on the internet. The closed dataset model is akin to adding guardrails so that the focus of the inquiry on a specific topic gives results that are of a higher quality output received from a closed dataset in the AI tool rather than having to focus on teaching how to assess the relevance and accuracy of the information returned in an open internet search. The former is an important lesson for students, too, and may be an important part of the desired learning experience. If it is, then it should be incorporated along with extra time for learning because of the additional knowledge and skills that will come into play for evaluating information for its relevance and accuracy.

By using a closed dataset, the novice teacher and school librarian can evaluate what is working and what is not working. Closed datasets ideally contain accurate and reliable information since they were handpicked for use in the prescribed learning experience. Their use controls the variables that are being measured and can help with isolating the effects of specific accommodations. At times, intended outcomes from accommodations may not actually lead to the learning desired. Corrections to the dataset or prompt engineering may be made if they are needed.

What the school librarian will need to do, once the dataset has been defined, is prepare the dataset for use in the generative AI. This may include cleaning and formatting the dataset for the AI tool that will be used. At this point, the dataset may be uploaded and is ready to use once all parameters are met for use with the AI tool. The parameters may include specifying the input and output formats and choosing the appropriate algorithms. Once this step has been completed, the novice teacher and school librarian will need to take time to test and refine the model to see if it is working correctly. Changes are made as needed. When both the novice teacher and librarian determine that the AI tool is ready for student use, the school librarian will provide access instructions, such as a login, and create any documentation or tutorials that might be needed. In addition, the school librarian's role will also include monitoring the data set to ensure it remains secure and protected as students continue to use it.

Creating a collaborative plan has important pieces of information that should be included for documentation. A sample collaborative plan that the school librarian constructs might look like Figure 1.

Figure 1.

Model of Collaborative Lesson Plan

Name of classroom teacher:	Other team members' names and roles:
Number of students involved:	Grade level of students:
Title of lesson:	
Topic:	
Standards to be met:	Skill to be learned:
Critical thinking skills to include in the lesson:	
Length of lesson in time periods and days:	Accommodations needed for students:
What do students already know about the topic?	
What have students demonstrated as an interest regarding this topic?	
What technology are students already using?	What technology do students prefer to use?
What AI tool will be used with students:	Define/describe the dataset to be used with students:
Responsibilities for each team member:	
Formative assessments of student learning to include:	Summative assessment of student learning:

The collaborative plan model is helpful to the novice teacher, too, because it provides the information that the school librarian has about students and their needs. In addition, the school librarian has identified the assessments that are expected. The formative assessment establishes common ground for the school librarian and novice teacher in understanding where students are as the learning experience advances. The summative assessment of learning and an overall evaluation of the learning experience will help provide feedback not only on what students learned and their use of GenAI but on how well the collaborative planning went.

ChatGPT can create a lesson or unit plan. The prompt used is key to output. Well-engineered prompts will support the correct response of ChatGPT and will lessen hallucinations as well as extraneous answers. The use of the chat function in Bing, now called Copilot, will also help identify references that the school librarian can then help locate.

There are many different scenarios in which GenAI can help to support not only the learning but also gains in experience for new teachers as well as preservice students. A closed dataset (such as a school's online public access catalog) will also allow the preservice student as well as the novice to then be aware of and utilize resources within their workplace to allow best practices sooner than can be seen in traditional scenarios.

The following is an engineered prompt submitted to ChatGPT for its response to the query. ChatGPT was required to include the National School Library Standards as well as national educational standards—Common Core and Next Generation Science Standards. The prompt and table follow.

Sample Lesson Plan

Prompt: You are an expert school librarian. I would like for you to generate the objectives, pre-assessment, activities, post-assessment, and accommodations for the lesson plan which should be about simple machines. This lesson will be a forty-minute session. In the standards column, include the full standards. In a separate column, add specific National School Library Standards for each corresponding aspect of the lesson. In the time column, include the amount of time that should be spent on that aspect of the lesson. Provide a pre-assessment activity to complete at the beginning of the lesson and a post-assessment activity to complete at the end of the full lesson. Please generate the above lesson into a table. The column headings should be columns for Objectives, Standards, Pre-Assessment, Activities, Post-Assessment, Accommodations, and Time. Table 1 shows a lesson plan for simple machines at the third-grade level.

Figure 2

Simple Machines Lesson Plan

Objectives	Standards	National School Library Standards	Pre-Assessment	Activities	Post-Assessment	Accommodations	Time
Identify and define common simple machines.	Next Generation Science Standards (NGSS): 4-PS3-2 - Common Core State Standards (CCSS): CCSS.ELA-LIT ERACY.RI.4.1	Inquire: Build new knowledge by inquiring, thinking critically, and gaining knowledge.	Distribute a worksheet with images of different objects labeled with corresponding simple machines.	Introduction (Include, Inquire): Discuss what students already know about machines. Introduce the concept of simple machines.	Create a poster or diagram showing at least three examples of simple machines.	Visual Learners: Provide visual aids, diagrams, and models. Auditory Learners: Allow for verbal discussions and group activities. Kinesthetic Learners: Set up hands-on activities. Special Needs: Provide additional time. Advanced Learners: Assign additional research tasks.	5
Under-stand the basic principles of each machine.	Next Generation Science Standards (NGSS): 4-PS3-2	Include: Demonstrate an understanding of and commitment to inclusiveness and respect for diversity in the learning community.		Exploration Stations (Include): Set up stations with different simple machines for hands-on interaction. Provide guiding questions.		Visual Learners: Encourage drawing and labeling. Auditory Learners: Provide audio resources. Kinesthetic Learners: Encourage physical demonstrations. Special Needs: Provide simplified materials.	15
Apply knowledge of simple machines to real-world examples.	Next Generation Science Standards (NGSS): 4-PS3-2 - Common Core State Standards (CCSS): CCSS.ELA-LIT ERACY.W.4.7	Collaborate: Work effectively with others to broaden perspectives and work toward common goals.		Reading and Research (Collaborate): Distribute reading materials about simple machines. Encourage notetaking.		Visual Learners: Provide visual aids and models. Auditory Learners: Encourage group discussions. Kinesthetic Learners: Encourage role-play. Special Needs: Offer additional support.	20

Experienced instructional technologists will note that the lesson plan refers to learning styles, which, while popular in the general understanding of learning, has no evidence to support it (Furey, 2020). However, this is an example of the ways that GenAI has used the internet to fill a request. Since the notion of learning styles can be found across the internet, it follows that ChatGPT will use this theory to help fill in the accommodations for teachers and students. The results must be vetted for accuracy, as can be seen here. ChatGPT did not supply an assessment, which would need to be created subsequent to the original query.

ChatGPT can reference many different standards at the same time, which is a great support for new teachers. In this lesson, specific National School Library Standards are referenced and integrated into each aspect of the lesson plan. This ensures that the lesson plan aligns with these standards and promotes the development of skills related to inquiry, inclusiveness, and collaboration in the learning community. Note also that ChatGPT has helpfully provided accommodations to nudge teachers' thinking about how to serve all students best. While not over-the-top innovative, it will provide teachers with thought-starters to add or revise the lesson with content that they believe will work for their own students. Remember that in this example, the teacher has not added the unique student profiles and needs in this query. With that information, ChatGPT might have come up with more varied accommodations and activities. This prompt has been adapted from <https://blog.tcea.org/prompts-for-lesson-planning-with-chatgpt/>.

PRACTICAL IMPLICATIONS

Known Issues with the Use of Generative Artificial Intelligence

Red Teams is a term that refers specifically to a group or groups who emulate a potential attacker's threat (National Institute of Standards and Technology, n.d.). These teams, founded on the idea that to make a tool better, one must find its weak points, are working together frequently to unearth hidden issues with, or "break," GenAI. One area that seems to repeat is the notion of bias. Large Language Models (LLM) like ChatGPT 3.5 have been trained on the toxic repository that is the internet, so bias against minorities and women, as well as preconceived ideas around specific populations, are current known issues. The dataset used is centered on North America, which also contributes to bias in a different way—the responses ignore the wider world. Notwithstanding the fact that ChatGPT 3.5, for example, has been trained on data that ends in 2021, reliance on such a product or tool is problematic.

Recently, a group of academic and research librarians asked ChatGPT to create a recipe for chicken enchiladas. GenAI returned the recipe without any ingredient measurements. When they asked for a reference, i.e., the cookbook where this recipe could be found, ChatGPT made up a reference for a cookbook that looked correct but did not exist. In this example, ChatGPT "knows" what good references look like but has no brake on creating well-formed and good-looking, but erroneous, responses.

In schools, the school librarians are the information specialists on campus and can fact-check quickly. Their charge is to teach others how to do this as well. The skill of information literacy will decrease acceptance of unacceptable responses. Information literacy is a skill that can be learned. This hallucinatory aspect of the tool is troubling. A suggestion and alternative for school communities may be to train GenAI on a closed dataset, such as the online public access catalog in schools and the paid databases to which the school has access to control the output. It may not cut down on the hallucinations, but it would be easier to view errors as such as well as be a teaching point regarding information literacy.

Prompt Drift

Recent research has explored the notion of prompt drift. This phenomenon happens when prompts that worked previously now return unexpected results (Chen et al., 2023). School communities may need to provide mitigation strategies should this become an issue. If the school librarian has access to prompts that the community has used successfully in the past, they would be able to check for continued accuracy. It makes sense that answers would change over time because the tool is still learning. Inputs over time will change outputs. Keeping GenAI on track is necessary.

Input Quality

The adage garbage in, garbage out implies that the input of any technology tool must have quality to produce a quality output. It is the same in the case of GenAI applications in schools. The creation of prompts that are specific, precise, and focused is known as prompt engineering. The notion of teaching users how to build prompts is part of the learning curve in any well-managed use of GenAI. It is conceivable that the school librarian will manage a database of prompts that teachers can rely on to formulate lesson and unit plans as well as ideas for teaching specific topics. Of course, prompts will need to be revisited as the model changes to allow for drift.

The Use of a Closed System

If the school were able to utilize all the materials housed under the aegis of the library to train GenAI, it would be to the great advantage of the school community in adapting GenAI as a tool for use in the school. An example of a closed system is a library's online public access catalog (OPAC) and its subscription databases. As the large language model (LLM) on which GenAI is trained, it will learn the patterns of this LLM, and will respond to subsequent prompts by using the data from this closed system. Everything in this system has already been vetted—that is, the books, articles, and visual media have all been chosen specifically for this educational community. The notion of training GenAI on closed-system LLMs is already being explored with products that users can access through repositories such as GitHub. If GenAI were to utilize the materials available within the library, including databases to which the school has access, it might help alleviate some of the known issues, such as bias and hallucinations. More study needs to be done in this area. As mentioned above, the ability of GenAI to

hallucinate and provide references and citations for papers and books that do not exist, as well as making up the biographies of people, for instance, loops back to the notion that all outputs must be vetted.

Technology and Cognitive Skills

The use of GenAI will allow users with low technology skills to build them in a more engaging and interactive way, should that be the goal. However, to apply GenAI, one need not have advanced technological skills. That is not the case with the evaluation of GenAI outputs. Teachers need information literacy skill-building at every level.

Information literacy is an umbrella term for critical thinking, logical reasoning, sense-making, self-questioning, and the ability to reframe a query and to consider and evaluate results for efficacy, accuracy, reliability, and relevance. Teachers are not able to teach information literacy and are not always able to meet their own information needs (Chen, 2023). Information literacy is an important aspect of the growth of preservice teachers. School librarians can provide support and instruction to impart these skills while also guiding the preservice teacher to cultivate them.

At the preservice level, instructors and academic librarians provide some instruction on this, but students, preservice teachers, and novice teachers need to hone those skills to interact with GenAI in productive, accurate, and relevant ways. Outputs need to be monitored for reliability continually. The lack of currency of the dataset used is also an issue, as previously discussed. For example, ChatGPT itself is notorious for insisting that current events haven't happened yet.

When teachers practice critical thinking skills to discern whether the outputs make sense and can fact-check the results of a query with the help of the school librarian, chances for a good outcome increase. Some ideas for the use of GenAI, guided by the school librarian, are:

- Adaptive programming for each individual student
- Ability for teachers to create lessons for a number of different student abilities and interests, all based on state standards
- Inquiry learning as the norm, school-wide, driven by the National School Library Standards
- Teaching and learning critical thinking skills

Working with the school librarian increases the efficacy of the new teacher and supports their learning in the profession. The collaboration allows preservice teachers to practice with lesson, unit, and curriculum planning to critically evaluate responses created by GenAI with the support of the school librarian. In addition, this opportunity increases their understanding of the scope and sequence regarding curriculum and lesson planning as well as the needs of a diverse student population. It will also increase the use of relevant resources for their work and for their students, which is an added (and excellent!) outcome.

Professional Development, Policy, and Change in General that Supports the Use of GenAI

To implement successful professional development in how librarians can support novice teachers using GenAI requires that many more people, processes, practices, and organizations establish best practices in using GenAI. Foundational education structures need to address and define how GenAI should be used for the greater good of all educators and students.

Educator leaders should spearhead the changes needed to build consensus on the importance of the use of GenAI with students. Complacency among faculty will need to be disrupted for those who are not yet willing to engage with GenAI. Leaders who are serious about incorporating GenAI throughout the curriculum should identify what they need to change within themselves, such as beliefs and practices, before moving forward to lead change in others. When they are ready, they need to focus on the people with whom they work. Begin with those who are held in esteem in the eyes of the faculty. These may even be people who have uninformed optimism in the use of GenAI in the beginning. The key here is to move them from uninformed to informed and away from resistance.

It is very important that leaders ask questions and listen well to what their faculty have to say. Not doing this could result in a less effective implementation in the use of GenAI. Meeting with them and addressing their questions and concerns is key to moving forward. Likely, they will have ideas that improve the implementation of including GenAI in the curriculum and the lessons they teach.

Leaders shouldn't be afraid of pushback from educators because they should prepare themselves for these encounters. Also, they should envision the inclusion of GenAI across the curriculum as a continual improvement

process. Thinking and working through the change while keeping in mind that the process will continue to evolve results in improved communication that supports the best use of GenAI in a school, college, or university.

Professional Growth and Development

With the rising interest in GenAI, professional growth and development for educators is in the best interest of all involved. Because of the potential that GenAI has for learning, GenAI can span the curriculum across many, if not all, subject areas. In areas such as special education, learning a second language, and other areas where adaptations for learning are made, professional learning opportunities in using GenAI may improve these adaptations and turn them into improved learning opportunities that better address students' individualized needs. Getting this right improves not only students' learning but also provides novice teachers with increased support, too. Individualized lessons take time for teachers to develop. With the help of GenAI, the development of these lessons requires less time and increases the likelihood of including improved learning through customization by meeting an individual's learning needs. Professional development can lead to these types of improved learning experiences.

To help educators incorporate best practices with GenAI, leaders will need to review current policies and put new ones into place as the need arises. These policies should adhere to the highest standards while lessening bias, ensuring quality and ethical use, and protecting individuals from security risks. In addition, educational leaders will need to ensure that necessary training in the use of GenAI is required and provided for all educators within the scope of their influence.

The responsibility for learning how to best use GenAI with students will need to be part of every teacher's repertoire. Additional professional development may be needed based on the ethical use of GenAI in the classroom and on the subject matter and its curriculum. Seeking sources for training outside of the school and district may prove valuable. However, teachers should remember to consult with their librarians. School librarians can provide not only professional development in GenAI, but also provide additional resources with which the teachers may not be familiar.

To provide cutting-edge professional learning for teachers, school librarians should watch for opportunities to expand their own repertoire concerning GenAI. These opportunities may come from national and state professional organizations, such as the American Library Association (ALA) and its divisions, and the International Society for Technology in Education (ISTE), and its ability to partner with school districts and other educational systems. These organizations and others like them produce webinars, podcasts, and professional association books and journals. These should be dedicated to technology infusion (Borthwick, et. al., 2020) that deliver opportunities for increasing professional knowledge and skills. These organizations also write standards for learners and educators. The standards already encompass information literacy, digital citizenship, and other related topics, including the use of GenAI. However, as GenAI continues to grow in use, these organizations may want to specifically address GenAI in future updates of their standards.

Implications for Educator Preparation Programs

For educator preparation programs, there are multiple levels of responsibility that must be included so that GenAI is not just a topic that is taught but is also infused throughout these programs. Design for how this will happen is important. The people who should be involved include deans, associate deans, department chairs, program coordinators, and any other levels of leadership that are supportive of the educator preparation programs. In addition to requiring their support, the faculty needs to identify best practices for including and teaching GenAI in their courses while modeling its ethical use. A systemic approach for shared responsibility for using, modeling, and teaching all aspects of GenAI is imperative.

School librarian preparation programs are part of educator preparation programs. Currently, many of these programs are attempting to address the use of GenAI in some form or fashion. This does not mean that these programs have infused the use of GenAI in and across the courses that lead to certification. A thoughtful look at the school librarian preparation program through curriculum mapping will help to identify areas or courses where GenAI should be included. Program reviews happen in cycles. GenAI should be included in the next review cycle if a program is not currently undergoing one. However, GenAI may prove to be such a motivational tool as to prompt earlier curriculum mapping prior to the scheduled program review. Those programs that seek or create such an opportunity will be on the cutting edge and offer a richer learning experience for their students.

VISION FOR THE FUTURE

School librarians can and should have a greater role in teacher education preparation programs and in professional development opportunities for teachers. In each of these roles, school librarians can help prepare teachers for their use of the school library's resources, which can include generative AI, and in their work with the school librarian as a collaborator and co-teacher. More specifically, teachers have little time to teach and reinforce information literacy skills that are so important for selecting and using factual, reliable, and relevant information. The inclusion of school librarians as more than support personnel but also as knowledgeable resources who know and use technology will help improve students' information literacy skills.

School librarians understand the need for reliable, accurate, and relevant information that informs. Add their knowledge and what generative AI can do, and the possibility for supporting authentic learning grows. Generative AI has the prospect of further developing personalized learning for students. Personalization may encourage more creative inquiries made by students who are following their interests. School librarians can support this. Personalized learning experiences may include additional accessible materials for students with disabilities that are not currently part of a school's toolkit. By combining presently useful tools to create a richer learning experience for students with disabilities, a subsequent implication might be that the learning experience of all students might be enriched. Universal Design for Learning has shown that this mindset has been a positive force in the school setting. Perhaps GenAI will give more students the help and service they need.

FURTHER READING

The National School Library Standards are available as a book from the American Library Association. More information can be found here: <https://standards.aasl.org>

More on the notion of information literacy can be found here:
<https://www.ala.org/acrl/issues/infolit/overview/glossary>

The Texas Computers in Education Association has an amazing number of vetted resources on GenAI and many, many other educational technology topics for educators: <http://blog.tcea.org>

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Generative AI to Improve Special Education Teacher Preparation for Inclusive Classrooms

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Emerging technologies, such as Artificial Intelligence (AI), machine learning, and data mining, have ushered in disruptive generative AI, revolutionizing various domains, including education. The advent of AI-based chatbots like ChatGPT has led to the widespread adoption of Generative AI tools in educational settings (Bahroun et al., 2023; Jeon & Lee, 2023). Generative AI tools enable the creation of new content, including text, images, and videos, potentially transforming teaching and learning processes (Wu et al., 2023). Generative AI tools are revolutionizing the educational landscape and offering new possibilities. Their application becomes particularly pertinent in special education, where they can play an important role in supporting teachers in navigating the complexities and demands of inclusive classroom environments.

The *Salamanca Statement and Framework for Action on Special Needs Education* (O. S. N., 2004) advocated for an inclusive education approach, striving to integrate students with special educational needs into mainstream education. In the United States, the prevalence of students eligible for special education services has steadily increased over the past decade, with a recent report from the National Center for Education Statistics (NCES, 2023) indicating that fifteen percent of public school students now receive special education services under the Individuals with Disabilities Education Act (IDEA). The percentage of students with disabilities aged 3-21 spending 80 percent or more of their time in general education classrooms has risen from 61 percent to 67 percent (NCES, 2023). This shift towards inclusion has brought new challenges for teachers. The growing diversity in classrooms has raised concerns among teachers regarding inadequate support and the practical implementation of inclusion (Glazzard, 2011; Horne & Timmons, 2009).

Special education teachers (SETs) face challenges in adapting curricula, providing individualized instruction, assistive technologies, and accommodations, and fostering support to meet the unique needs of students with disabilities in the inclusive classroom (Shepherd et al., 2016). Generative AI tools like ChatGPT have emerged as a promising resource in addressing these challenges and assisting teachers in acquiring pedagogical knowledge related to adapting and differentiating curricula for inclusive classrooms. This book chapter provides a comprehensive overview of the potential of generative AI tools to improve the preparation of SETs in the context of inclusive education. It underscores the ethical implications of leveraging these AI-driven technologies to bridge educational disparities.

OVERVIEW OF GENERATIVE AI

Recently, generative AI has witnessed remarkable strides, especially with the launching of ChatGPT (Bahroun et al., 2023). Generative AI comprises a transformer model and a generator model. The transformer model is trained on a designated data set and can map the input information into a latent high-dimensional space and a generator model that facilitates generating novel content consistently, even when provided with the same prompts (Gozalo-Brizuela et al., 2023). Generative Pre-Trained Transformer (GPT) models achieve the ability to comprehend and generate text that closely resembles human-like language through the utilization of a large amount of digital content and advanced natural language processing techniques (Alawida et al., 2023). Generative AI encompasses a diverse array of capabilities to produce entirely new content, including but not limited to text, audio, images, and videos (Cao et al., 2023; Dasborough., 2023).

The advent of Generative AI has sparked widespread interest and attention, attributed to its ability to carry out complex tasks that involve creative content generation instantly. Consequently, the global impact of generative

AI is transformative (Bahroun et al., 2023; Dwivedi et al., 2023), exerting a profound influence on societies worldwide and fundamentally reshaping the dynamics in various domains including, but not limited to, education, medicine, healthcare, and business (Bahroun et al., 2023). This disruptive technology has swiftly changed the way of working, and the widespread adoption of these technologies will make many contemporary jobs obsolete in the ever-evolving landscape of the modern world (Budhwar et al., 2023; Rudolph et al., 2023). Generative AI has revolutionized the way we interact with AI-driven tools, such as chatbots and conversational agents, including ChatGPT, DALL-E, Bard, Scribe, Jasper, and a host of others (Kaplan-Rakowski et al., 2023). Generative AI technologies can assist educators in training SETs in teacher preparation programs to create lesson plans, generate assessments, differentiate curricula, and adapt the content based on students' diverse needs.

NEED FOR INCREASING DEMAND FOR PREPARATION OF SETS FOR INCLUSION CLASSROOMS

The increasing need for an expanded focus on preparing SETs for inclusion classrooms in the United States is multifaceted (Hamilton-Jones & Vail, 2014; Woulfin & Jones, 2021). School districts grapple with the ongoing challenge of sourcing qualified SETs for inclusive educational environments (Billingsley & Bettini, 2019), exacerbated by increasing accountability requirements imposed by State and National Departments of Education (Brownell et al., 2012; Óskarsdóttir, 2020). This dilemma is further exacerbated by persistent teacher shortages and a concerning attrition rate within the special education field, necessitating the urgent development and sustenance of a highly skilled SET workforce tailored for inclusion classrooms (Billingsley & Bettini, 2019; Hagaman et al., 2018). In 2021, there were 476,300 special education teaching positions, and projections indicate an annual demand for 37,600 new SETs, with a potential growth rate of 4% from 2021 to 2031, according to the U.S. Bureau of Labor Statistics (2023). To address this imperative, universities must take proactive steps to establish and offer high-quality preparation programs geared towards enhancing the competence of SETs within inclusive educational settings. Universities are shifting from the traditional model of a classroom to project-based learning to improve teaching practices and offer high-quality preparation programs (Tsybulsky et al., 2020). Project-based learning will provide SETs with hands-on, practical training and collaborative type of learning to help teachers feel more successful in the classroom (MacMath et al., 2017). These programs should focus on equipping SETs with the necessary skills and knowledge to teach students with disabilities effectively within an inclusive classroom environment. Teacher education programs' emphasis on project-based learning will help SETs gain theoretical knowledge and become practically adept at handling a variety of classroom scenarios (Yuwono & Rapisa, 2021).

Identification of Barriers Faced in Preparing SETs

Prior research has highlighted the inadequate training provided to SETs in effectively managing students with disabilities within inclusive classrooms (Costigan et al., 2010; Hagaman et al., 2018; Harvey et al., 2010). SETs confront difficulties encompassing classroom management, student engagement, and tailoring instruction to cater to diverse academic requirements (Shank & Santiago, 2022). In the context of training SETs, teacher preparation programs must equip teachers with the essential skills for developing authentic lesson plans, formulating effective classroom management strategies, and adapting the curriculum to align with the specific needs of their students (Ginja & Chen, 2020; Sushama et al., 2022).

Within the university setting, the challenges encountered in the preparation of SETs include (1) securing the needed number of field hours, encompassing both general and special education classrooms, (2) reducing the overall workload and mandatory hours for coursework and field experiences, and (3) adequately preparing teachers to address the unique needs of students within low-incidence populations, thereby enhancing their ability to serve effectively within self-contained or inclusive classroom environments (Kent & Giles, 2016).

The Potential of Generative AI to Transform Teaching and Learning Processes.

Generative AI, driven by advanced machine learning algorithms, has the potential to revolutionize the teacher preparation program. Its potential lies in its capacity to generate, mimic, or create content, facilitating personalized, adaptive, and highly efficient learning experiences (see Table 1). Generative AI can tailor learning pathways, harnessing individual students' learning patterns, preferences, and strengths to customize the educational materials and activities (Bahroun et al., 2023; Baidoo-Anu & Ansah, 2023; Su & Yang., 2023). This personalization

improves students' engagement and comprehension and extends to real-time feedback and guidance for both students and educators, fostering a dynamic and responsive learning environment (Grassini, 2023; Smolensky et al., 2023).

Generative AI promises to automate administrative burdens, freeing SETs to dedicate more time to teaching and innovation (Kamalov et al., 2023). It can also assist in content creation, ensuring inclusivity and up-to-date relevance (Alasadi & Baiz, 2023). Generative AI can be vital for educators' professional development, offering tailored recommendations and coaching (Kaplan-Rakowski et al., 2023). They can even assume roles as virtual tutors, providing immediate support and enhancing independent learning (Bahroun et al., 2023; Baidoo-Anu & Ansah, 2023; Su & Yang, 2023). Integrating Generative AI requires a careful look into ethical, privacy, and pedagogical concerns (Alasadi & Baiz, 2023). Balancing automation with human interaction and creativity remains a pivotal challenge (Kasneci et al., 2023). The multifaceted potential of Generative AI in teaching SETs signifies a profound transformation (see Table 1). Collaboration among educators, policymakers, and technologists is essential to navigate this complex landscape, ensuring that Generative AI enriches learning outcomes while upholding educational equity and ethical standards (Marino et al., 2023).

Table 1*The potential of Generative AI to transform teaching and practices*

Aspect of Generative AI	Description	References
Personalized Planning and Content Development	Utilizes machine learning to tailor learning materials and activities based on individual students' learning patterns, preferences, and strengths, thus enhancing student engagement and comprehension.	(Baidoo-Anu & Ansah, 2023; Bahroun et al., 2023; Hashem et al., 2024; Su & Yang, 2023)
Real-Time Feedback and Guidance	Provides dynamic feedback and guidance for students and educators, fostering a responsive learning environment.	(Bahroun et al., 2023; Grassini, 2023)
Automation of Administrative Tasks	Reduces administrative burdens, allowing SETs more time for teaching and innovation.	(Kamalov et al., 2023)
Content Creation and Inclusivity	Assists in creating educational content that is inclusive and relevant to current topics.	(Alasadi & Baiz, 2023)
Professional Development for Educators	Offers tailored recommendations and coaching for educators' professional development.	(Kaplan-Rakowski et al., 2023; Su & Yang, 2023)
Virtual Tutoring	Acts as virtual tutors for immediate student support, enhancing independent learning.	(Baidoo-Anu & Ansah, 2023; Su & Yang, 2023)
Ethical and Privacy Considerations	Requires careful consideration of ethical, privacy, and pedagogical concerns in its integration.	(Alasadi & Baiz, 2023)
Balancing Automation and Human Interaction	Challenges in maintaining a balance between automated processes and the need for human creativity and interaction.	(Kasneci et al., 2023)
Collaborative Approach	Emphasizes the need for collaboration among educators, policymakers, and technologists to navigate the complex landscape of integrating Generative AI.	(Marino et al., 2023)

Application of Generative AI in Enhancing Preparation of SETs

To effectively address the diverse needs of students with disabilities, SETs can leverage Generative AI (Ruiz-Rojas et al., 2023) as a multifaceted tool (see Table 2), as highlighted by Kamalov et al. (2023). Generative AI can assist SETs in creating tailored learning materials that align with each student's unique cognitive abilities, sensory preferences, and technological needs (Adiguzel et al., 2023; Baidoo-Anu & Ansah, 2023). Analyzing student performance and engagement data through Generative AI allows educators to develop and refine teaching strategies (Ruiz-Rojas et al., 2023). This data-driven approach enables educators to identify and implement targeted interventions and alternative teaching methods that are more responsive to the individual needs of their students.

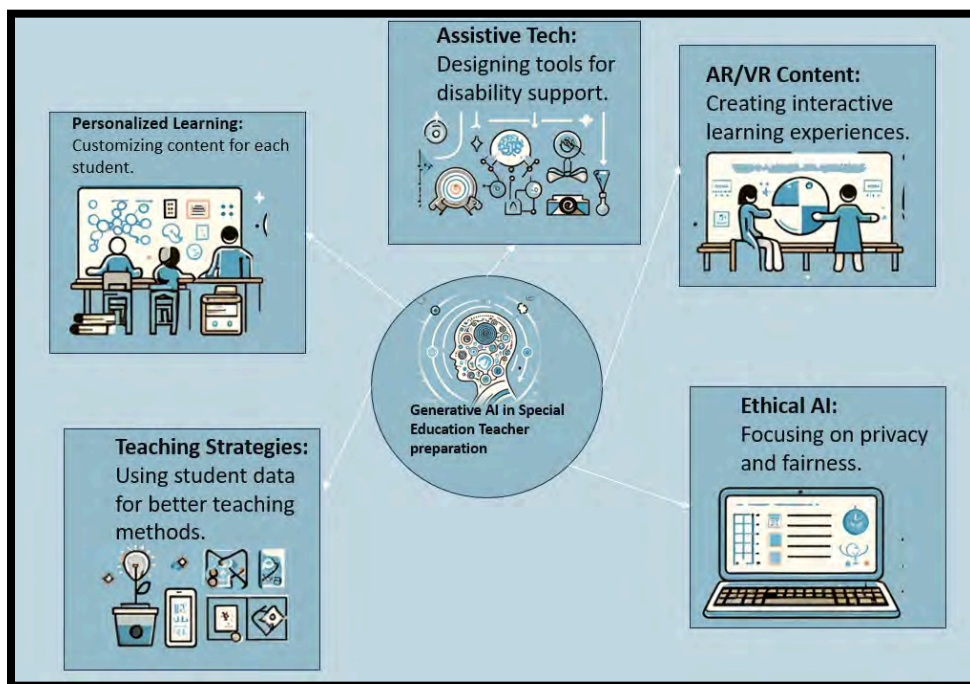
Table 2*Application of Generative AI in Preparing Special Education Teachers*

Aspect of Teacher Preparation	Application of Generative AI	References
Data Analysis for Learning Challenges	Generative AI analyzes extensive educational data to identify specific learning challenges students with special needs face.	(Ruiz-Rojas et al., 2023)
Personalized Training Modules for Teachers	Development of customized training modules focused on addressing the identified challenges.	(Chan & Hu, 2023; Escotet, 2023; Ruiz-Rojas et al., 2023; Su & Yang, 2023)
Innovative Teaching Techniques	Generative AI suggests adaptive and innovative teaching methods suitable for diverse learning needs.	(Adiguzel et al., 2023; Chen et al., 2020)
Individualized Student Focus	Enables future teachers to understand and cater to the unique educational requirements of each student in special education.	(Pons, 2023)
Interactive Learning Scenarios	Provides simulated environments where teachers can practice and refine their skills in handling various special education scenarios.	(Chiu, 2023)
Continuous Learning and Adaptation	Generative AI continuously updates training content based on emerging educational research and trends in special education.	(Kumar et al., 2022)
Assessment and Feedback	Offers tools for assessing teaching strategies and providing feedback, facilitating continuous improvement in teaching methods.	(Grassini, 2023; Smolensky et al., 2023)

Generative AI facilitates the creation of augmented reality and virtual reality educational content, providing immersive and interactive learning experiences. This technology is particularly beneficial in inclusive classrooms, offering students with disabilities new ways to engage with and understand educational material. SETs in teacher preparation programs can learn the skills to utilize Generative AI to develop or recommend assistive technologies tailored to specific disabilities. Generative AI might suggest custom input devices or advanced speech recognition software to support students with motor impairments, enhancing their ability to participate in learning activities. Educators are tasked with ensuring the ethical use of Generative AI, which includes maintaining data privacy, security, and confidentiality and being aware of potential algorithmic biases. By integrating Generative AI into their practices, SETs will be better equipped to meet the diverse and unique needs of students with disabilities, leading to more inclusive and effective educational outcomes.

Figure 1

The Use of Generative AI in Special Education Teacher Preparation



Note. This image was adapted and created by DALL-E, an AI system developed by OpenAI

EXAMINATION OF HOW GENERATIVE AI CAN IMPROVE THE ACCESSIBILITY OF LEARNING MATERIALS

Generative AI shows potential for improving the accessibility of learning materials (Grassini, 2023). SETs can be taught by educators in teacher preparation programs to use generative AI to tailor the content, adapt teaching strategies, create immersive experiences, address language barriers, and simplify the steps to achieve the task. Generative AI can help SETs foster inclusive learning environments where every learner can learn by using the accessibility of learning features included in generative AI (Adiguzel et al., 2023; Ruiz-Rojas et al., 2023).

Customized Learning Materials

Generative AI tools, powered by advanced machine learning algorithms, can meticulously assess course content and offer individualized recommendations that cater to educators' specific learning requirements (Ruiz-Rojas et al., 2023). Various tools, including Fliki AI for content creation, you.com for presenting information in a structured manner, chatpdf.com for synthesizing essential learning material ideas, Leonardo AI for image and video analysis, humata.ai for adapting learning content to student needs, and ChatGPT for real-time personalized support, collectively contribute to this endeavor (Ruiz-Rojas et al., 2023).

Adaptive Teaching Strategies

Generative AI, such as ChatGPT, has the potential to bolster teachers' teaching capabilities and support the implementation of adaptive teaching strategies (Adiguzel et al., 2023). It can provide educators with immediate feedback, comments, and suggestions (see Table 3.) for enhancing their classroom practices by analyzing real-time

data, enabling teachers to adapt and refine their teaching strategies (Chiu, 2023; Smolensky et al., 2023). ChatGPT can be used to provide personalized feedback using a conversational agent that provides explanations tailored to teachers' needs and adapts to their level of understanding. In response to the proposed innovative ideas by generative AI, teachers can adapt and design a teaching unit with a detailed plan and learning objectives aligned with state standards (Ruiz-Rojas et al., 2023).

Table 3

Feedback Capabilities of Generative AI

Feedback Capabilities of Generative AI	Explanation
Content Understanding	<ul style="list-style-type: none"> ● Review written assignments ● offer suggestions when deeper exploration is needed
Writing and Grammar	<ul style="list-style-type: none"> ● Check grammar, punctuation, spelling, and syntax ● Provide corrections and explanations to improve writing skills.
Structure and Flow	<ul style="list-style-type: none"> ● Provides guidance to structure the essays or reports ● help to bring the logical flow of content ● support to organize the ideas and coherence of arguments.
Originality and Creativity	<ul style="list-style-type: none"> ● Encourages original thoughts and ideas ● Provides feedback on the uniqueness of content
Critical Thinking	<ul style="list-style-type: none"> ● Questions assumptions and arguments ● Promotes deeper analytical thinking
Adherence to Rubrics	<ul style="list-style-type: none"> ● Evaluates work against provided rubrics or criteria ● Determines if requirements are met
Constructive Feedback	<ul style="list-style-type: none"> ● Highlights strengths and areas that need improvement ● Provides supportive and learning-focused feedback
Prompting Revision	<ul style="list-style-type: none"> ● Suggests areas for revision ● Encourages self-reflection and consideration of different perspectives
Resources and References	<ul style="list-style-type: none"> ● Suggests additional resources, such as articles, books, or tutorials ● Helps in further understanding of the content

Immersive Learning Experiences

With the transformative power of generative AI, an inclusive classroom's dynamic, immersive, and interactive virtual world may be created to help SETs learn to apply and adapt their teaching practices. The Metaverse offers a dynamic virtual learning environment (Chamola et al., 2023). Within this environment, virtual landscapes, objects, and avatars can be created, allowing SETs to interact with both each other and the digital content in their classrooms (see Figure 2). This interaction enhances their teaching experience and learning process. Several generative AI technologies contribute to building this virtual world. Tools like Bard, Llama, GPT, paLM, and XLNet are used for text generation. Regarding image generation, technologies such as DALL-E, Crayon, NightCafe, Lensa, Open Art, MidJourney, and Stable Diffusion come into play. Flicks, Runway, Hour One, Tavus,

Rephrase.ai, and Synthesia are the key tools for video generation. 3D-GAN, CSM, Mirage, ControlNet, Imagen, Point-E, Lumirithmic, ShapeNet, and DeepSDF also support 3D object generation.

Figure 2

The Metaverse As A Virtual Training Environment For Pre-service Special Education Teachers



Note. This image was created by DALL-E, an AI system developed by OpenAI

All these technologies collectively create an interactive virtual environment in the Metaverse (see Figure 2). This environment significantly improves the capabilities and potential of SETs, particularly in working effectively in inclusive classroom settings (Chamola et al., 2023). In teacher training programs, virtual whiteboards and 3D simulations will enable educators to bring lessons to life (Escotet, 2023). Educators in teacher education programs may create realistic classroom scenarios (Chiu, 2023) for pre-service SETs to practice and refine their teaching strategies in a 3D simulated environment. Through virtual whiteboards, the SETs can model the use of digital technology in teaching students in inclusive classrooms. Virtual whiteboards and 3D simulations will make learning more accessible and interactive for students who cannot physically attend regular classes. Content created by generative AI can be projected on the whiteboard that the SETs can access in real time.

Exploration of Personalized Learning Experiences Facilitated by Generative AI

Personalized learning, also called individualized instruction, adaptive learning, and student-centered learning, helps SETs tailor education to meet students' unique needs, strengths, preferences, and capabilities (Basham et al., 2016; Shemshack & Spector, 2020). Generative AI can help support SETs by offering tailored, adaptive, and innovative experiences. Utilizing sophisticated machine learning algorithms to analyze vast datasets, generative AI can create customized learning pathways for SETs in teacher training programs, generating highly original output (Chan & Hu, 2023; Escotet, 2023). For SETs, generative AI-powered personalized learning experiences may address their unique needs and preferences.

Generative AI algorithms can assess individual learning styles, strengths, areas for improvement, and even the specific challenges faced in special education contexts (Pons, 2023). This analysis may lay the steps for highly personalized learning journeys. One fundamental characteristic of personalized learning is the adaptability of content and resources (Kumar et al., 2022). Generative AI, working alongside educators in teacher training programs, can develop and continually refine a range of materials like articles, videos, webinars, and interactive modules, specifically designed and aligned with the evolving needs and pedagogical strategies for training preservice SETs (Cao et al., 2023; Dasborough, 2023; Ruiz-Rojas et al., 2023).

AI-driven personalized learning experiences in teacher training programs can provide SETs with opportunities for self-assessment and self-directed growth. For instance, within these programs, generative AI can offer adaptive quizzes and assessments that assess SETs' knowledge and identify areas for further development tailored to the individual learning pace and understanding level of each SET. By analyzing previous responses and learning trajectories, the generative AI can adjust the level of difficulty and content focus on subsequent questions so that the assessments match the learner's current knowledge and skill level. Generative AI can suggest resources, courses, or workshops tailored to address these specific gaps in the knowledge or skills of SETs in the context of their training. For example, if a SET has difficulty with assistive technology, generative AI might recommend a course focused on the latest developments in this area. Generative AI can personalize learning in teacher training programs, offering real-time feedback and support (see Table 3) on assignments and activities (Escotet, 2023; Smolensky et al., 2023). AI can provide immediate insights and recommendations as SETs engage with learning materials or instructional scenarios in their training. For example, suppose a SET in a teacher training program is exploring new teaching methods for students with dyslexia. In that case, generative AI can recommend efficient classroom management strategies and provide resources to develop inclusive lesson plans. The adaptability of generative AI also extends to the pacing of learning experiences in these teacher training programs (Shepherd et al., 2016).

SETs have diverse and busy schedules with commitments (Zaier & Maina, 2022), and generative AI can cater to these variations. It can suggest bite-sized, on-the-go learning modules for SETs with busy schedules in teacher training programs or offer more immersive, in-depth course materials for those seeking a deeper understanding of special education topics within these programs. The effectiveness of these recommendations depends on the quality of the input data and the AI's understanding of educational content, which can be limited. Generative AI can generate text, create basic outlines for courses, or suggest content based on specific educational goals, but it may require further refinement by human educators to ensure accuracy, relevance, and pedagogical effectiveness. Educators can use generative AI to create interactive elements within courses, such as quizzes, practice exercises, and simulations, which can adapt in real time based on learner's responses. generative AI can improve collaboration among SETs through personalized learning experiences (Marino et al., 2023). It can facilitate virtual communities or discussion forums where SETs and educators can share their insights, challenges, and success stories. Generative AI can moderate discussions, summarize key points, and pose questions to stimulate discussion, although the depth and quality of these interactions are augmented by human participation. These platforms enable peer learning, where educators can draw upon the expertise and experiences of their colleagues to enrich their teaching practices (Chang et al., 2023). In conclusion, generative AI can be best used in conjunction with traditional teaching methods, providing a blended approach that leverages the strengths of both AI and human instruction.

Exploration of Personalized Feedback Generation and Adaptive Learning Approaches

In teacher training programs and the training of SETs, grading assignments and providing feedback are notably time-consuming tasks for educators (Hashem et al., 2024; Walvoord & Anderson, 2011). One remarkable application of generative AI in teaching and learning contexts is its ability to assist SETs by leveraging learning data to identify effective pedagogies, generate assessments, and provide constructive feedback automatically (Chaudhry

& Kazim, 2022; Smolensky et al., 2023). Generative AI can generate personalized feedback for each SET, highlighting areas where improvement is needed and suggesting additional resources to reinforce learning (Smolensky et al., 2023). Generative AI, such as ChatGPT, can provide immediate personalized feedback based on the input it receives (Smolensky et al., 2023) as SETs complete assessments and quizzes. This personalization is based on algorithms and data patterns, which may not be genuine in understanding the individual student's needs or learning goals. The constructive feedback will allow SETs to improve their teaching practice and adapt to the changing classroom dynamics in inclusion classrooms. Relying on AI for feedback and assessment in educational settings raises ethical and practical questions. Educators should ensure that the use of such technology aligns with educational standards, respects student privacy, and provides equitable and fair evaluations. The quality, context, and depth of the AI-generated content may not always meet the high standards required in education. Therefore, human expertise and judgment remain indispensable in these areas.

ENHANCING ACCESSIBLE LEARNING MATERIALS

In the context of preparing SETs for inclusive classrooms, the availability of accessible learning materials is vital. Accessible learning materials ensure that students with disabilities can engage with the curriculum effectively and equitably. Generative AI may help to enhance the accessibility of learning resources. Generative AI can be leveraged to improve the creation and adaptation of accessible learning materials, thereby empowering SETs to better meet the diverse needs of their students in inclusive educational settings (Burley & Stubbs, 2023). Generative AI enables the creation of adaptive learning resources that can continually assess students' progress and comprehension, with supplementary explanations, examples, and assignments as needed.

Generative AI can integrate text-based content with visuals to enhance the comprehension of the learning materials, though the accuracy and relevance of these integrations are not always guaranteed. It can generate detailed textual explanations for visual elements such as charts, diagrams, or images, providing SETs with a deeper understanding of the complex concepts of inclusion, but there might be a risk of these explanations being overly generic, not perfectly aligned with the educational context, or missing the nuanced interpretations that a human educator could provide. Generative AI can generate audio descriptions of the learning content for students with challenges accessing and comprehending visual content effectively. The quality of these descriptions can vary and may lack the depth or clarity provided by human-generated descriptions. The interactive multimedia presentations created by generative AI with text, images, audio, and video features may help SETs highly engage students with diverse learning styles. Generative AI can effectively generate transcripts for audio and video materials to help SETs assist students with hearing impairment or those who prefer reading along. The accuracy of these transcripts, especially in capturing nuances or technical terminology, can sometimes be a challenge. The multilingual support features of generative AI can assist SETs who speak different languages to access learning materials in their preferred language. This feature's effectiveness is contingent upon the AI's proficiency in those languages and its understanding of cultural nuances, which can be limited. While generative AI offers promising tools for enhancing educational materials, its current capabilities come with limitations that require careful consideration and often human intervention. The technology can significantly support SETs, but it should be seen as a complement to, rather than a replacement for, the nuanced and adaptive approaches that human educators bring to special education.

Investigation of How Generative AI Can Support the Creation of Accessible Learning Materials

Generative AI can support SETs to provide personalized and adequate instructions to students with disabilities. Generative AI can facilitate the development of accessible learning materials and make educational content more inclusive. It not only enhances the accessibility of educational content but also fosters independent learning and promotes inclusivity. Continuous advancement in cutting-edge technologies will advance generative AI and help with further creation and enhancement of the accessibility of educational content, ensuring equitable educational outcomes for all students.

Training in Creating Accessible Learning Materials

SETs can be trained to use generative AI to develop accessible educational content (Glazko et al., 2023). This includes using text-to-speech technology for students with visual impairments or reading difficulties and

ensuring that materials are formatted for accessibility with features like proper heading structure and screen reader compatibility.

Workshops on Utilizing Speech Recognition and Transcription Tools

Teacher training programs can include workshops for SETs on effectively using speech recognition and transcription features of generative AI. This is particularly beneficial for students with dyslexia, motor skill limitations, or deficits in written expression (Iyer et al., 2023).

Learning to Implement Image Descriptors and Language Translation Tools

SET preparation can involve training on using generative AI for image description and language translation, making visual content accessible, and localizing content for students who are non-native speakers of the instruction language.

Practice with Adaptive Content Generation

Generative AI can assist in generating alternative text for visual content, a skill SETs can develop during their training. This ensures that students with visual impairments have equal access to graphical information.

Developing Summarization Techniques for Complex Texts

Training programs can teach SETs how to use generative AI for summarizing complex texts, making content more comprehensible for students with cognitive disabilities or those who require simplified material.

Creating Interactive and Customizable Learning Materials

Generative AI can be used to create interactive learning materials that adapt to the progress and needs of students. SETs can learn to customize these materials to provide personalized learning experiences and immediate feedback.

Using Data-Driven Insights to Enhance Accessibility

Generative AI can provide insights into how students interact with learning materials, allowing SETs to adjust and improve content to make it more inclusive.

Implementing Assistive Chatbots in Classroom Settings

Training can include steps to integrate AI-driven chatbots, like ChatGPT, into the classroom to assist students with disabilities. These chatbots can offer real-time assistance, answer questions, and support accessible learning.

ASSISTIVE TECHNOLOGY AND COMMUNICATION

SETs encounter a multifaceted set of challenges when addressing the diverse needs of students with disabilities (Kamalov et al., 2023). These challenges encompass the domains of social, behavioral, academic, cognitive, perceptive, and motor development. In the context of assistive technology integration, SETs grapple with a complex set of considerations that include not only selecting the appropriate technology but also determining its sources, ensuring its appropriate utilization, effectively integrating them into the curriculum, and continuously evaluating their effectiveness in maximizing the learning of students with disabilities (Adebisi et al., 2015). Teaching programs can assist preservice SETs in mastering a range of assistive technologies, demonstrating their integration into classroom teaching methods. This includes employing generative AI to adapt or develop assistive tools tailored to individual students' unique requirements (Barua et al., 2022).

Selecting the right assistive technology tools for students with disabilities helps them maximize their learning and achieve their target goals. SETs need hands-on experience with assistive technology (Park et al., 2021).

Teacher training programs could provide workshops, labs, and in-classroom experiences to SETs to experiment with different generative AI technologies and understand how they can support students with diverse needs.

Examination of Generative AI's Potential to Develop Assistive Technologies for Students with Disabilities

Students with speech and communication challenges need augmentative and alternative communication (AAC) systems to express themselves. Educators in teacher preparation programs can teach SETs to develop AAC solutions using a generative AI model and generate predictive text or speech output based on the user's input. The predictive capability of generative AI will aid students with speech impairment in inclusive classrooms to formulate sentences and communicate effectively. Educators may train SETs to effectively use conversational chatbots, socially assistive robots, and virtual assistants to improve the social and emotional well-being of students with disabilities in inclusive classrooms (Kaplan-Rakowski et al., 2023). Teacher education programs could include labs where SETs experiment with AAC systems enhanced by generative AI. These labs would allow them to understand how predictive text and speech output can aid students with speech impairments.

Conversational chatbots are designed to engage in natural language conversations with users (Yang & Evans, 2019) and can be invaluable tools for SETs to promote social and emotional well-being. A chatbot can engage in conversations that help students express their feelings, reducing social anxiety or emotional distress. Educators can guide SETs through the process of customizing chatbots to meet the individual learning needs of students. Teacher preparation programs can offer workshops on customizing chatbots to meet individual students' needs. This training would include programming chatbots to engage in meaningful conversations that support students' social and emotional well-being. Using simulations, SETs can practice integrating chatbots into classroom settings, learning how to guide students in their interactions with these AI tools.

Socially assistive robots, designed to provide emotional and social support to users (Matarić. & Scassellati, 2016), may engage students in inclusive classrooms. Preservice SETs in their teacher preparation program can learn to integrate these robots to assist students with disabilities in developing social skills, managing emotions, and practicing empathy. Educators may teach SETs how to program socially assistive robots to meet the diverse needs of students with disabilities. Preservice SETs could have hands-on experience in programming and integrating socially assistive robots in technology labs (see Figure 3). These labs would provide opportunities to learn how these robots can aid in developing social skills and emotional management for students with disabilities. Education programs could collaborate with engineering or computer science departments to give SETs a multidisciplinary perspective on effectively using these robots in educational settings.

Figure 3

Teachers Learning to Interact with Socially Assistive Robots in Technology Lab



Note. This image was created by DALL-E, an AI system developed by OpenAI

Virtual assistants can help students with disabilities locate resources related to emotional regulation or social interaction strategies. Educators can train SETs to utilize virtual assistants in inclusive classrooms and help them guide students with disabilities in using virtual assistants to regulate their emotions (Dhimolea et al., 2022). Courses could include training on using virtual assistants to help students with disabilities access resources for emotional regulation and social interaction. SETs can learn to incorporate virtual assistants into their teaching strategies, understanding how to guide students using these tools for emotional and social support.

Universities could establish technology labs where SETs explore and interact with a variety of assistive devices, some of which are enhanced with generative AI capabilities. Unlike predictive AI, which would typically provide responses based on predefined rules or datasets, generative AI can create new, contextually appropriate responses. Generative AI will allow for the creation of complex, realistic educational simulations where SETs can practice and refine their skills. When a student with disabilities seeks assistance with emotional regulation or social interaction strategies, the virtual assistant can generate personalized suggestions or resources, taking into account the student's specific needs and preferences. These AI-enhanced tools can generate a wide range of student behaviors and learning challenges, providing SETs with comprehensive training experiences. These labs would serve as

innovative learning and testing grounds for future educators. In these labs, SETs could simulate real classroom scenarios, testing and refining the use of AI-enhanced tools in diverse educational contexts. Integrating generative AI into the training of SETs offers transformative possibilities, especially in developing skills to use advanced technologies like AAC systems, conversational chatbots, socially assistive robots, and virtual assistants.

ADAPTIVE ASSESSMENTS AND EVALUATION

Adaptive assessments, facilitated by generative AI tools, mark a significant departure from traditional evaluation methods in inclusive classrooms, offering a personalized approach that responds in real time to individual students' learning profiles (Kadaruddin, 2023). By leveraging the capabilities of generative AI, educators, and SETs can revolutionize the assessment process, tailoring it to each student's strengths and areas needing improvement. For instance, when a student excels in a particular area, the AI system can seamlessly introduce more challenging tasks to stimulate cognitive development while providing additional support and practice for areas where a student may struggle. This personalized approach deepens subject comprehension and fosters students' sense of accomplishment and self-confidence. Adaptive assessments that typically use discriminative AI based on a predefined set of rules and data, along with generative AI, which could potentially be used to create new questions or learning materials, can alleviate the stress and anxiety typically associated with standardized testing, as students are evaluated based on their abilities, fostering a positive learning environment. The integration of generative AI-driven adaptive assessments may be used for creating inclusive, equitable, and empowering educational settings for students with disabilities in collaboration with educators and SETs who are increasingly recognizing its transformative impact.

Universities must equip SETs with the necessary skills to navigate an AI-driven landscape where generative AI tools are pervasive. SETs need to develop proficiencies in harnessing generative AI effectively, particularly in creating and implementing dynamic, personalized assessment experiences within inclusive classrooms. Educators may encounter various hurdles when developing adaptive assessments, including the allocation of extra time for assessment development, considerations related to technology accessibility and usability, the challenge of familiarizing students with novel assessment approaches, and potential departmental policies that could hinder the integration of adaptive assessments (Smolensky et al., 2023). Preservice SETs should receive comprehensive training that includes both designing adaptive assessments and utilizing generative AI tools. This training should focus on the creation of assessments tailored to the unique learning needs of individual students, leveraging the capabilities of generative AI to dynamically generate questions and content. It is important to enhance their professional development with sessions dedicated to the practical application of generative AI in special education. These sessions should incorporate case studies, highlight best practices, and promote collaborative projects, all aimed at deepening the preservice SETs' understanding and proficiency in this innovative area of educational technology.

CHALLENGES AND BARRIERS

Integrating generative AI in pre-service SET training programs presents a unique set of challenges and opportunities. Generative AI holds the potential to revolutionize teaching and learning practices. Still, its adoption in the context of SET preparation must be navigated with careful consideration of ethical, privacy, and bias issues. Holstein et al. (2019) highlight the ethical implications of AI in education, emphasizing the importance of transparency and accountability. This is particularly relevant for pre-service SET training, where the ethical use of technology is crucial in shaping future educators who are sensitive to the diverse needs of students with disabilities (Pons, 2023).

Generative AI involves handling sensitive data, including personal information about teachers and students. Su and Yang (2023) note the risks of collecting data without consent. In SET training, safeguarding the confidentiality of student and educator data is important, as well as ensuring data protection measures. Generative AI tools may inadvertently perpetuate existing societal biases, a concern raised by Pasquinelli (2019). In the context of special education, this could lead to biased educational content or assessments that do not accurately reflect the diverse abilities and needs of all students. The potential for generative AI to create misleading or biased content requires vigilance. As Marino et al. (2023) discuss, there are risks of generative AI manipulating or deceiving students, making it crucial for pre-service SETs in teacher training programs to ensure that AI-generated materials are accurate, adhere to educational standards, and are suitable for effective teaching.

Michel-Villarreal et al. (2023) explore the difficulties in integrating generative AI in higher education settings, including the need for significant technological investment and capability. These challenges extend to

preparing SETs, where teacher training programs must equip future educators with the skills to use these technologies effectively (Pons, 2023). With the advent of generative AI, concerns about increased plagiarism arise. Ahmad et al. (2023) mention tools like GPTZero and OpenAI's Text Classifier that can help detect AI-generated content, a helpful resource in maintaining academic integrity in SET training programs. AI capability is only confined to solving some of the limited challenges and cannot entirely relapse human judgment and decision-making. The AI tools lack inherent human traits such as creativity, empathy, and a nuanced understanding of human emotions (Haleem et al., 2022). Generative AI operates on raw text without links or citations, and SETs need to confirm the accuracy of their responses directly. Teacher training programs aiming to incorporate generative AI in pre-service SET education must focus on reducing algorithmic biases, ensuring responsible content creation, maintaining rigorous privacy standards, and educating future educators about the capabilities and limitations of generative AI for its ethical and inclusive use in their future classrooms.

CONCLUSION

In conclusion, within teacher training programs for SETs, generative AI tools like ChatGPT, Bard, Jasper, the new Bing, and DALL-E hold the potential to significantly enhance the preparation of SETs for inclusive classrooms. These tools can generate diverse content, including texts, images, and videos, revolutionizing teaching and learning for students with disabilities. They offer improved accessibility to educational content, promoting equitable learning opportunities. However, SETs often encounter challenges such as limited resources and training in preparing for inclusive environments. Generative AI can address these challenges by providing accessible and interactive learning materials tailored to diverse student needs. These tools may enable SETs to develop adaptive teaching strategies by analyzing student performance and engagement data. Despite these advantages, there are potential drawbacks and ethical concerns, especially the risk of perpetuating biases against certain groups of preservice teachers. There is a need for a responsible and ethical approach when integrating generative AI into teacher training programs. Overall, this chapter describes the transformative potential of generative AI in SET training, balanced with the need for cautious and conscientious use.

Recommendations for Future Research and Practical Implications

This chapter describes the role of generative AI in enhancing the training of SETs for inclusive classrooms. Future research should investigate the transformative potential of generative AI tools in improving SETs for inclusive environments. Future research must explore how educators in teacher training programs can effectively employ generative AI tools to train SETs comprehensively. This research should focus on addressing the varied needs of learners and integrating technology-driven teaching methods as a core component of fostering inclusivity in education. It should also focus on evaluating the impact of generative AI tools on SETs' knowledge, skills, and attitudes toward inclusive education. Future research should explore the potential of generative AI tools to provide personalized learning experiences for students with disabilities and how AI-driven chatbots can assist with tailored learning materials and pedagogical practices to meet the unique needs of individual students. Future studies must also tackle the ethical and privacy issues associated with using generative AI in teacher training programs, aiming to establish ethical guidelines and best practices for the conscientious utilization of AI-powered tools.

Considering the enduring presence of generative AI, teacher training programs must establish guidelines, protocols, educational programs, and assistance mechanisms to ensure AI's ethical integration in preparing future SETs (Chan, 2023; Marino et al., 2023). In the future, generative AI will hold remarkable potential in training SETs to support students with disabilities in inclusive classrooms (Sushama et al., 2022). Generative AI will continue to revolutionize personalized learning experiences and creative content creation, identify data and natural language understanding patterns, improve increased collaboration between humans and machines (Chen et al., 2020; Timms, 2016), and provide tools for speech synthesis, alternative communication systems, and customized learning materials to support students in inclusive classrooms. Generative AI also has the potential to transform the preparation of SETs (Marino et al., 2023).

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Social, Cultural and Political Perspectives of Generative AI in Teacher Education: Lesson Planning in Japanese Teacher Education

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INTRODUCTION

Teaching is more than standing in front of a room with learners imparting information for their consumption. Teachers' tasks include preparing for classes, collaborating and discussing with colleagues, grading assignments, administrative work, contacting parents, and leading extracurricular activities. Classroom preparation includes preparing instructional plans (lesson plans), researching teaching materials, developing and preparing teaching materials, and negotiating with extra-curricular activities. In particular, preparing instructional plans is an inescapable must for teachers (Spellman, 1955).

Preparing an instructional plan requires good knowledge of one's classroom and the skills required (Taylan, 2016). For example, what types of students are there, where they stumble in their learning, what should be asked in this unit and why, etc. These abilities and skills are unique to teachers, unlike the skills of writing reports and planning. Haryani et al. (2019), who created and analyzed a rubric for evaluating lesson plans, found that even in-service teachers need to sufficiently describe the learning activities and students to keep in mind as they proceed in their classes. They also found that teachers should plan more opportunities for students to construct knowledge. Naturally, novice and veteran teachers differ not only in the amount of time it takes to complete these tasks but also in the wealth of information that a skilled teacher's lesson plans contain, including knowledge and interpretations of the material being covered and the expected various responses when students are asked questions (Borg, 2005).

What will be written universally in the lesson plan will probably be the class's goals, teaching and learning activities, perspectives and evaluation methods, and preparation materials. The plan is a blueprint or flow diagram for a curriculum-based class, an instructional manual that guarantees the quality of the teacher's teaching, and a contract between the teacher and students or their guardians (Morine-Dershimer, 1977; Peterson et al., 1978; Pressley et al., 1989). In Japan, there are two types of lesson plans: abbreviated plans, such as universal statements, and detailed plans that describe, in addition to these, the unit concept, the positioning of the lesson, and the teacher's values regarding students, materials, and instruction (Takahashi & Yoshida, 2004). Teachers create short plans that include lesson procedures to think about daily teaching. On the other hand, teachers make lesson plans to share the contents of the lessons with in-service teachers, teacher trainees, and in-service teachers for "Kenkyuu Jugyou," a Japanese term for research lessons or "lesson study."

This chapter describes the possibilities and challenges of using generative AI in teacher education from the perspective of classroom researchers. We followed these steps in the chapter: select a lesson, analyze the lesson, use the results of the lesson analysis to create prompts in generative AI, ask the generative AI to make a lesson plan using the prompt, and discuss the possibilities and limitations of the lesson plan. Considering that teachers work long hours and are inevitably involved in planning lessons, it is essential to focus on creating lesson plans, a part of lesson preparation. We will make clear whether there is potential for teachers to interact with generative AI when creating lesson plans and whether there is potential for the created lesson plans to be accepted into the school and teacher culture. If it were possible to create lesson plans using generative AI, or if it were possible to create

instructional plans that would suggest lesson content, it would contribute to reducing the burden on teachers even if it does not directly contribute to improving their work style.

LESSON PLANNING IN THE CURRENT CONTEXT

In a book published more than 100 years ago, Colvin (1919) noted that when he asked candidate teachers to write a lesson plan, they may only write an outline of the day's lesson content, which led him to emphasize the importance of writing a careful and thoughtful lesson plan. This notion is further supported by Frudden (1984), who states, "A good lesson plan is a key component of every lesson," and the quality of a lesson plan determines the quality of the lesson.

As lesson planning plays a vital role in determining the quality of a lesson, many initiatives have been taken to refine and shape the creation of lesson plans. Hatfield (1927) listed 24 words that 11-year-olds are likely to misspell and then gave an example of a simple, universally understandable lesson plan consisting of "Check. -Write the words on the board. Have pupils exchange papers and correct them? Ask how many papers have each word wrong," "Class study. -Take up all words on which there have been errors, giving more time to those marked M," and "Assignment -Remind pupils of the study procedure" to teach them. The lesson plan description is not procedural but a declarative list of what the teacher will teach the students. The Madeline Hunter model lesson plan (see Figure 1) would be more procedural than this one (Hunter, 1976; Stallings, 1985; Stallings et al., 1986). The phases (anticipatory set, objective and purpose, input, modeling, check for understanding, guided practice, independent practice, and closure) accompanied the activities described in the corresponding description column. Baylor et al. (2001) developed the Instructional Planning Self-Reflective Tool (IPSRT), referring to Zimmerman's (1999) self-regulated learning and Reiser and Dick's (1995) instructional-planning model. Teachers answer 35 prepared questions with a Yes or No response using IPSRT. For example, the procedure included questions such as "Do you inform the students of what it is that they are going to be able to do when they finish the instructional process?" and "Do you provide examples so that the students can see how they can use the information?" Compared with Hatfield's (1927) lesson plan, this procedure is more specific regarding what should be considered or designed in advance.

Figure 1

The Template of Madeline Hunter Model Lesson Plan

Name:		Subject:	
Grade:		Unit:	
Lesson Title:			
Anticipatory set			
Objectives/ Standards			
Teaching/ Input			
Modeling			
Guided practice			
Check for understanding			
Independent practice			
Closure			

Note. Prepared by the authors based on Hunter (1976)

Yonkaitis (2020) presents a template that divides lesson plans into four sections: Vital Information, Planning and Implementing a Lesson, Assessment of Student Learning, and Lesson Evaluation and Reflection on Your Professional Development (see Figure 2). The "Vital Information" section includes the author's name (teacher's name), grade/classroom, subject and unit, learning standard, and essential question of enduring. "Planning

and Implementing a Lesson” includes the purpose, objectives, strategies to assess readiness to learn, materials and resources, procedures and activities, and planning of diverse learners. “Assessment of Student Learning” includes strategies to evaluate learning and analysis of impact on student learning. Finally, “Lesson Evaluation and Reflection on Your Professional Development” includes effectiveness, evaluation of the teaching professional, and personal reflection. Compared to Hatfield’s (1927) and Baylor et al.’s (2001) lesson plans, the template has the number of items to be filled in by the teacher and the degree of professionalism to be considered. The degree of teacher expertise could be enhanced by the teacher’s rich acquisition of PCK (Pedagogical Content Knowledge) (Shulman, 1987). However, as Van Driel and Berry (2012) discuss, acquiring PCK is nonlinear, so explicitly indicating stages is difficult. Moreover, it becomes even more difficult if teachers need to understand “how students develop insights in a specific subject matter.”

Figure 2

The Template for a Four-Section Lesson Plan

Vital Information	
Author	
Main subject area	
Topic or unit of study	
Title of lesson	
Learning standard	
Grade/ developmental level	
Essential questions of enduring understanding	<i>note: What questions does the teacher want the students to be able to answer after his/her lesson?</i>
Type of classroom	<i>note: Brief description of type of class, classroom, and number of students</i>
Estimated time	<i>note: Align with developmental level and attention span of students.</i>
Part I: Planning and Implementing a Lesson	
Purpose	
Objectives	
Strategies to assess readiness to learn	<i>note: Describe how teacher will gauge student readiness to learn and baseline knowledge</i>
Materials and resources	
Procedures and activities	<i>note: Outline teacher's teaching plan (he/she can use bullets or brief narrative)</i>
Planning of diverse learners/ differentiated instruction	<i>note: Describe how the teacher will accommodate different learning styles and abilities, such as visual/ auditory learners, alternative learners, English language learners, special education students (if any), etc.</i>
Part II: Assessment of Student Learning	
Strategies to assess learning	
Analysis of impact on student learning	<i>note: Describe how teacher will determine if his/her teaching will impact behavior change</i>
Part III: Lesson Evaluation and Reflection on Your Professional Development	
Effectiveness	<i>note: Describe how teacher will determine if the students were engaged or enjoyed his/her lesson</i>
Evaluation of teaching professional	<i>note: Describe a tool or method advisor will use to give feedback on teacher's teaching and student learning</i>
Personal reflection	<i>note: List at least three questions teacher will ask himself/herself after teaching his/her lesson about his/her experience and what he/she might do to improve</i>

Note. Prepared by the authors based on Yonkaitis (2020)

As O'Donnell and Taylor (2006) state, some teachers may position the lesson plan as necessary but feel bored because they are writing it to please university supervisors or principals, or they may feel it is a challenge to overcome. To overcome this, they proposed a four-step lesson plan development process (see Figure 3). This is an adaptation of the original multicolumn lesson plan format, a four-column lesson plan in which the columns are filled from left to right as the steps progress. Step 1 describes the task portions with allotted time; Step 2 describes the teacher activity; Step 3 describes the anticipated student activity and thinking; and Step 4 describes the intervention (anticipated actions and questions to maintain high cognitive demand). This format is similar to the Japanese lesson plan described below.

Figure 3

Template for a Four-Step Lesson Plan

Description of Task Portions with Allotted Time	Teacher Activity	Anticipated Student Activity and Thinking	Intervention: Anticipated Action and Questions to Keep Task at High Level of Cognitive Demand

Note. Prepared by the authors based on O'Donnell and Taylor (2006)

A similar four-column lesson plan (see Figure 4) was also developed by Matthews et al. (2009), with, from left to right, Steps of the Lesson: Learning Activities and Key Questions, Expected Student Reactions or Responses, Teacher's Response to Student Reactions/Things to Remember, and Goals And Method(S) Of Evaluation. This format is also very similar to the Japanese lesson plan. However, as far as the examples show, the number of Learning Activities and Key Questions on the leftmost column has much to do with the quantity and quality of the information in the columns to its right. In other words, most of the descriptions are one-to-one relationships, and even if there is more than one, they are case descriptions, and it is hard to see the point of teachers taking the time to write anything other than Key Questions. From a Japanese value point of view, what teachers want students to learn throughout the unit is not only Content Knowledge (hereafter referred to as CK) but also questions relevant to students' daily lives and opinions on social issues. Therefore, the Key Question may not be a direct CK related to the unit but an indirect CK that only the teacher knows if it is related to the unit. If the teacher can write such Key Questions, the column to the right will contain the teacher's rich imagination of the students.

Figure 4

Template for a Four-Column Lesson Plan

Overall goal:			
Materials needed:			
Steps of the Lesson: Learning Activities and Key Questions	Expected Student Reactions or Responses	Teacher's Response to Student Reactions/ Things to Remember	Goals and Method(s) of Evaluation

Note. Prepared by the authors based on Matthews et al. (2009)

As mentioned above, Japanese lesson plans are characterized by two types: abbreviated plans and detailed plans. Both include unit objectives, lesson objectives, and the teaching process. In addition to the unit concept, the detailed plan included the teacher's view of the teaching materials, students, and teaching. The teacher's view of the teaching material is not a description of the material created to facilitate teaching but rather a description of how the material should be in light of the related unit and its connection to the teacher's interpretations and social concerns. In the student views section of the lesson plan, the teacher describes not how many students are in the classroom or whether it is noisy but what students need attention. For example, the teachers might write, "I will make sure that student x understands my questions and provides verbal support as needed," or "Student y disagrees with student z, so I will encourage them to exchange their opinions and help them understand each other's ideas." In addition, they should also write about what the students have trouble with daily, such as parent-child relationships, friendships, etc., and what they would like to do about those problems. Some teachers take notes on the student's behavior in the previous class and write a view of the student based on how he or she behaved in class, what he or she said, how much he or she was engaged in the lesson content, etc. In the teaching views section, the teacher describes how he/she will teach the lesson to the students described in the section on student views, using the materials written in the section on teaching-materials views. Assuming that the teacher has planned a lesson that stimulates students' thinking so that students actively express their opinions and the lesson cannot proceed as planned, the teacher describes the words or ideas that he/she wishes to spontaneously come out from the students. The format consists of the Name of the Unit, the Instructional Plan for the unit (total of xx lessons), and the Plan of the Present Lesson, as indicated by Fernandez et al. (2003) (see Figure 5). The Plan further consists of the Goal of the Lesson, the Relationship between the lesson study Goal and the Goal of the Lesson, the Plan of the Present Lesson, and the Evaluation of the Entire Lesson. There are four columns under these, from left to right: steps, Students' Activities, Teachers' Support for Students' Activities and Things to Remember, and the Method of Evaluation. While not all teachers follow the same format, it is generally common for them to find lesson plans written in a similar style regardless of where they go in Japan.

Figure 5

Japanese style template for lesson plan

___th Grade Lesson Plan

Date:

Period and Location:

Instruction:

1. Name of the Unit:

2. Instructional Plan for the Unit (Total of ___ lessons)

Phase 1:	___ lessons
Phase 2:	___ lessons
Phase 3:	___ lessons
Phase 4:	___ lessons
Phase 5:	___ lessons

3. Teacher's View

Students:

Teaching Materials:

Teaching:

4. Plan of the Present Lesson

(1) Goal of the Lesson

(2) The Relationship between the Lesson Study Goal and the Goal of the Lesson

(3) Plan of the Present Lesson

(4) Evaluation of Entire Lesson

Steps	Student Activities	Teachers' Support of Student Activities and Things to Remember	Method of Evaluation

Note. Adapted by the authors based on Fernandez et al. (2003)

"Research lesson" is the most common occasion in Japan in which lesson plans are used. Research lessons are classes in which the school or class teacher sets goals and examines whether they have been achieved

(verification-based teaching). It is also a class in which one or several teachers represent the school in a post-class discussion to explore the possibilities of the school and the class (exploratory teaching). In other words, Research lessons are part of lesson study in the broadest sense and are materials for discussion among teachers inside and outside the school. Sometimes, university professors participate in and advise these discussions through observations of the lessons. Teachers in Japan have been observing and discussing each other's classes for about 100 years to improve their teaching methods, teaching materials, or the view of students through Jugyuu Kenkyuu (lesson study).

In some cases, experimental classes are open to the public, while in other cases, classes for teachers who need to be improved are taken up. Above all, it is more meaningful to discuss the lessons democratically face-to-face afterward, regardless of years of experience or the superiority of PCK, than to openly or observe them publicly. Thus, as Lewis et al. (2009) state, lesson study can contribute to changing teachers' knowledge and beliefs, to change the professional community, or to teaching and learning resources. By observing or analyzing a lesson in detail, as lesson study, it is possible to improve the lesson plan not only "literally" but also "in content" through the teacher's understanding of the fundamental lesson mechanism and changes in the values (values toward teaching materials, students, and the classroom itself) held by the teacher.

USING GENERATIVE AI TO CREATE LESSON PLANS

In the previous sections, we have discussed how creating lesson plans is essential for teachers, yet it has become a labor burden. The primary focus of this chapter is to explore the possibilities and challenges of using generative AI to create lesson plans. To this end, we create lesson plans that apply to the abovementioned formats. In this chapter, the first author used OpenAI's ChatGPT 4.0 to create a lesson plan for the elementary arithmetic unit "Hidden Number." He chose to create a lesson plan for this unit for two reasons. One reason is that this study is situated in a series of collaborations with Clivaz and Tan (Clivaz et al., 2021; Tan et al., 2023), and we wanted to obtain useful insights for lesson plan development from the matters revealed through our analysis. The specific results of the analysis are presented in the next section. During the observation and recording of this lesson, some students were able to solve the teacher's problem at an early progress in the lesson but were confused about whether to use addition or subtraction when they thought about how to solve the problem. The teacher had to anticipate the possibility of students' mistakes and also had to grasp the students' understanding as the lesson progressed, which required various considerations. Out of this interest, we let the generative AI create a lesson plan.

After this, the first author will stage the creation of a lesson plan using ChatGPT, in which he writes a prompt in English, but to compare the crafted results, he will show the prompts and results, which are the simplest ones at first. The following are some of the prompts, but as is well known, no matter who writes the same prompt, the results will always be different and may show better or worse results.

[Prompt 1]

You are a public school teacher. From now on, would you make a lesson plan for the unit "hidden number"?

Figure 6

ChatGPT Output Results Part 1

Certainly! Let's design a lesson plan for a unit on the "hidden number" concept, which is commonly introduced in elementary mathematics. This lesson plan will be designed for a general public school setting, spanning multiple lessons within the unit.
Lesson Plan: Hidden Numbers
Grade Level: 2nd Grade (Can be adjusted for other levels)
Duration: Five 45-minute sessions
Objectives:
By the end of this unit, students will be able to:
1. Understand the concept of a hidden number in a mathematical equation.
2. Solve for the hidden number in addition and subtraction equations.
3. Apply logical thinking to identify patterns and deduce hidden numbers.
Materials:

•Number cards (0-9)
•Whiteboard and markers
•Worksheets with hidden number problems
•Puzzles related to hidden numbers
•Math notebooks for students
Lesson Breakdown:
Day 1: Introduction to the Concept
1. Warm-up: Begin with simple counting exercises.
2. Introduction: Use number cards to show simple equations with a hidden number (e.g., $4 + ? = 7$).
3. Class Activity: Allow students to use number cards to find the hidden number.
4. Homework: Provide a worksheet with similar equations for practice.
Day 2: Hidden Numbers in Addition
1. Warm-up: Review the previous day's worksheet.
2. Explanation: Introduce more complex addition problems with hidden numbers.
3. Group Activity: In groups, students solve given problems using number cards.
4. Individual Work: Students practice in their notebooks.
5. Homework: Worksheet focused on addition problems with hidden numbers.
Day 3: Hidden Numbers in Subtraction
1. Warm-up: Begin with a quick review of addition problems.
2. Explanation: Introduce subtraction problems with hidden numbers.
3. Group Activity: Students collaborate to solve subtraction problems.
4. Individual Work: Students practice subtraction problems in their notebooks.
5. Homework: Worksheet focused on subtraction problems.
Day 4: Patterns and Sequences
1. Warm-up: Review subtraction homework.
2. Explanation: Discuss how hidden numbers can be part of larger patterns or sequences.
3. Class Activity: Introduce sequences with hidden numbers. Students identify and fill in the gaps.
4. Group Work: Provide sequences where groups have to identify multiple hidden numbers.
5. Homework: Worksheet on identifying and filling hidden numbers in sequences.
Day 5: Review and Application
1. Warm-up: Fun puzzle involving hidden numbers.
2. Review: Go over the concepts from the entire week.
3. Class Activity: Jeopardy-style game where students answer hidden number problems from all the categories.
4. Reflection: Discuss where they might see hidden number scenarios in real life.
5. Homework: Comprehensive worksheet for the weekend reviewing all concepts.
Assessment:
1. Formative: Observe group activities, review daily worksheets, and note participation in class discussions.
2. Summative: At the end of the unit, provide a test covering all concepts of hidden numbers in different contexts.
This is a basic structure and can be customized based on the specific needs of your students, the curriculum guidelines, and available resources.

The results show what is taught in the "hidden number" unit, how often it is implemented, what kind of content, what procedures are used, and how it is evaluated. It is exciting to see that ChatGPT knows what the "lesson plan" looks like and what to teach, how many times to implement it, what the content is, what the procedures are, and how to evaluate the results. It is also surprising that ChatGPT knows what they will learn in the

second grade and that ChatGPT knows how to solve for addition and subtraction. On the other hand, because the contents of each lesson are itemized on the lesson plan, the reader can only understand the problem-solving, explanation, and games themselves. It is also doubtful that readers of this lesson plan will be able to close their eyes and easily imagine the lessons being taught in this sequence or, if they could, whether it would be enjoyable as a learning experience. As mentioned above, the teacher does not teach only direct CK in class but uses the student's moment-to-moment observations as a cue to go back to the previous unit or to re-teach related content that the student would have learned by the previous grade level. Furthermore, the formative assessment states, "record participation in class discussions," but if teachers were to conduct a formative assessment, they would need to record not only participation and whether or not students spoke up but also in detail what they said, what arguments they supported, whose opinions they agreed and disagreed with, and so on.

[Prompt 2]

Would you make two lesson plans: Day 2: Hidden Numbers in Addition and Day 3: Hidden Numbers in Subtraction?

Figure 7

ChatGPT Output Results Part 2

Of course! Here's a detailed lesson plan for Day 2 and Day 3 focusing on "Hidden Numbers in Addition" and "Hidden Numbers in Subtraction."
Day 2: Hidden Numbers in Addition
Objective: Students will understand and solve for the hidden number in addition equations.
Materials:
•Number cards (0-9)
•Whiteboard and markers
•Worksheets with addition problems having hidden numbers
•Math notebooks for students
Activities and Procedures:
1. Warm-up (10 minutes):
•Review the concept from Day 1 using a few examples on the whiteboard.
•Engage students in a quick pop quiz, asking them additional questions and letting them respond.
2. Direct Instruction (10 minutes):
•Write a few addition equations on the whiteboard, e.g., $6 + ? = 11$, and solve them with the class.
•Emphasize the process of "finding out what you need to add to the known number to get the total."
3. Group Activity (10 minutes):
•Divide students into small groups and provide each with a set of addition problems.
•Allow them to use number cards to manipulate and find the hidden number.
•Circulate to monitor student understanding and to provide guidance as needed.
4. Individual Work (10 minutes):
•Students will solve a set of problems in their notebooks.
•Encourage them to draw or use counters if needed.
5. Class Sharing (5 minutes):
•Ask a few students to share their solutions and explain their thought process.
Homework:
Provide a worksheet focused on addition problems with hidden numbers for reinforcement.
Day 3: Hidden Numbers in Subtraction
Objective: Students will understand and solve for the hidden number in subtraction equations.
Materials:
•Number cards (0-9)
•Whiteboard and markers
•Worksheets with subtraction problems having hidden numbers

•Math notebooks for students
Activities and Procedures:
1. Warm-up (10 minutes):
•Review the homework from Day 2.
•Discuss any common mistakes or patterns observed.
2. Direct Instruction (10 minutes):
•Introduce subtraction problems, e.g., $11 - ? = 6$.
•Demonstrate how to solve for the hidden number using the inverse operation of addition.
3. Group Activity (10 minutes):
•Divide students into small groups and give each a set of subtraction problems.
•Let them use number cards to manipulate and find the hidden number.
•Circulate to ensure understanding and offer help where necessary.
4. Individual Work (10 minutes):
•Students solve a set of subtraction problems in their notebooks.
•Remind them of the inverse operation method and allow them to use tools or drawings.
5. Class Sharing (5 minutes):
•Invite some students to share their answers and explain their methodology.
Homework:
Assign a worksheet focused on subtraction problems with hidden numbers for practice.
These plans provide structured learning experiences for the students while allowing for interaction and hands-on activities. Adjustments can be made based on the class's pace and understanding.

Using the “Hidden Number in Addition” on Day 2 and “Hidden Number in Subtraction” on Day 3 of the “Hidden Number” unit concept created above, we asked ChatGPT to create lesson plans for these sessions. It is fascinating to note that both sessions consisted of warm-up, direct instruction, group activity, individual work, class sharing, and homework, incorporating the general components of a class. The order of these components is also impressive in that it considers students' learning by directing their interest to the content of the class in Warm-up, explaining the content, and having them solve practice problems. Furthermore, the lesson plans are created in the order of group activities, individual activities, and class sharing. ChatGPT is creating lesson plans not only by considering the elements as elements but also by combining them. In Japan, however, although there are “introduction,” “development,” and “summary,” these are higher-level concepts of activities and are not specific teaching strategies such as Direct Instruction and class sharing from the teacher's viewpoint, or group activity and individual work from the student's viewpoint. The specific descriptions of teaching strategies from the teacher's perspective, such as direct instruction and class sharing, and teaching styles from the student's perspective, such as group activity and individual work, are not written in the section on the phases of the class.

Focusing on Day 2, “2. direct instruction” states, “Write a few addition equations on the whiteboard, e.g., $6 + x = 11$, and solve them with the class.” Although this seems to be a strategy of presenting several problems and having students solve them, the goal of the unit here is for students to determine whether a given number represents a whole or a part and whether the number is obtained by addition or subtraction. For example, when solving $6 + 5$, the whole is obtained by addition, but when solving $6 + x = 11$, the part is obtained by subtraction, as in $11 - 6$, but it can also be obtained by counting from 6 to 11 (incomplete addition). In addition to simply having the students solve the problem and checking whether they are right or wrong, the teacher's idea of what kind of solution the teacher wants the students to do “here” and the teacher's rich prediction of what kind of solution the students will do are necessary. These are not readily apparent from the lesson plan prepared by ChatGPT.

The authors continued by instructing ChatGPT to output the lesson plan created above in the format of the four-column lesson plan described in the previous section. Figure 8 shows the authors' tabular representation of ChatGPT's response in plain text. The horizontal columns show the items in the indicated columns, and the vertical columns show the contents according to each step. In particular, “Students' Activities” and “Teachers' Support of Students' Activities and Things to Remember” have different subjects. However, ChatGPT shows the appropriate content in each cell with the appropriate subject. On the other hand, the “Teachers' Support of Students' Activities” column should generally contain predictions and variations of students' activities, e.g., some processes leading to correct answers and possible errors. However, it mainly contains the words “emphasize” and “confirm.”

Figure 8

ChatGPT Output Results by Instructions to Output in 4-column Lesson Plan

Lesson Plan: Hidden Numbers in Subtraction			
Steps	Students' Activities	Teachers' Support of Students' Activities and Things to Remember	Method of Evaluation
Introduction	Listen attentively and respond to the warm-up questions.	Begin with a review of the previous lesson on addition to set the context. Use probing questions to gauge student recall and understanding.	Evaluate students' engagement and responses to gauge prior knowledge.
Direct Instruction	Observe subtraction problems on the board, participate by answering questions, and note the method to solve for hidden numbers.	Clearly demonstrate how to solve for the hidden number in subtraction equations, using the inverse operation method. Emphasize the importance of the relationship between addition and subtraction.	Quick formative assessment by asking questions to the class and noting their responses.
Group Activity	Collaborate in small groups, discuss with peers, and solve provided subtraction problems using number cards or other tools.	Monitor group discussions, ensuring all students are engaged. Provide guidance where necessary and ensure that students understand the concept, not just guessing.	Assess collaboration skills, the accuracy of answers, and the variety of methods used.
Individual Practice	Work on subtraction problems independently in their notebooks, using the inverse operation or drawings as needed.	Circulate around the classroom, assisting students who may struggle. Encourage students to think critically and to utilize different strategies.	Collect and mark students' notebooks for accuracy and understanding.
Class Sharing and Discussion	Volunteer to share their answers and explain their methods. Engage in discussion and ask questions if uncertain about any concept.	Facilitate the sharing process, ensure a variety of methods are highlighted, and correct any misconceptions.	Formatively assess students' comprehension by the depth of their explanations and the quality of the discussions.
Closure	Reflect on what they've learned and ask any lingering questions.	Summarize the day's lesson, praising efforts and addressing any common issues observed. Give a hint of the next lesson to build anticipation.	Use an exit ticket or a quick quiz to assess understanding of the day's lesson.

FOUR STEPS TO CREATING A LESSON PLAN

ChatGPT's ability to generate text is particularly remarkable. As indicated above, even with the lesson plans, ChatGPT can fully understand the content of the prompts, develop a unit concept, create lesson plans for each period, and apply these plans to the designated lesson plan template. On the other hand, ChatGPT does not have a sufficient ability to imagine or visualize the students in the class, something that the authors have consistently pointed out as something to consider when preparing lesson plans. This problem is not limited to ChatGPT but is something many teacher educators realize, especially in teacher education.

Most teachers will have a "wish" (Negai) to conduct their daily lessons well and to follow the curriculum. They may also have "wishes" for all students in their classroom that are expressed in their learning and teaching goals, such as "I want the students to learn xx well today." They may also have "wishes" for specific students rather than the whole class in each segment of the lesson, such as "I want that student to understand xx" or "I want to bring out the xx in that student." While it is relatively easy for teachers to set such "wishes" in advance in their daily classes, it is not easy to set them dynamically while teaching. For this reason, it is necessary to carefully consider this at the stage of creating a lesson plan. It is difficult for a teacher to create a detailed lesson plan from the beginning, but the following four steps can be taken.

First, concerning PCK, write, "In this lesson or situation, I want the students to learn about this subject content using this teaching method." However, simply thinking about what to say and how to say it may lead to a teacher-led or procedural-oriented class. The learning objectives for Day 2 of the lesson plan prepared by ChatGPT shown in the previous section were "Students will understand and solve for the hidden number in addition equations," and the learning objectives for Day 3 were "Students will understand and solve for the hidden number in subtraction equations." The only difference between them was "in addition equations" or "in subtraction equations," which shows an authoritative push from the teacher to make the students understand but does not show a desire to make them learn with care and ingenuity.

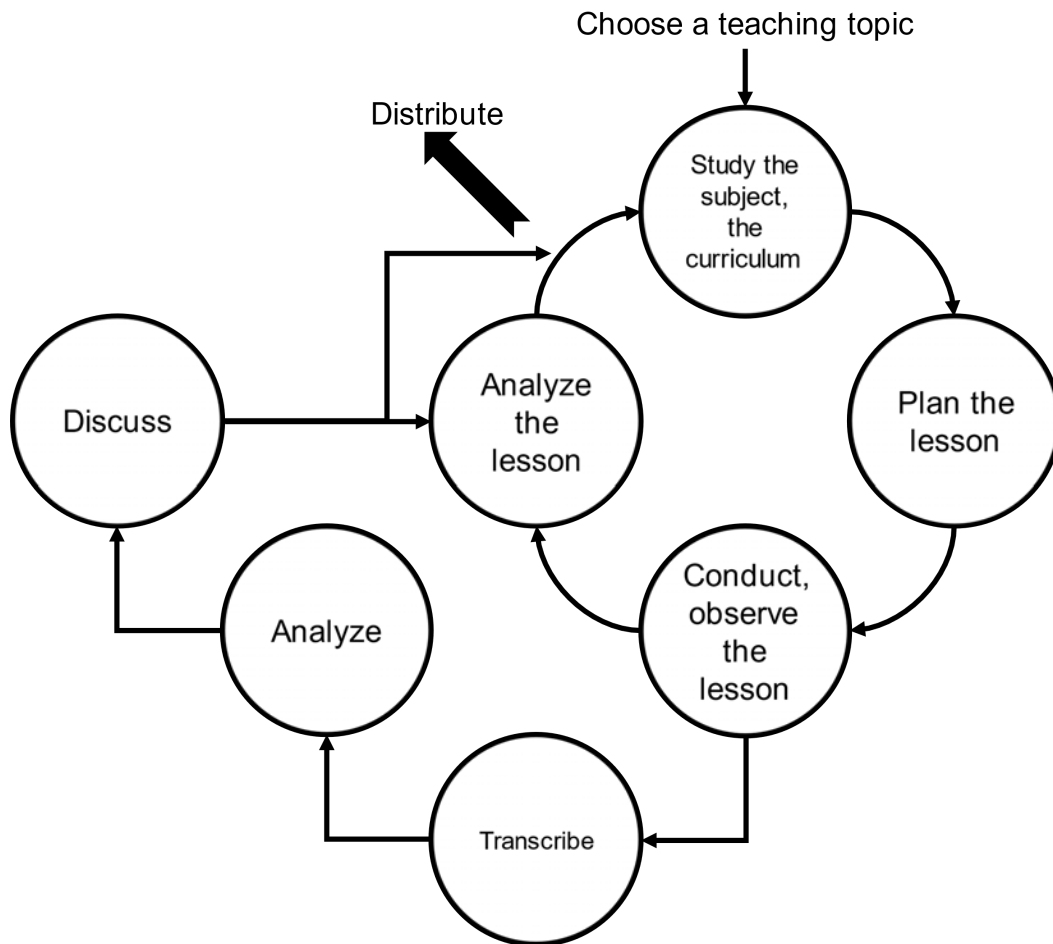
Suppose the teacher can imagine a situation where a student needs to learn better while preparing a lesson plan. In that case, the teacher can think of a more specific way to support the student by using the scaffolding concept to think about "how to apply such scaffolding." In this case, the "what scaffolding" (what) supplements CK, and the "how to scaffold" (how) supplements PK. Many students can solve problems given an equation from the beginning, such as the problem $6+x=11$ created by ChatGPT, by repeating the practice problems. In Japan, students who understand why addition/subtraction is used in this situation, as in drill calculations, solve problems given an equation to confirm their understanding or train themselves to eliminate calculation errors. However, the written problems that resemble PISA-type questions (OECD, n.d.) make this unit difficult for students. As it will be shown later, when the teacher asked second-grade students the question, "In the beginning, 24 children were playing. Then their friends came. That makes it 35 people altogether. How many children came?" students may have understood which numbers represented parts and which numbers represented the whole, but they could not explain it immediately. Nor could students confidently answer whether they were calculating by addition or subtraction. In this case, the teacher needs to anticipate the students' stumbling blocks and think of another way to teach them. In Japan, in this unit, teachers do not teach with formulas from the beginning but use tape diagrams to represent and confirm the situation of the problem. It then becomes clear that some students who can solve the problem need help to understand the situation accurately; they got the correct answer but did not solve it. If this can be imagined, it is easier for the teacher to imagine scaffolding.

The teacher can add ideas to the lesson plan to develop the lesson more strategically by supplementing the scaffolding with Van Der Stuyf's (2002) instructional design ideas of "who scaffolds" (who) and "when to scaffold" (when). Naturally, the first person to scaffold would be the teacher. However, if there are other students in the classroom besides the one who is stumbling, they can be asked to apply scaffolding based on the idea of social constructivism. Teachers also need to consider when to apply scaffolding. It is easy to help students as soon as they stumble over a given problem. Van Der Stuyf (2002) gives a specific example of scaffolding, such as getting students to think about what they must do now. In other words, scaffolding can be used as a guide when the teacher can see a lack of clarity of purpose or focus in the student.

Based on these conditions, the teacher's "wishes" should be considered in the lesson plan. In other words, it is crucial to further ponder and supplement that scaffolding with "who to scaffold" (whom) and "why to scaffold" (why). As is well known, lesson study (Lewis, 2009) is a teacher-led research method that originated in Japan to improve lessons and academic achievement. It is a repetitive cycle of planning a lesson, conducting it, reflecting on it, developing ideas for the next lesson, and planning it (see Figure 9). One of the research methods of lesson study is lesson analysis (Shigematsu, 1961), proposed by Shigematsu and Ueda.

Figure 9

Lesson Analysis's Research Cycle



As mentioned above, lesson analysis is a method of hermeneutically revealing the "earnest wishes" behind students' statements based on transcripts (Shigematsu, 1961). It is similar to qualitative research in that observation and recording are the starting point for analysis; it does not worship subjectivity in the analysis and the data compression process (treatment of parts and higher-order conceptualization) (Denzin & Lincoln, 1994). Lesson analysis aims not only to improve classes and academic performance but also to help teachers (or lesson study researchers) realize students' potential through lessons and to consider how to construct lessons while aiming to elucidate the mechanisms of lessons. Shigematsu and Ueda aimed to discuss the lesson study democratically, using common materials to avoid the authoritative lesson study conducted until then. The common material was a "lesson record" (transcript), a transcription of class discussions. Authority can be an "organization" such as the national government or a board of education or a "person" such as a minister, a committee chairman, or a school principal. Interestingly, Shigematsu and Ueda also considered authority a "preconceived hypothesis" that people tend to fall into blind faith. These preconceived hypotheses are akin to preconceived notions or labels, such as "this is the way it will be" or "this is the way it is," and stop us from thinking. If we accept the preconceived hypothesis, teachers may overlook students' individuality and the changes (growth and development) that result from their elongation, and they may teach without realizing the various possibilities of children. They conducted lesson analysis using lesson records, believing that Child X and Child Y in front of them are naturally different and that today's Child X and tomorrow's Child X must not be the same.

In the next section, we will use actual lesson analysis perspectives and actual lesson transcripts to show how students perceive and solve problems in the “hidden number” lessons.

THE ACTUAL STUDENTS’ STATE BASED ON LESSON ANALYSIS

Lesson Analysis for this lesson study is a hidden number lesson in the second-grade math class at an elementary school in Japan. The school is located in a mountainous area known as a depopulated area, so there are only four students. This makes it easier for students to speak out what they think and what comes to mind, and it is easier for the researchers to focus on what they are thinking at that moment in time.

In this section, the authors first use the lesson analysis method (Matoba, 2017; Sarkar et al., 2017) to conduct a brief analysis based on the statements to identify students' misconceptions about “hidden numbers,” the mistakes they are likely to make, and the possibilities for what to do next. Then, based on the results, the ChatGPT are prompted again to create a lesson plan for “hidden numbers” that includes the students' information. Lesson analysis is conducted through interpretive analysis using transcripts to reveal the students' thinking, the fastidiousness of one student, or the relationship between the students' daily experiences and the knowledge learned in school that underlies his or her statements; we call TBLA (Transcript Based Lesson Analysis) (Nozaki, 2022). After observing and recording the lesson, a transcript was prepared by listening to the audio file (see Figure 10). Sometimes, characteristic student behaviors were added to the transcript, but in most cases, the transcript used in Lesson Analysis consists of the speakers, serial numbers, and statements. Some students made their answers and thoughts known explicitly. However, this is not always the case; students from lower grades or statements produced while students were thinking could be unclear and ambiguous. Since such statements are vague and unstructured, it is deemed difficult to understand the essence and rationale behind the student's statements as they are. Therefore, they should be analyzed in relation to the same student's statements, in relation to other statements within the same segment or topic, or in the entire class by Lesson Analysis. In this study, Lesson Analysis is used to identify issues that teachers should be aware of during lessons and to gain insights for preparing lesson plans.

Figure 10

The Sample of Transcript for Lesson Analysis

Speaker	No	Statement
S-D	1	Yes, stand up. We are going to begin our mathematics lesson now.
cc	2	Yes.
T	3	Yes, please. Please have your pencil ready.
cc	4	Just a moment.
T	5	Ok, I am going to start writing.
S-C	6	Write?
T	7	Please write it down.
S-D	8	(Looking at the board) Kaki, kaku
T	9	Hidden
S-D	10	Writing practice
T	11	Hidden
S-B	12	It's a number, right? Next.
S-D	13	I wrote hide-and-seek. Hahaha!
(abbreviation)		
S-B	182	I can't do it either.
S-C	183	How can it be 1,1?
T	184	Those who are done, please tell us, please explain it to us later.
S-A	185	Eh,I can't explain it.
S-C	186	Why is it 1,1? This is what I don't understand.
S-B	187	Because I don't know what this part is, so I have to solve this part, that's why it's 1 and 1.
S-C	188	It's here. I'll teach you how.
S-A	189	We all know already.
T	190	(Timer went off) S-C, are you ready?
(abbreviation)		
T	493	Up to here? 24. 24 people. There were 24 people at the beginning, right? So, subtract 24 people. Where do you want me to subtracting from?
cc	494	stop
T	495	Subtracting (Moving the group of 24 number-figure blocks to the left-side of the blackboard). And then, what's the answer?
cc	496	stop.
T	497	What's the answer after subtraction? What's the hidden number?
cc	498	11
T	499	What's the hidden number? When you subtract it, did you get 11?
cc	500	Yeah.
T	501	S-D, you've noticed something really wonderful. Even though it says "altogether", it became subtraction. That's the gist of the question, that's the important part.Ok, so we'll stop here.(Bell rings)
S-D	502	That's the end of the math class. Thank you.
T	503	Thank you very much.

At the beginning of this lesson, which has a total of 503 statements, the teacher read a question text for the students to think about now (henceforth, T represents the teacher, S-A through S-D represents the respective students, and the numbers represent the statement numbers). The classes were taught in Japanese, and the first two authors transcribed the lesson and translated the transcript into English.

T26 "So now, I am going to tell you a story now. Please make a note of the important points of the story."
T28 "Here we go. Here we go. In the beginning, there were twenty-four children playing. And then,"
T31 "I'll tell you twice, so listen carefully. Then the children's friends came. That makes it thirty-five people altogether. I'll repeat the story. In the beginning, there were, please listen carefully, there were twenty-four children playing. Then their friends came."
T33 "That makes it thirty-five people altogether."

The teacher then confirmed with the students to see the problem's content. This was to make sure that the students knew which number they had to do, whether they had come to thirty-five or had come to thirty-five combined. Then, the teacher made the students recognize the "hidden number," the main question.

T36 "Who can tell me what the story was about? It's fine to just talk about the parts that you know. Yes, please tell me. Anyone? Yes, S-D."
S-D37 "There were twenty-four children."
S-D39 "Their friends came and that makes it thirty-five."
T42 "24. Then their friends came?"
S-D48 "Thirty-five people."
T49 "What, thirty-five people?"
S-D50 "It's not like thirty-five people showed up, though."
T51 "Didn't you say something before 35 people?"
S-D52 "Their friends came, and that makes it thirty-five people."
T53 "That makes it thirty-five people?"
S-B54 "Thirty-five people altogether."
T55 "Altogether. Let's just add the word 'altogether'. So, is that what the story was about?"
T57 "Yes, okay, this is the story for our lesson today. Okay? You see it's written here: what is the hidden number? That means, there's some kind of hidden number here. Where do you think the hidden number is?"
S-C58 "About how many people have come?"

The teacher did not immediately ask the students to formulate an equation or solve it but drew a tape diagram on the blackboard to visually inform them what (where in the diagram) the students should think about. According to Clivaz et al. (2021), this type of diagram is widely used in Singapore and Japan. They also state and value that this type of diagram graphically represents the relationships among the quantities present in a problem.

T72 "Yes, so I'll draw a square now. What kind of diagram is this? We had it yesterday."
S-B73 "Tape diagram."
T74 "Yes, tape diagram. I'm going to draw one now. First of all, I'll draw the first one. The first one. The children."
S-B77 "twenty-four people."
T78 "Yes, there were twenty-four people. I'll write that down. When you draw the diagram in your notebook."

When the teacher drew the tape diagram and was about to add the numbers we already knew (twenty-four and thirty-five), the students, wanting to be quick, said the number of the answer. However, the teacher did not ignore them but did not say they were the correct answers, saying he would still keep them hidden.

S-B92 "The friends have come."
T93 "The friends have come. The friends have come. We don't know how many, huh?"
cc94 "Yes! Yes! I know! I know how many friends have come!"
S-C95 "Eleven."
S-B96 "He said it."
S-A97 "He said it."
T98 "The friends have come, right? The friends have come."
S-C99 "Eleven people."
S-B100 "Eleven people have come."
T101 "No, you knew it. But since we will study the hidden numbers now, I'll hide it still."
S-C102 "I think it's 11."

Thus, even though the students were saying the answer “eleven,” the teacher never said it was the correct answer but instead asked the students to write down how to give the answer. Then, the students who had been calling out the answer up to that point reacted with a gasp, “Huh?” and they reacted breathlessly. The teacher continued, “It can be an equation or a story. Okay?”

T133 “Well, now, you know the answer to that question, but there's a way to solve the question, right? Okay? Please write it here, how you found the answer to that question.”

S-A134 “Huh?”

S-B135 “Huh?”

S-D137 “Huh?”

S-C138 “Huh?”

T139 “It can be an equation or a story. Okay?”

T144 “Write down how you solved the question. It can be either an equation or a story.”

S-C145 “Can we use a column addition?”

S-A147 “Is eleven, okay? eleven, okay? eleven...”

T152 “I'll ask you how you solved it in three minutes. Make sure everyone is ready to present.”

The students, who had insisted earlier that eleven was the answer, could not understand how it came to be eleven and were going through a trial-and-error process. The teacher should have instructed the students to think individually or consult with other students around them. However, the students were writing in their notebooks and trying to explain their ideas about their own situations while talking to those around them. In other words, while the primary focus is on the individual work area, the students maintain a loosely social constructivist relationship, working in both individuals and groups seamlessly and almost simultaneously.

S-C152 “That's eleven. one and one... let's make it a little closer.”

S-B154 “Hey, is that addition?”

S-B156 “I don't think it's an addition.”

S-D159 “I can't, I can't, I can't, I can't, I can't, I can't...”

S-B160 “No, I can't.”

S-A166 “Column addition is not working...”

S-B167 “Oh, no, this has eleven in it.”

S-C170 “Hey, I got it. Got it, teacher. I got it. Hey, look, you see, 1 minus five is four, right, and one minus three is two. The answer is forty-two... twenty-six.”

S-B173 “Isn't that a subtraction? Finally! I'm glad I subtracted.”

S-B177 “Uh, this... this won't work. Subtract... that one.”

S-A178 “thirty plus five is thirty-five...”

S-B179 “Uh, but if you don't carry 1 down, you'll have to carry this 1 down.”

S-A180 “Carry it down? Oh, that was easy.”

S-B182 “One, one. I can't do it either.”

S-C183 “How can it be one, one?”

The key to this problem is whether the known numbers represent a whole or a part. If the two known numbers represent parts, then the whole can be obtained by adding them together. If the known numbers are a whole and a part, another number representing a part can be obtained by subtracting the number representing the part from the number representing the whole. However, Clivaz et al. (2021) stated that there are two ways to solve this problem: one is to solve it in the chronological aspect, equivalent to the expression “ $24 + \dots = 35$ ” or “24 makes 35.” The other is to solve it in the aggregate aspect, equivalent to the expressions “the whole is 35”, “ $35 - 24 = \dots$ ”, or “remove known parts from the whole.” The former is the addition method, and S-A, S-C, and S-D used this method. The latter is by subtraction, and only S-B used this method.

S-A210 “Let's see... twenty-four plus eleven.”

S-B305 “Thirty-five minus twenty-four is eleven.”

However, when the teacher asked him to explain using a tape diagram and named S-A, S-A remarked that it was appropriate to find the number by subtraction, which S-B supported, rather than addition. He stated that this was

because subtraction would reveal the number to be added, eleven. S-C responded, "I do not know why it is a good idea," to which S-D replied, "The altogether part is the addition part," and stated why he supported addition.

T314 "Now, please show me how to do this, using the diagram above. How? This. Can you explain how to do this using the diagram above? Then you know which one is better, right? Before that, you know, I've been talking with S-C and S-B here for a while now, right?"

S-A317 "I think it's better to subtract it. The reason for this is that by subtracting it, we know eleven plus twenty-four."

T318 "We know eleven plus twenty-four?"

T333 "Yes. What do you think? S-C and S-D, you know, S-A and S-B said that this is a better way to do it though."

S-C334 "I don't know why it's a good. You know, it's an equation..."

T335 "Tell me about it."

S-D344 "It's addition."

T345 "Addition, where is the addition?"

S-D346 "Twenty-four children and then friends came. I thought the altogether part is the addition part."

T347 "Here? Here? Adding up here? (Pointing to the children on the board.)"

S-D348 "No. Altogether"

T349 "Altogether! I see, I see, I see. So this is where the addition is. I see. Yes, S-A."

Specific problems with S-D are, as noted above, one of the kernels of the unit. Although it can be solved by either addition or subtraction, the teacher thinks it is essential for the students to explain why they used addition or subtraction based on their awareness of what the known numbers represent. Therefore, the teacher asked the students to look again at the tape diagram and reconfirm which numbers represent which part of the tape diagram. Still, S-D was not convinced that "altogether" was stuck or that subtraction was the way to find it. The teacher tried to get through by having the students explain to each other in a social constructivist way, but judging from S-D's unconvinced about subtraction, the teacher gradually supplemented the students' explanations and helped S-D's understanding and conviction to progress.

T359 "Ah, yes. Look at this diagram, this diagram. I hope you can use this diagram to explain where to subtract or add. Use this diagram. The hidden number is the number of friends, right? This is all we need to know, right?"

T363 "What do you think? What did you subtract from where? In this diagram."

T365 "That's the numbers. The location. Where is thirty-five?"

S-A 366 "Thirty-five. The location, here. (Pointing to the end of the tape diagram.)"

T367 "Here? Thirty-five, where does it start and end?"

T381 "Where's twenty-four? From where to where?"

T389 "So, where did this subtraction come from?"

T399 "What do you think? Convinced? By the explanation. Still not convinced?"

S-C402 "If it's ok to be the same as S-B. It's thirty-five from here to here, right? S-D, answer me please. It's twenty-four from here to here, right? So, twenty-four minus thirty-five, right, thirty-five minus twenty-four is eleven, right? So I think the hidden number is eleven."

T405 "Why did it become a subtraction? A little bit troubled. Mmm.. Can you tell us what's bothering you? What is it that you find it difficult to understand? Remember what S-D said?"

S-D406 "Nope."

T407 "That's why you don't know what's troubling him. S-D said that there were thirty-five people altogether, right? That's why the addition. Do all of you know what S-D is trying to say? Let's go over it one more time. There were thirty-five people altogether. You said "altogether", that's why the addition. How does this sound? Wrong?"

As an attempt, instead of creating a lesson plan at once, we will proceed interactively with the Generative AI and create a lesson plan based on the results we obtained using the lesson analysis described above. In order to create lesson plans interactively, the following four steps are taken in this study:

Step One

Assign the role of an elementary school teacher to the Generative AI and assign it the task of creating a lesson plan for "hidden numbers." (see Figure 11) This is the same as the first lesson plan created by the Generative AI in this study and corresponds to the first step of the lesson plan creation described in the previous section.

[Prompt Step 1]

You are an elementary school teacher in Japan and you are in charge of second grade. Please make a lesson plan for "hidden number" in mathematics.

[Result Step 1]

See Figure 11.

Figure 11

ChatGPT Output Result for Prompts Reflecting Lesson Analysis Results (Step 1)

Creating a lesson plan for teaching "hidden numbers" in arithmetic to a second-grade class can be both fun and educational. Here's a structured plan to guide the lesson:
Lesson Plan: Discovering Hidden Numbers
Grade: 2nd Subject: Arithmetic Duration: 1 hour
Objective: Students will understand the concept of "hidden numbers" in arithmetic problems and be able to identify and solve for them.
Materials: Whiteboard and markers Worksheets with arithmetic problems Number cards Small objects for counting (e.g., blocks, beads) Hidden number game boards
Introduction (10 minutes): Warm-up Activity: Start with a counting song or game to get the students excited about numbers. Concept Introduction: Introduce the concept of "hidden numbers" as numbers that are part of an equation but we don't know their value yet.
Instruction (15 minutes): Visual Explanation: Use the whiteboard to demonstrate a simple arithmetic problem where one number is hidden (e.g., $5 + \square = 8$). Interactive Demonstration: Invite students to the board to try and find the hidden number using number cards.
Guided Practice (15 minutes): Small Groups: Divide the class into small groups and provide each group with objects for counting and hidden number game boards. Problem Solving: Each group works through provided arithmetic problems, using objects to find the hidden number.
Independent Practice (10 minutes): Worksheets: Hand out worksheets with arithmetic problems that have a hidden number. Allow students to work independently to solve the problems. Peer Review: After completion, students can swap worksheets to check each other's work.
Conclusion (10 minutes): Group Discussion: Bring the class back together and discuss what strategies worked best for finding the hidden numbers. Reflection: Ask students to share how they felt about the activity and what they learned about hidden numbers.
Assessment: Monitor group activities to assess participation and understanding. Review completed worksheets for accuracy. Listen to group discussions and individual reflections to gauge comprehension.
Follow-Up: For homework, assign a few hidden number problems. In the next class, review the homework and reinforce the concept with more complex problems.
By using a variety of teaching methods such as visual aids, group work, and hands-on activities, you can cater to different learning styles and keep the lesson engaging. The lesson plan aims to build a strong foundation in understanding the concept of hidden numbers, which is essential for developing arithmetic skills.

Step Two

The AI is given the information to create a specific lesson plan, such as class size, goals, and a four-column format consisting of from left to right: stage, students' activities, teacher's activities, and evaluation (see Figure 12). This corresponds to the second step of lesson plan creation described in the previous section.

[Prompt Step 2]

Please revise this lesson plan with the following conditions.

<Condition>

There are 4 students in the class. Ask the students to consider the following questions throughout the lesson: "In the beginning, 24 children were playing. Then their friends came. That makes it 35 people altogether. How many children came?" Use a tape diagram for this lesson. Please think about the goals of this lesson and set them. The lesson plan uses a four-column template. From left to right, the following table should be used: "Stages of the lesson (time required)," "Students' learning activities," "Teacher's considerations," and "Evaluation."

[Result Step 2]

See Figure 12.

Figure 12

ChatGPT Output Result for Prompts Reflecting Lesson Analysis Results (Step 2)

<p>Revised Lesson Plan: Solving for Hidden Numbers Using Tape Diagrams Grade: 2nd Subject: Mathematics Duration: 45 minutes Objective: Students will be able to use a tape diagram to solve arithmetic problems that involve finding a hidden number. They will also develop the ability to explain their mathematical thinking. Lesson Goals: Students will understand the use of tape diagrams as a visual tool to find hidden numbers in a sum. Students will improve their problem-solving skills by applying tape diagrams to real-world scenarios. Students will be able to articulate their mathematical process and reasoning.</p>			
Stages of the Lesson			
Lesson (Time Required)	Students' Learning Activities	Teacher's Considerations	Evaluation
Introduction (5 minutes)	Students will listen to the problem scenario: "24 children were playing; then their friends came, making 35."	Present the problem in a story format to engage students. Ensure Students understand the problem before moving forward.	Observe if students can articulate the problem and what is being asked.
Instruction (10 minutes)	Students will draw tape diagrams on their whiteboards to represent the problem.	Demonstrate how to use a tape diagram to visualize the problem. Guide students through the steps of creating a diagram.	Check the accuracy of the students' tape diagrams.
Guided Practice (15 minutes)	Working with the teacher, students will use the tape diagrams to find the hidden number of children.	Assist each student individually, as there are only four students. Encourage students to explain their thinking aloud.	Assess students' ability to use the diagram and their verbal explanation of the process.
Independent Practice (10 minutes)	Students will attempt a similar problem independently, using tape diagrams to find the hidden number.	Observe and take notes on students' independent work. Be available for guidance but encourage autonomy.	Review each student's work for correct application of tape diagrams and solution.
Conclusion (5 minutes)	Students will share their diagrams and explain how they found the hidden number.	Facilitate a discussion where each student explains their method. Reinforce correct strategies and clarify misconceptions.	Evaluate students' understanding and ability to communicate their reasoning.
<p>Assessment: Formative assessment will be conducted through observations during the introduction, instruction, and guided practice stages. Summative assessment will be based on the students' ability to independently apply the concept during the independent practice stage and their explanations during the conclusion.</p> <p>Follow-Up: Assign a similar problem for homework, asking students to create a tape diagram and explain their solution. Review the homework in the next class, focusing on the students' explanations to ensure a deep understanding of the concept. This revised plan caters to a small class size, allowing for individual attention during the learning process. It emphasizes understanding the use of tape diagrams as a visual aid in solving arithmetic problems and the importance of explaining mathematical thinking.</p>			

Step Three

As can be seen from the lesson transcript, the teacher used tape diagrams as teaching materials in this unit. In addition, the students could not explain how to solve the problem, although they immediately knew the answer. Such matters that teachers keep in mind when conducting the class are communicated to the generative AI (see Figure 13). This corresponds to the third step of the lesson plan development described in the previous section.

[Prompt Step 3]

As you proceed through this unit, please modify your lesson plan to take the following into consideration.

<Notes>

Since this is a written problem, not just a calculation problem, you should work with students to find the numbers in the text and identify what they represent. The student immediately knows the answer, but does not know how to solve the problem. Please consider how to proceed with the class with such a student.

[Result Step 3] See Figure 13

Figure 13

ChatGPT Output Result for Prompts Reflecting Lesson Analysis Results (Step 3)

<p>Modified Lesson Plan: Understanding and Solving Written Arithmetic Problems Grade: 2nd Subject: Mathematics Duration: 45 minutes Objective: Students will identify numerical information within a text and apply this to solve arithmetic problems using tape diagrams.</p> <p>Lesson Goals: Develop students' ability to extract numerical data and their meanings from a word problem. Guide students to understand the process of solving a problem, not just finding the answer. Encourage mathematical communication skills through explanation of their reasoning.</p>			
Stages of the Lesson (Time Required)			
Lesson (Time Required)	Students' Learning Activities	Teacher's Considerations	Evaluation
Introduction (5 minutes)	Read the problem aloud and discuss what the numbers represent.	Ask guiding questions to help students identify the key numerical information and what they represent. Clarify any misunderstandings.	Can students correctly identify and articulate what the numbers in the problem represent?
Instruction (10 minutes)	With teacher assistance, identify the total number of children and the hidden number represented in the diagram.	Show how the tape diagram corresponds to the numbers and their relationships in the problem Emphasize the meaning behind each segment.	Are students able to relate the tape diagram segments to the numbers in the problem?
Guided Practice (15 minutes)	Collaboratively solve the problem using the tape diagram, discussing each step.	Guide the student who knows the answer to explain their reasoning. Encourage students to articulate each step of the problem-solving process.	Do students understand each step of the process? Can the knowledgeable student explain how they arrived at the answer?
Independent Practice (10 minutes)	Attempt a new problem individually, extracting numbers and solving with a tape diagram.	Circulate and support students as needed. Pay special attention to the student who may rush to the answer without understanding the process.	Review the tape diagrams for accuracy and whether students can explain their process.
Conclusion (5 minutes)	Share solutions and explain the reasoning behind each step.	Reinforce the value of the process over just getting the answer. Correct any misconceptions and praise clear explanations of reasoning.	Assess students' ability to explain their thinking clearly and correctly.
<p>Assessment: Continuous assessment through observation of students' ability to identify numbers in text and use them correctly. Summative assessment based on students' ability to independently solve a similar problem and explain their reasoning.</p>			

Follow-Up:

Provide additional word problems for homework that require students to explain each step of their solution. In the next class, have students present their homework solutions and reasoning.

This lesson plan focuses on understanding the arithmetic problem-solving process, with particular attention on a student who may arrive at the answer without understanding how to solve the problem. It is important for the teacher to ensure that all students are able to find and understand the significance of the numbers in the text and can communicate the steps they take to arrive at the solution. The small class size allows for individualized attention, ensuring that each student fully grasps the concepts taught.

Step Four

The characteristics of the students identified through Lesson Analysis are communicated to the AI as points to keep in mind when conducting the lesson (see Figure 14). This corresponds to the fourth step of lesson plan preparation.

[Prompt Step 4]

The class you are teaching will have students with the following characteristics. Please modify your lesson plan with this in mind.

<Note>

Even if they have their own opinions, they are influenced by the opinions of other students. Rather than denying it, the teacher should accept it as part of the change that occurred to the student and carefully ask the student why he/she was influenced and how he/she changed his/her mind. One student, D, is concerned about the word "altogether" in the question text. Because of this, he/she is not sure whether to use addition or subtraction to answer the question. If he/she cannot explain it well in his/her own words, take time to draw it out. If necessary, communicate with other students in the class to check with the S-D. Since students in the class tend to try to finish by giving the answer right away, politely ask them how they came up with the answer and why they did the calculation the way they did.

[Result Step 4]. See Figure 14

Figure 14

ChatGPT Output Result for Prompts Reflecting Lesson Analysis Results (Step 4)

<p>Adjusted Lesson Plan: Collaborative Problem-Solving in Arithmetic Grade: 2nd Subject: Mathematics Duration: 45 minutes Objective: Students will collaboratively identify and understand numerical information and operations in a word problem, and articulate their reasoning process.</p> <p>Lesson Goals: Foster an environment where students feel comfortable sharing and adjusting their ideas based on peer input. Help students, especially student D, understand the operational words in a problem, like "together," and their implications for the arithmetic operation to be used. Encourage students to explain their thought processes in detail, rather than rushing to the answer.</p>			
Stages of the Lesson			
Lesson (Time Required)	Students' Learning Activities	Teacher's Considerations	Evaluation
Introduction (5 minutes)	Discuss as a group the meaning of "together" in the context of the problem.	Validate all contributions, guiding the discussion to understand "together" implies addition. Ensure all students are engaged and feel heard.	Can students explain what "together" indicates in the problem?
Instruction (10 minutes)	As a group, create a tape diagram based on the problem, discussing each part of the diagram.	Explain the significance of each section of the tape diagram. Encourage student D to express their understanding and clarify as needed.	Is student D more confident in explaining the use of addition?
Guided Practice (15 minutes)	In pairs, students will solve a similar problem, explaining their reasoning to each other and questioning their partner's ideas.	Circulate and listen to student discussions, prompting deeper explanations. Foster a respectful dialogue where students question and influence each other.	Do students respect each other's input and build upon it? Can they explain their reasoning clearly?
Independent Practice (10 minutes)	Individually solve a new problem, writing down each step and the reasoning behind it.	Monitor for students rushing to the answer. Politely ask them to explain each step. Pay particular attention to the individual responses and reasoning.	Are students able to write down their thought process step by step?
Conclusion (5 minutes)	Share solutions and reasoning with the class.	Encourage a discussion on the different approaches taken. Highlight the importance of understanding the process, not just the answer.	Can students articulate their process and are they considering their peers' strategies?
<p>Assessment: Assess students' ability to interpret the word "together" and other operational words correctly. Evaluate their written explanations during independent practice for clarity and thoroughness. Observe how students interact with and influence each other, ensuring they build on others' ideas respectfully.</p> <p>Follow-Up: Assign homework that requires students to solve word problems and explain their reasoning in writing. Review homework in the next class, focusing on how students articulate their mathematical reasoning.</p>			

This lesson plan is tailored to a classroom dynamic where students' opinions are influenced by their peers. It emphasizes respectful peer influence and detailed explanation of thought processes. Special attention is given to student D to ensure they understand the concept of "together" as it applies to the problem, fostering their confidence in using addition to solve the problem. The teacher's role is to facilitate discussions, validate all contributions, and ensure a thorough understanding of the problem-solving process.

SOCIAL, CULTURAL, AND POLICY PERSPECTIVES ON GENERATIVE AI USE

In this chapter, we attempted to create lesson plans using a generative AI to reduce the time teachers spend thinking about teaching and creating lesson plans, an increasingly busy part of their work. It became clear that the lesson plans generated by ChatGPT without sufficient information about the students were not adequate, so the authors used their expertise in lesson analysis based on transcripts to clarify the elements that teachers should consider during lessons, created prompts equipped with these elements, and then created the lesson plans again.

Experimentally, when the generated instructional plans were presented to teachers whom the first author knows in Japan, the Philippines, and Canada, the Filipino and Canadian teachers were impressed and responded that the quality and quantity of the descriptions of PK and CK were sufficient, even before including student information in the plans. On the other hand, Japanese teachers noted the need for descriptions of not only PK and CK but also students and commented that the lesson plans could have been more helpful. The above results were only partially up to the context of Japanese detailed lesson plans. In particular, teachers who value students' "earnest issues" throughout their daily lives noted this point. Since the number of surveys is insufficient for statistics, they are described here for reference purposes. When we look at the sum of the averages of the items evaluated by Japanese and Canadian teachers (see Table 1), we find that there is a significant difference between Japan and Canada: for lesson plan A, Japan scores 19.5 and Canada 33.5; for lesson plan B, Japan scores 25.5 and Canada 34.5; and for lesson plan C, Japan scores 24 and Canada scores 32.5, all significant differences. Japanese and Canadian teachers do not show significant differences in quality and quantity regarding CK assessment. However, they show differences in quality and quantity regarding PK assessment and content richness. This can be attributed to the differences in cultural substrates that Arani et al. (2017) point out, or in this study, to differences in the detail of the descriptions in the lesson plans, the recognition of the students' situations, and the descriptions of how to respond to them. This study will be conducted in the future for a wide range of countries and regions and will be discussed in light of teacher and school cultures.

Table 1

Differences in Evaluation by Japanese and Canadian Teachers

	Lesson Plan A		Lesson Plan B		Lesson Plan C	
	Japan	Canada	Japan	Canada	Japan	Canada
Overall Volume of Content	2.5	4	2.5	3	2.5	3.5
Overall Quality of Content	2	3	3	3.5	2	3.5
Volume of PK (Pedagogical Knowledge)	2	4	2.5	4	2.5	3
Quality of PK (Pedagogical Knowledge)	1	4	2.5	4	2.5	3
Volume of CK (Content Knowledge)	2	3	3	3.5	2.5	3.5
Quality of CK (Content Knowledge)	2	3	2.5	3.5	2.5	3.5
Enrichment of Content	1.5	3.5	2	4	2	3.5
Versatility	2.5	3	2.5	3.5	2.5	3.5
Availability	2	3	2.5	2.5	2.5	3
Comprehensive Evaluation	2	3	2.5	3	2.5	2.5
	19.5	33.5	25.5	34.5	24	32.5

As noted above, Japanese lesson plans are unique in that they are difficult to reuse, imagining the students' learning in the classroom in a positive sense. On the other hand, in a more negative sense, they are often made up from scratch because they are unique, and even if they are abbreviated lesson plans, the amount of description is so large that the amount of description of the view of students, teaching materials, and instruction is reduced. Even experienced in-service teachers often find it challenging to make it up quickly and go through a process of divergence and convergence of ideas. Inexperienced pre-service teachers may spend much time writing lesson plans, and even if they can write them quickly, they may need help fully imagining the students' learning in their classrooms. Thus, the teacher is faced with a dilemma. Even though a teacher's primary job content is to teach, without the originality of that teacher, it no longer matters who teaches the class. If this happens, the AI will create lesson plans and even teach the class. At the same time, teachers are becoming busier and busier, and trainees are working late into the night on lesson plans to bring out the originality of the "me" who is teaching. Furthermore, some teachers view the curriculum as a fetter of originality.

There are two ways out of the above dilemma: first, instead of thinking of class ideas as coming from oneself, one should think of them as being created together with the students in the classroom who are taking the class. As discussed above, from a social constructivist perspective there are as many possibilities for initiatives as there are teachers and students in the classroom plus any number of combinations of the two, and as Lesson Analysis in this chapter has shown, if we try to apply the views gained from daily teacher observation in the classroom, we can come up with exciting ideas can be floated without losing sight of the learning objectives. Busy teachers and teachers who cannot come up with enough ideas could conceivably be helped by being freed from the mental spell of having to create them on their own. The second is the use of generative AI. As is widely acknowledged, generative AI can generate sentences, interact with humans, and create sentences and pictures in combinations beyond our imagination. As indicated in this chapter, it is not easy to use the generated lesson plans as they are, at least in the Japanese context. For pre-service and in-service teachers without sufficient experience, the lesson plans created by the generative AI could be used to generate or replace parts of their ideas. In this study, we considered a prompt to create a completed lesson plan at a time. However, the teachers could position generative AI as a "buddy" for generating ideas by dialoguing with the generative AI; they could read the generated lesson plans and ask, "Is this okay?" by dialoguing with their own; or could imagine a veteran teacher and consider the results by dialoguing with him/ her in order to refine the lesson plan into a more appropriate one.

The first author has had students write lesson plans using the same prompts in both English and Japanese. While there are some differences (the results of the questions asked in Japanese contain slightly more information about the students than the results of the questions asked in English), the first author did not perceive any difference in language in the contents of the lesson plan. As we have previously emphasized, the one thing in common is that the generated lesson plans contain little, if any, information about the students. This is fatal to the use of generative AI in teacher education. It is conceivable that the generative AI has not learned enough to incorporate this information because teachers have not culturally or ethically included student information in their lesson plans in the past. Neither the former nor the latter is easy to change but stated as an idea, we believe that if we can overcome the ethical issues, it will be possible to bring about cultural change. Since it is too large at the national or state/provincial level, if it were possible at the school board or city level or even at the school level to manage class records such as those addressed in this chapter or notes about students that teachers document in class and to build and fine-tune a generative AI at that level, it would be possible to create lesson plans that are more accurate and rich in information about students. Building on this research, we expect to see an ever-expanding body of derivative and developmental research in which generative AI can be used in the work of teachers.

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GenAI and The Teacher Education Researcher

Reflections of Scholars on the Use of Generative AI to Support Research

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INTRODUCTION

Before we begin, a statement to the reader: notably, none of what follows was drafted by AI. Perhaps we should have asked ChatGPT to author it for us. Perhaps the result would have been “better”—more clearly written, enjoyable, salient and relevant. You, dear reader, can tell us what you think. I will note that we occasionally turned to AI to ask a question or explore an idea. When we used ChatGPT to aid our thinking, we made that transparent in our writing and conversation with one another.

Artificial intelligence (AI) is a complex of computer-based tools or applications designed to mimic the problem-solving, decision-making, and creative thinking processes typically engaged by humans (Duan et al., 2019; Hwang et al., 2020). These tools can potentially support humans, making our work more supported, efficient, and effective. Research is a critical component of teacher programs and teacher educators’ professional practice. Engagement in research supports teacher educators in remaining current in the field as well as leading in the field through seeking innovation. The use of AI in research spaces includes supporting researchers in posing and answering questions, facilitating brainstorming, summarizing text, drafting language, finding appropriate references, annotating sources, creating outlines, and organizing ideas (Kasneci et al., 2023; King & ChatGPT, 2023; Rahman & Watanobe, 2023; Sok & Heng, 2023; Stokel-Walker, 2023; Zhai, 2023). For example, Rahman and Watanobe (2023) found

At its most basic, [ChatGPT] can improve writing by finding and correcting typographical errors, improving grammatical inconsistencies, providing advanced vocabulary, and recommending improvement strategies. This allows researchers to devote more time to experimentation and implementation. The model can also summarize published work on a particular topic, which helps researchers understand the work. It can also provide clues and research ideas by analyzing a specific topic (Para., 20).

While the potential benefits of using AI to support research are significant, there are also apparent drawbacks that must be addressed, including inaccurate information, the risk of plagiarism, and limitations to the learner in developing essential knowledge and skills such as critical thinking, problem-solving, research, and writing (Gordijn & Have, 2023; Mhlanga, 2023; Mogali, 2023; Qadir, 2022; Shiri, 2023). As Rahman and Watanobe (2023) note, “A heavy reliance on generative AI tools such as ChatGPT can negatively affect education and research. This is because the ease of obtaining answers, problem-solving strategies, and scientific text generation can limit critical thinking and problem-solving skills.” These authors note the ethical issues inherent in AI (Krutka et al., 2021; Krutka et al., 2019), which also concern us. For example, AI has significant potential to perpetuate bias and misinformation (Lee et al., 2019; Mattas, 2023; Sok & Heng, 2023; Trust et al., 2023). Yet, the potential of AI to disrupt traditional practices is imminent and foregrounded in a long history of technology redefining how humans engage in their work (Rahman & Watanobe, 2023).

In this chapter, we use a duoethnographic reflection to explicate our experiences engaging in research while exploring the use of AI to support our work. Whereas autoethnography is an approach to research supporting the writer in systematically analyzing personal experience to understand a phenomenon of interest (Ellis et al., 2010), duoethnography is a collaborative research approach where two or more researchers explore their experiences with a particular phenomenon to complicate and develop multiple perspectives through a dialectic process (Norris & Sawyer, 2016). The tenets of duoethnography include a specific focus on the identities of the researchers, elevating the importance of differences in their experiences (Norris, 2008). These differences are central to the inquiry as they

create space to interrogate the chosen phenomenon from multiple perspectives. In this study, the differences in the two authors' level of experience in academia are significant in framing the study as described below.

Matthew (white, male) is a visiting professor with 15+ years of experience in education as a K12 teacher and administrator, serving his first year as faculty in a higher education setting. He has taken a visiting position in a teacher education program supporting teacher candidates at the undergraduate and graduate levels. His research experiences are limited to writing and defending his dissertation and working to reframe his dissertation for publication in peer-reviewed journals. He is a novice researcher finding his path forward, hoping to secure a permanent tenure track position and realizing the higher education expectation of scholarly writing. His institution is a teaching-focused university, and his assigned mentor at this institution is Donna (the second researcher and author).

Donna (white, female) has worked in higher education contexts for 20+ years in private and public universities in both the south and northeast United States. She describes herself as a “less-novice” researcher, eschewing the title of “veteran researcher.” Viewing herself primarily as a teacher educator, she engages in research to remain current in the field, to ensure her coursework is current, and to provide her students with the most up-to-date information. Notably, she recently started teaching qualitative methods in the college's doctoral program and supports multiple graduate students in moving through the research process. She is also the college's assessment director. Donna sees herself as a lifelong learner and sees research as one way to fulfill that goal. She enjoys research but also carries a significant weight of imposter syndrome in thinking about herself as a researcher, even though she has won several research awards (i.e., AACTE, AERA TACTL SIG) and has a relatively robust publication record.

Both authors have significant time constraints in conducting their research due to the institutional requirement to carry a 4:4 load. Both authors routinely accept overloads as needed by the department. They also participate in student advising and serve on department, college, and university-level committees.

We used this duoethnography to exchange our stories, challenge one another, look for nuance, uncover the potential of our practice, and problematize the ethical concerns we were uncovering in our work. In full disclosure, Donna brought Matthew into this idea as a means to extend her mentoring relationship with him and saw this project as a space for learning. We envision this chapter as a space to describe our experiences using AI to support our research and outline the concerns and potential we see with integrating AI into our research practice. While both of us approach research with a sense of our professional obligation to be visible in contributing to our field, we want to do more than “check the box” of our academic expectations. We realized the potential of AI to facilitate moving past obligation to empowerment in our research agendas. Ultimately, we hope our stories can support other researchers in thinking about the potential and pitfalls inherent in the intersection of research and AI. As such, our research questions are as follows:

- (1) What role can Generative AI play in supporting teacher education faculty research?
- (2) What ethical implications are implicit in using Generative AI to support teacher education faculty research?

THEORETICAL FRAMEWORK

This study's underlying theoretical framework is the cognitive process theory of writing (Flower & Hayes, 1981), which we contend mirrors the research process. We are fully aware that duoethnographies do not require the inclusion of a theoretical framework (Burleigh & Burm, 2022). When theoretical frameworks are included in duoethnographies, they are often selected and applied as a lens after data collection. Sawyer and Liggett (2012) guide us in understanding the inquiry process is the product of our findings emerging through our co-constructive dialogue with the theory lens applied late in the process to engender additional insight. However, Donna felt having a theoretical frame could be a useful starting point to frame our conversation and data collection.

The cognitive process theory of the writing framework contends that the act of writing involves a series of choices in an iterative inner process the author must engage in as they navigate multiple decisions. This framework outlines four key points authors use in navigating these decisions: (1) writing is a set of distinctive thinking processes the writer orchestrates during the act of composing, (2) these processes have a hierarchical embedded organization wherein any given process can be embedded within any other, (3) the act of composing is a goal-directed thinking process, and (4) writers create their own goals by both generating high-level goals and developing supporting sub-goals as they develop their sense of purpose.

The model underlying this framework involves the writer framing the composition (or the researcher framing the study) by establishing the task (e.g., topic, audience, exigency) related to (a) the existing research base and (b) the writer's existing knowledge of the topic. The act of writing within this frame involves planning

(organizing, goal setting), translating (writing), and reviewing (evaluating, revising). We contend the act of conducting research follows a similar pathway as the researcher engages in planning (organizing the study, setting the goal in the form of research questions), translating (enacting the study through data collection and analysis), and reviewing (refining the study in process, interpreting, staging results).

Our work as researchers involves enacting formal research studies and engaging in the act of writing to talk about our research. As such, we found this model to be a fluid foundation for thinking about our work. Specifically, we were interested in using this frame to explore how AI could be used to support our work in these complex and complicated processes.

METHODOLOGY

This study is structured as a duoethnography - a dialogic method involving two researchers (Norris & Sawyer, 2016) wherein the researchers are the site of inquiry, and the juxtaposition of their voices makes their experiences explicit as they work together to “untangle and disrupt meanings about a particular social phenomenon” (Burleigh & Burm, 2022, ¶1). An extension of auto-ethnography, duoethnography is predicated on the idea that a phenomenon can be more fully explored through intentional dialogue than in solo reflection (Ellis, 2009). In this case, the researchers embody different identities, positionalities, and experiences with research - each bringing a unique lens to using AI to support our research practices.

In duoethnography, the data results from the researchers' reflexivity in sharing stories and experiences with one another (Savin-Baden & Major, 2013) and is possibly supported by the inclusion of key artifacts (Burleigh & Burm, 2022). The data are the dialogue between the product and process, along with archived material produced from the exchange (e.g., emails, texts, artwork). Meaning is constructed from that corpus by identifying themes to answer the research question (Burleigh & Burm, 2022). The process is flexible, with data both generated and analyzed at the same time for insights. While centering “self” as the primary data instrument may be seen as a limitation, duoethnography challenges the researchers to complicate and interrogate each other as part of the process. The researchers in this method rely on one another to engage in open collaboration as an act of vulnerability and openness (Norris & Sawyer, 2016).

As a method, duoethnography is an act of constructionism in using the researchers' own experiences in conversation with one another to examine interactions with the phenomenon of interest (Savin-Baden & Major, 2013). In constructionism, knowledge is produced and understood through exchanges between people in a shared activity, focusing on dialogue, interpretation, and negotiation of meaning (Kvale, 1996). As technology evolves, researchers will engage in social reconstruction of the work we do to refine and create knowledge (Berger & Luckmann, 1967). In particular, knowledge generated or facilitated by AI is a social construct. The acceptance, validation, and dissemination of research findings supported by AI will intersect with social dynamics and academic norms. In this case, the authors are exploring their experiences with AI in support of their research efforts. Duoethnography centers on the idea that meaning can be created or transformed through the research act, with both the researchers and the readers involved as active meaning-makers (Norris & Sawyer, 2016).

While Norris (2008) originally articulated four tenets of duoethnography, these tenets have developed and evolved over time to include nine tenets (Norris et al., 2012) as follows: (1) life as curriculum, (2) polyvocal and dialogic, (3) deliberate juxtaposition, (4) differences are articulated and discussed to interrogate and disrupt stories, (5) question meanings held about the past to invite reconceptualization, (6) universal truths are not sought, (7) a form of praxis, (8) an ethical stance is negotiated space, and (9) deep layers of trust grow over time and allow disclosure and rigorous conversation.

We used duoethnography to tell our stories, which we present as a conversation between the two of us as we sought to understand the complexities of using AI to engage in research. Specifically, we focused our conversations on using ChatGPT to support our research. While we are aware many other generative AI tools exist to support academic research and writing (e.g., AcademicGPT, AI Cowriter, Sudowrite, Zotero, Grammarly, Mendeley), we focused our conversation on ChatGPT because of its renown and accessibility. Notably, by January 2023, ChatGPT had become the fastest-growing consumer software application in history (Hu, 2023). ChatGPT is an artificial intelligence (AI) application based on a large language model and designed to create dialogue in response to questions or prompts. Due to its recency, there is minimal research on its impact on education and research (Qadir, 2022), but there is potential for ChatGPT to be useful for research (Sok & Heng, 2023).

Using the theoretical framework as our guide (Flower & Hayes, 1981), we created a question protocol around using AI in research as an anchor (Burleigh & Burm, 2022) to explore this chosen phenomenon. The overlap of research, writing, and AI is not well explored in the field but has been noted in a few instances (Kasneji et al.,

2023; Trust et al., 2023). We conceptualized our extended conversation with one another to mirror the cognitive process of writing, which we contend mirrors the process of conducting research.

First, we began by exploring what motivated us to use AI in supporting our efforts. In this section, we also explored our motivations for engaging in research and writing relative to our positions within the academy (the task). Next, we focused on using AI to plan our work, including generating ideas, setting our research, and writing goals (planning). Then, we looked at how we use AI to engage in research and draft our writing (translating). Finally, we thought together about using AI to review our work for publication and presentation purposes (reviewing).

Our writing process was iterative. We interviewed one another in person while using Google Documents to capture our thinking for analysis. We did not use any of the Generative AI tools embedded in Google Documents, except for Grammarly. When interacting with ChatGPT, both researchers would log into their ChatGPT free accounts to conduct queries. Both of us worked on the document synchronously and asynchronously. We had almost continuous in-person sidebar discussions while also exchanging emails and texts. Our offices are adjacent to one another, and in the course of writing, we would engage each other in our office spaces with the document pulled up concurrently to embed notes and questions for one another as a result of our conversations. Outside of office hours, we would continue to use the document to embed comments and questions for each other to review for continued conversation. We worked in tandem to complicate our thinking by offering questions, comments, suggestions, and edits to each other's work. We visited and revisited our discussion to reflect on prominent themes and to create more questions for discussion. Our final product organizes our dialogue thematically, with literature included as part of the conversation rather than as a separate review, as is common in duoethnographic approaches to inquiry (Daly & Shah, 2022; Norris & Sawyer, 2016).

The Role of AI in Research for Teacher Educators

Why do we engage in research at all?

Donna: I've been researching for a while, and it's a mixed bag for me. The pressure to "publish or perish" in academia affects job security and income. This pressure used to affect my view of research negatively. That imperative instilled in me a sense of urgency and maybe a little fear. That has definitely tinged my relationship with research and writing. The start of my journey wasn't easy for me. I made a lot of rookie missteps in the beginning. For example, I submitted my writing to journals inappropriate to my studies. Completing a dissertation felt quite different to me than writing for publication. I did not feel prepared for the research expectations of my tenure track line based solely on my doctoral degree journey. As I navigated the research expectations of my new tenure track position, I burdened the senior faculty around with my concerns and anxiety. I'm grateful for the grace and support I received from those who mentored me, but I also wonder how I could have used a tool like ChatGPT to lessen that burden from others around me.

After 20 years in the field, I have a different take on research. My current view of research is that it is an act of collaboration that is mentally stimulating and allows me to stay updated in my field. I enjoy the process of designing studies, identifying research gaps, collecting data, and sharing findings. Twenty years ago, I just didn't have a perspective on what research could be or could look like. I thought it was all ANOVAs and Chi Squares. My depth of training in qualitative research was minimal. It's only through my continued engagement in research and self-education that I found out that qualitative research sings to me. Now, my only regret is not having enough time in my schedule to focus on research and support others in their research endeavors.

Matthew: As someone new to higher education, I can already see the tension between research for the altruistic joy of learning versus having to publish regularly to keep a job or be promoted. This friction between the product and the productivity probably exists in most professions. But if the purpose of scholarly research is to increase knowledge and guide practice, then I think AI definitely has a place in it, just like any other tool we use.

How do you think using AI in research will support or complicate this work?

Donna: I'm enthusiastic about using AI, specifically ChatGPT, to support my research. I know other researchers are also exploring the potential of AI to support research, although research in this area is still sparse (Rahman & Watanobe, 2023). ChatGPT is not the only AI I've explored, but it is the only one I've explored in support of my research efforts. So far, I have been very encouraged by what I've done with ChatGPT. As a "less-novice" researcher, I see so much potential in ChatGPT to "share the load" (Rahman & Watanobe, 2023). Even though I'm using the free beta version, I've been exploring its potential and limitations since November 2022. I'm

excited about how ChatGPT can assist me as a busy researcher with heavy teaching and service commitments. Some might see it as a shortcut, but I view it as an empowering tool, similar to calculators in math education. Remember that people questioned if Google would lead us to take knowledge shortcuts (Carr, 2010). I see the same conversations playing out now around AI.

I've used ChatGPT extensively for brainstorming, question generation, idea clarification, writing improvement, study planning, source finding, and more (Rahman & Watanobe, 2023; Sok & Heng, 2023). However, I'm also mindful of the ethical concerns, such as maintaining research integrity and avoiding plagiarism and misinformation (Sok & Heng, 2023; Trust et al., 2023), as well as the ethics inherent in the technology (Krutka et al., 2021; Krutka et al., 2019). I think the ethical implications are the complications I worry about the most, including researchers taking actual shortcuts that damage the integrity of their work, plagiarizing their work, including misinformation in their work, and so forth.

Matthew: The concerns about ethics and the integrity of the work are very real. When I initially became aware of AI in research, particularly ChatGPT, I was still teaching at the middle school level. I had the reaction that I think many educators had: this seems like a great tool for learning, but how do I make it authentic and ethical in my classroom? Now, I am in higher education and really starting out as a researcher myself, and my approach is similar. AI can be a great tool for research and publishing, but it must be tempered with caution.

What motivated you to integrate AI into your research? What specific problems or opportunities does it address?

Matthew: AI is a huge topic in education right now, and any tool that can help me do my job more efficiently and effectively interests me. AI can be useful at every stage of the research process, from brainstorming to designing a study to writing up the findings (Sok & Heng, 2023). At the same time, I want to ensure it is just serving as a tool without replacing the critical elements of humanity needed for research and reasoning. It almost feels like the old science-fiction trope of man versus machine, where one gets the feeling the writers are trying to justify what makes the human valuable while warning against overreliance on the machine (Trust et al., 2023). Researchers' primary motivation to use AI is that we are expected to publish regularly, and it's a great tool. Still, I can easily imagine us becoming too reliant on AI without taking the necessary steps to protect our purpose.

Donna: I really like your man versus machine framing here. I remember being new to the field and feeling pressured to meet the publish-or-perish mandate because I needed to keep my job. My goal was straightforward. I didn't have visions of becoming a "thought leader" and being someone who does keynotes at big conferences for my groundbreaking research. I just wanted to keep my job. I feel that pressure may lead some researchers to over-rely on the machine and lose the critical elements of humanity you noted (Qadir, 2022; Trust et al., 2023). If I were just starting out now, I think I would find tools like ChatGPT to be really attractive to me to make my workload a bit more efficient.

I also wonder about how AI has the potential to make my work better. Even as I work on this document with you right now, I am correcting my writing because I have Grammarly turned on. It makes my voice more concise and stronger. It's still my voice, but it's my voice supported by an AI editor. I'm thinking about running my language through ChatGPT to shorten and tighten my verbiage because I know this chapter (probably) has a word limit. I think it is an excellent example to illustrate a problem AI can solve, which motivates me.

Can you share some examples of recent or ongoing research projects where AI has been particularly beneficial?

Matthew: I recently used AI to brainstorm a topic I considered for a study. ChatGPT gave me several possible avenues to consider regarding this topic. As a researcher, I still need to sift through that and shape it into a plausible direction, but the assistance in generating ideas and angles is certainly beneficial.

Donna: I am engaged in multiple research projects at the same time. Of course, writing this chapter as I explore duoethnography as a method rises to the top of my mind. My most recent project was a resource I wrote for a professional organization I work with. I gave ChatGPT examples of public policy (for example, faculty handbooks) I had collected from various universities. I asked ChatGPT to look for common themes across those various pieces of text. It would have taken me hours to do that work. I still did the work of hand-coding all of the text I had gathered, but the work ChatGPT did for me first gave me a starting point - a type of "codebook" to make my work easier. I ended up rejecting most of the codes ChatGPT had generated. However, the structure ChatGPT gave me as a starting point was invaluable to that work. I also recently wrote a literature review for another project. I started by asking ChatGPT to create an annotated bibliography on the topic. In full disclosure, it did a terrible job.

Several of the sources it gave me did not actually exist. But again, it did give me a launch point for my thinking, and a few of the references were actually valid and valuable.

How are you using AI in your research?

Matthew: I have used the chat function of ChatGPT to help with brainstorming and summarizing (Rahman & Watanobe, 2023; Sok & Heng, 2023), but I am also exploring using it to help develop research questions and provide some much-appreciated guidance on statistical analysis. As far as statistics, I took two classes in my doctoral program, but I lack experience and expertise in figuring out which test is most appropriate for determining what I am looking for. I can always Google it or look it up in my trusty stats book I keep nearby, but I wondered if ChatGPT could help. I asked the program which statistical test would be most appropriate for a hypothetical situation involving multiple variables, and it quickly presented me with several options and explanations of what each one could do. Researchers already use technology for statistical analysis, so it does not seem too far off to let the technology help you find the most appropriate test to get the most accurate results. Perhaps some programs already do, but this is another tool.

Donna: I know there is an AI called Copilot that I really want to explore. It's a Microsoft product that supports data analysis and statistics. I would love to find a tool that made my work with college data less of a heavy lift. So it's on my list, for sure. I mentioned above that I used ChatGPT to look for themes and codes in a set of text I provided. I have been curious about how ChatGPT might help me to think about the data I collect through interviews or focus group events. Again, I don't think ChatGPT should replace "me" in data analysis. But I think it could help me think about HOW I might code the data. I use nVivo to do a lot of my coding, but the process is incredibly laborious and time-consuming. It's joyful work, but it just takes so much time. It's not like putting a bunch of numbers into SPSS and then interpreting the output. So I worry that the work of qualitative researchers can't be as productive as quantitative researchers, and how that plays out in the tenure and promotion process. Of course, I also worry about the ethics of it all. How do I feel about putting the language people shared with me through those personal interactions into the "machine" that is ChatGPT? (Krutka et al., 2021).

Matthew: It's interesting to think about how the information we are entering into ChatGPT may become part of the database we are later pulling from. So we enter a prompt into ChatGPT. Then we usually have to rephrase that prompt based on the output we receive. It's an iterative process until we decide to end that chat session. In that sense, we are also feeding the machine. We are contributing to the large language model. I know some of my students use ChatGPT to summarize texts and pieces of information for them. I am curious about the "loop" of putting this conversation between us into ChatGPT to look for themes, and I wonder what it will find. This is not unlike what qualitative researchers do. We need something to talk about for a conclusion anyway.

Donna: Ha! And now that's going to happen! But also... this is making me wonder about the veracity of what we find in ChatGPT. You know there is an old saying that comes to my mind... "Garbage In, Garbage Out." If we can all add to the large language model, it seems the risk of bias and misinformation is greatly increased.

How have you used AI to support research while planning your study?

Matthew: First, I should reiterate that I am a novice researcher. After completing my dissertation in 2021, I continued to work in K-12 without any expectation of additional publishing. Since beginning a faculty position at a university just a few months ago, I have only had time to adapt my dissertation study into an article and to work on this chapter with you. So, my experience with the research process is fairly limited, with or without AI. Most of my experience has just been exploring the tool, and mostly for purposes of supporting my teaching practices. I do think the implications of AI for use in publication are putting us into uncharted territory.

So far, I have found ChatGPT to be really helpful with brainstorming and finding approaches to a topic (Sok & Heng, 2023), but I am also aware of its limitations. For example, I recently tried to use it to find scholarly sources related to the effects of school desegregation on African-American educators, and I was surprised when ChatGPT responded that it could not supply specific articles due to its limited training. I have also experienced a response from ChatGPT regarding a lack of new resources because it is using an "outdated" database. It is possible this output comes from my using the free version of ChatGPT. I wonder if a different AI tool would have the same limitation, or even if the most current version of ChatGPT4 would have the same limitations. Still, the response was helpful as it suggested possible databases and search terms to consider. I do wonder if using other GenAI tools would have given me different, and potentially better, results. Would I have still received the same "limited training" response?

Donna: I also like it for brainstorming (Sok & Heng, 2023). I suffer from “blank page” syndrome pretty frequently. So I’ve used ChatGPT to ask a simple query. For example, I might ask ChatGPT to “plan a study examining undergraduate students' perceptions of mental stressors they experience” or “write research questions for a study exploring how novice teachers integrate technology into their pedagogy.” Usually, what I get is not something I can take directly and “run with.” That last question resulted in twelve research questions! But it gets me over the hump (Rahman & Watanobe, 2023). I find the trick is asking ChatGPT the question multiple times using different verbs (Qadir, 2022).

I also think what I am discovering is my own depth of knowledge in my research areas allows me to parse what ChatGPT gives me with some level of assurance. If I didn’t have a depth of knowledge in these areas, I would not be able to determine if what ChatGPT gives me is “good” or “bad” (Qadir, 2022). For example, I’ve had ChatGPT generate a reference list, but it frequently fabricates the article's name or the journal. But I know enough to validate and use that list as a starting point.

Matthew: So you are talking about research design and research questions. That’s the starting point of the study. Interestingly, I read an article where the author argued that “AI can be seen as ‘a valuable means and tool’ for progressing our theoretical understanding and possibly contributing to theory building and development, but it is not to be regarded as ‘theory building machines’ ” as they lack the nuanced insights and interpretations of a researcher (Christou, 2023b). In other words, AI can be helpful for finding or understanding theory, but it is not sufficient for building a new theory.

Donna: That actually makes me feel better. I’ll need to go read that author! I don’t want AI building theory for us - or building other high-impact or significant works, like policy, for example - although I know it is being used for this purpose (Hwang et al., 2020). It’s just like when I code data for a qualitative study. I know AI could generate themes and codes if I put data into the system, but AI lacks my expertise or depth of knowledge in the topic or in research practices. It doesn’t bring the lenses I do to the work. I will say I have used AI to recommend theoretical frameworks for me to use in a study. I’ve asked ChatGPT to generate a list of possible theoretical frameworks for me to consider based on my research design. But I wouldn’t ask it to generate theory.

Going back to the start of the study, I have used ChatGPT to help explain theory and research design to my students. I have a particular student in mind who struggled to understand the complexity of phenomenology as a research approach based on the materials I provided for her in the course. One day, out of sheer frustration, I asked ChatGPT to give me 4-6 paragraphs at the 8th-grade reading level describing phenomenological research, including the primary authors in that methodology. I also asked it to contrast descriptive and interpretive phenomenological approaches. It actually did a fantastic job at that. I sent her that text to support our continued conversation.

Matthew: One of my first introductions to ChatGPT was from my wife, who works in public relations. She sometimes has to interview people for various stories, and she told me she uses it to generate potential questions. It occurred to me that this tool could likewise be used to help develop interview or survey questions for qualitative research. For practice, I asked ChatGPT to generate questions related to my dissertation research. Even though the study was long since over, I just wanted an idea of how it would have helped. I keyed in a request for qualitative interview questions for high school principals regarding policies and practices related to accommodating the needs of transgender students. ChatGPT came up with several useful questions that addressed several angles of this issue. This tool would certainly have been useful to me in the early stages of my study and given me something to go on as I narrowed my focus. I imagine even the most seasoned qualitative researchers need some support in that.

Donna: I’ve also used ChatGPT to help me think about data collection by drafting interview questions and observation protocols. I’m working with a doctoral student now who was struggling to write focus group questions for her study. We logged into ChatGPT together and just played around with generating different question sets based on her research questions. Again, the trick really does seem to be in how you ask the question or prompt the machine (Qadir, 2022).

How have you used AI to support your writing?

Matthew: I recently set out to turn my dissertation research into a journal article. The journal’s length requirement was smaller for the abstract than the original text, and I also wanted to avoid just copying the original. I asked ChatGPT to summarize the abstract for me in 250 words, and it produced a solid summary of the study and key ideas. Of course, there were still things I wanted to change about it, but it gave me a good look at how to trim some of the fat. I imagine AI as a summarization tool would be useful in other parts of academic writing, such as summarizing findings or chapter summaries.

Donna: I’ve used ChatGPT for that purpose too. I have a manuscript in process that I hope to send out for review later this term. I received a “call for proposals” that seemed like a good match for the manuscript, but the

editors only wanted a 500-word abstract. I have 24 pages! I could paste key pieces of my writing (e.g., introduction, methodology, findings) into ChatGPT and ask it to summarize that into 500 words. I did not paste my literature review or theoretical framework into the request because I was worried about plagiarizing. What I got wasn't perfect, but after another 20 minutes with the text, I had something I felt was good enough to submit. Again, my own depth of knowledge guided me in that process. I estimate ChatGPT saved me hours of time.

I've also used ChatGPT to help me write pieces like the introduction, conclusion, and abstract. I call those the "bookend" pieces. When I write, I tend to jump straight to the action pieces. So I start with the methodology and key findings. Those are the exciting pieces for me. At that point, I have roughly sketched out the introduction and literature review. After I write the methodology and findings, I then turn to the literature review to make it as good as I can make it. At that point, I am worn out and a little "over" the topic I am writing about, and my other responsibilities are calling for my attention. I've found ChatGPT to be really helpful in giving me draft language I can use to finish off my manuscript. Again, it's not perfect, but I've found it to be a good starting point.

How have you used AI to support your revising and editing?

Matthew: I have used ChatGPT to help me reword material. How can I say this differently or in fewer words? I assume it can also be used for grammar, spelling, and mechanics.

Donna: Yes. It absolutely can be used for grammar, spelling, and mechanics. I've used it for that. My request to ChatGPT often takes a few attempts. So I've tried things like "Can you fix this piece of writing" or "What might make this text better". I actually like Grammarly for that work as well. It corrects and improves my writing as I am in the process. So that's easier for me to think about compared to contrasting what I plugged into ChatGPT and what I got out of ChatGPT.

Your statement here made me think about some older research in the writing field. Nancy Sommers writes about revision as an act of "re-vision" or "re-visioning" (Sommers, 1980). That is, we engage in the act of re-seeing as we compose and revise. I've always liked that framing. I find revising my writing to be painful, but generative. I often write, then walk away from my draft for several weeks. Often this is because of the other demands of my job. But the benefit is that when I re-enter the text, it feels new to me. I can more easily see the errors and awkwardness of my initial draft. But what if I asked ChatGPT to clean up and improve my writing for me? Would that mean I could go to the publication stage more quickly? Would I be more productive? After all, we do publish or perish. Then again, what would be lost to me? What insights would I miss out on?

What impact do you expect AI to have on your research?

Donna: I know we talked about ethics in several places in this dialogue already, but let's focus just on ethics for a minute. I think it's important to think about it.

Matthew: As someone who came into a higher ed faculty position shortly after ChatGPT took off, I see AI as critical to my research and teaching duties. It's like having a second set of eyes and ears to assist me. Christou (2023a) provides five steps for using AI in research, things like knowing the material and cross-referencing the AI output, but the author emphasizes the "most important key consideration is the demonstration of cognitive input and skills by the researcher throughout the process of using AI in any qualitative research study and in reaching conclusions." This is important for the ethical implications as well as the quality of writing.

Donna: Ah...your phrase "knowing the material and cross-referencing the AI output" screamed out at me. A theme I've been seeing in my own writing for this chapter is that my own depth of knowledge in my field is necessary when engaging with ChatGPT (Qadir, 2022). I know what I should be seeing and the names that should show up when I conduct a search in AI.

My concern is how do we develop depth of knowledge when we are engaging with a new area of research. I think I know enough as a researcher to realize what I don't know. For example, I did a search recently to help one of my students who works in another industry. I had to spend several hours vetting what ChatGPT gave me because I didn't know their field as well. But also, I knew enough to cross-reference what it provided me and to go read what it told me was important to include. And I had the time and fortitude to engage in that work. I worry that my students will just take what ChatGPT gives them as gospel (excuse my southernness) and not do the work of developing a deeper understanding of their topic. And perhaps not even go read the source material that ChatGPT used to generate the output.

Are there any ethical considerations, potential biases, or privacy considerations associated with AI-based research?

Matthew: I worry if researchers rely too heavily on AI, they will lose the complex and human elements that make research so meaningful (Qadir, 2022). As an 8th-grade teacher last year when ChatGPT first became available, I had students who turned in AI-generated papers as their own work. In addition to the obvious concerns about their learning and assessment, another glaring issue usually arose -- the responses were off-target. They were usually well-written and somewhat related to the topic, but there was a divide between what I had asked them to research or write and what AI had given them. Students and AI will both improve working with each other over time, but the concern here is that the researcher must know enough about the study or research question to know if the machine is actually answering it. Otherwise, we get something less precise and less useful for answering the question or solving the problem. This type of watered-down result may seem “good enough” for an 8th grader just trying to pass an assignment, but true scholarly research must be scholarly.

Donna: So your young students didn’t have depth of knowledge in the topic, and they took shortcuts that meant they would not develop depth of knowledge. They were checking the assignment box for you (Herman, 2023; Qadir, 2022). Does that mean what you assigned wasn’t intrinsically engaging or relevant to them? Does that mean we have to rethink how we teach? How do we move learners of all ages to true engagement with a topic? I may be naive, but I worry less about this in terms of the graduate students I teach. I think they are self-motivated and want to engage in the hard work of learning. But they are also adults with many demands on their time so may turn to “blind reliance” on generative tools (Rahman & Watanobe, 2023).

I think ChatGPT does have the potential to tempt us into taking shortcuts, which means we lose the nuance necessary by developing a deep understanding of the topic we are researching and writing. I’ll be honest, I don’t have any answers here. I am struggling to think about how to guide my own students on when and how to use ChatGPT to support their research work. I also worry about what we are giving up in this exchange with the machine. Right now, the beta version of ChatGPT is free. But nothing is really free, is it? So when we put questions or information into ChatGPT, who then owns that information? What is being done with it? I’m thinking about coding interview transcripts in the qualitative work I’ve done. If I put the words of other people into the machine (Krutka et al., 2021; Krutka et al., 2019; Trust et al., 2023), even if I have de-identified that information, what am I putting out into the world, and where will it show up again, or how will it be used?

Matthew: Your question about making assignments intrinsically engaging and relevant brings me back to the purpose of research and the use of AI. The lesson was a curriculum handed to me and mandated by my district. I don’t think any standard curriculum will be engaging to all students. That’s the work of the teacher, if allowed, to make that connection from curriculum to students. I think the same goes for us as researchers. We must connect our research and writing to our audience. A canned or scripted curriculum can be valuable for schools, but it cannot meet the needs of all learners without the teachers using their skills and training. In the same way, AI can be useful for research, but it should not substitute for the humanity of the researcher.

Donna: That’s a great parallel you just made that elevates the need for human engagement in the work of teaching and research. So one thought I’m having here is that writing is really “thinking on paper” (Zinsser, 2016). I develop my depth of knowledge and my rhetorical position as I move through the process of reading other people’s texts and then engaging with writing my own text. Often poorly at first, which I’ve come to embrace. And then gradually, through the iterative process, learning to craft my position or my message. If ChatGPT allows me to shortcut certain aspects of this process, then what might I lose? An over-reliance on AI may result in limited development of important knowledge and skills (e.g., critical thinking) (Rahman & Watanobe, 2023; Sok & Heng, 2023). Also, I am well aware of the conversations around how AI may perpetuate biases and generate misinformation (Lee et al., 2019; Kleiman, 2023; Mattas, 2023; Qadir, 2022; Sok & Heng, 2023; Trust et al., 2023).

Are there any specific challenges or limitations you've encountered when using AI in your research, and how do you overcome them?

Matthew: I recently asked ChatGPT to provide me with some scholarly articles on a specific research topic, and it responded that it was limited in its training. I wondered if it was an issue of having access to journals and databases. Unlike Donna, who got a somewhat usable bibliography on a topic, I just received a list of databases and search terms. This was still useful, but it may be that the researcher has to know what to ask for and also must double-check the work.

Donna: I worry about Generative AI creating fake content and fake data as well as deepfake video and audio (Biniyaz, 2023). I've had ChatGPT give me some interesting messaging as well, and I appreciate its efforts to caution me. I couldn't remember the exact phrasing, so for fun, I asked ChatGPT this question: "What are some messages ChatGPT gives to let someone know you may not be right or up to date." It gave me a list of ten phrases it uses, followed by this caveat: "Remember that it's your responsibility to ensure the information you provide is accurate and up to date, and it's good practice to guide users to reliable sources for the latest information" (OpenAI, 2023). I would say that about sums it up!

ALIGNING FINDINGS TO THE THEORETICAL FRAMEWORK

Before we engage in our key takeaways, we are explicitly aligning our inquiry with our theoretical framework (Flower & Hayes, 1981). Overall, the findings of our inquiry explore how ChatGPT can be used to support research processes across all stages of the model, from initial planning to idea generation to writing and revising. We noted that the benefits of using AI focused on increased efficiency and provision of additional insight; however, we also wish to emphasize several concerns in using AI to support our work in the form of specific caveats we offer below. We wish to stress that in all stages of research, ethical considerations should be a priority, and researchers should be vigilant about issues related to data privacy, plagiarism, bias, and misinformation. AI should be viewed as a complementary tool supporting human expertise, not as a replacement.

Ironically, although we selected a theoretical framework to guide our conversation, at times, it was hard to "stick with" the framework. As Flower and Hayes (1981) noted, writing (and research) is iterative and involves a set of processes and decisions writers (and researchers) use to organize and produce their work. The process is highly subjective and variable. There is not a fixed and rigid order, and any given process may be evident at any time and embedded within other processes. In other words, it's complicated. Given that caveat, we found AI to be a useful tool across all parts of the model (Christou, 2023a; Rahman & Watanobe, 2023) as described below.

Task Environment. We posited that research began with establishing the study focus by examining the existing literature base and drawing from the researchers' existing knowledge of and curiosity around the topic. In this way, AI can serve as a "virtual tutor" (Qadir, 2022). Here our initial discussion was grounded in the academic mandate to "publish or perish" in counterbalance to the researcher's agency in designing a study based on an area of interest and in the spirit of true curiosity with the intent to contribute to the literature base. We both acknowledged the existing challenges in academia, including the need to adapt to the changing landscape of research and publishing. We explored how AI could assist researchers in quickly identifying, gathering, and summarizing existing literature through scanning vast databases; identifying gaps in the literature; and generating reference lists, annotated bibliographies, and literature reviews (Rahman & Watanobe, 2023; Sok & Heng, 2023).

The caveat in this area of the model was the researchers' existing depth of knowledge as a guide to this work. Depth of existing knowledge in the research topic allows the researcher to identify AI generated content as valid or not (Qadir, 2022). Chat GPT can provide incomplete or biased information (Sok & Heng, 2023; Trust et al., 2023). In particular, the free version does not provide access to the most recent or authoritative sources. Christou (2023a) recommends that researchers must use due diligence in familiarizing themselves with AI-generated content, taking intentional steps to eliminate bias in the produced AI content, and cross-referencing information provided by AI. These steps can only be supported if the researcher has a developed depth of knowledge.

Additionally, the process of reading the literature base thoroughly promotes a deep and nuanced understanding of the research base that may support quality research and writing. Shortcutting this process of in-depth engagement with the research base could result in shallow or badly informed research studies because the researcher did not take the time to fully immerse themselves into the topic (Qadir, 2022). Researchers should use AI as a supplement to their existing knowledge and critically evaluate the information provided. Additionally, we both noted the importance of maintaining the human element in research (Qadir, 2022).

Planning (Organizing, Goal Setting). Here we both focused on using ChatGPT to brainstorm, generate questions, and summarize topics related to research (Rahman & Watanobe, 2023; Sok & Heng, 2023). We noted the use of AI to suggest various study designs and support work by refining research questions. AI can also be used to organize ideas in terms of suggesting draft outlines for the overall research paper or for sections of the larger paper.

The caveat in this area of the model is that researchers do need to have ownership of the structure and content of their study and ensure that the structure aligns with best practices and with the specific requirements of the research project. Over-reliance on AI for organizations might result in generic templates that do not suit the project's unique needs (Qadir, 2022). Additionally, AI questions may lack originality. Researchers should critically

evaluate AI suggestions and contribute their own insights and language to develop well-crafted and targeted research suggestions.

Translanguaging (Enacting the Study, Writing the Study). We focused our conversation here on how ChatGPT might support data analysis, by asking ChatGPT to suggest quantitative tests to use or to support our work coding or summarizing provided language (e.g., interview transcripts). We have both used AI to support our writing by asking ChatGPT to summarize, reword material, shorten produced language, tighten the language, and draft framing pieces commonly found in research papers (e.g., introduction, abstract) (Qadir, 2022).

The caveat in this area of the model focuses on AI's lack of depth of knowledge for data analysis, specifically qualitative data analysis. AI lacks the researcher's unique voice and perspective and cannot fully capture the nuance and complexity of the participant experience or study context (Christou, 2023a). Braun and Clark (2019) clearly signal that any data analysis must be guided by the researcher's knowledge of the topic. Without this expertise, the AI-generated analysis cannot be grounded or contextualized appropriately. While Donna has piloted the use of ChatGPT to analyze publicly available qualitative data, the results did not use the lenses Donna brought to the work based on her years of experience and immersion in the research base. AI analysis lacks the researcher's unique voice and perspective. Although the use of AI for data analysis might provide some insight or inspiration, the researcher's unique expertise should be used to align data analysis with the intended focus of the research project. Our takeaway in this section of the model is that researchers must use caution when using AI for data analysis and interpretation.

Reviewing (Evaluating, Revising). ChatGPT supported both Matthew and Donna in revising and editing their work. Both researchers had used AI to rephrase language, edit content to make it more concise and improve grammar, spelling, and mechanics (Rahman & Watanobe, 2023; Sok & Heng, 2023). This supported both researchers to communicate their thoughts and their research more clearly and effectively.

The caveat in this area of the model includes cautioning researchers in vetting the suggestions made by ChatGPT, which may not fully understand the context or intent of the text, capture the essence of the research, or may generate hallucinative misinformation (Christou, 2023a; Qadir, 2022). Both authors recommend that researchers maintain creative control and draw on their own established depth of knowledge to revise and refine anything generated by AI as well as engage in due diligence in vetting any information generated by the AI. Additionally, feeding our language into ChatGPT means that our language is being used by the model in ways that may pose privacy risks as our language may be accessed or misused by others (Krutka et al., 2021; Krutka et al., 2019; Rahman & Watanobe, 2023; Trust et al., 2023).

THEMATIC ANALYSIS

In addition to analyzing our conversation using our chosen theoretical framework to establish a priori codes, we also examined our data to identify codes and themes outside of that framework. For this work, we followed Braun and Clarke's (2006) phases for thematic analysis. In full disclosure, We did ask ChatGPT to look for key themes in our conversation. Again, we felt it did a dreadful job. So we engaged in hand coding our data.

First, we both identified that AI has the potential to enhance productivity and efficiency in engaging in our research. In particular, we were intrigued by the possibility that AI might allow us to better match production with faculty at research universities who do not carry the teaching and service loads we shoulder at a teaching institution. We may not be able to be as productive as someone at a research institution, but perhaps AI can provide some efficiencies for us to be more productive (Rahman & Watanobe, 2023). Additionally, AI may support efficiencies in qualitative research to support data analysis practices, which often take more effort and time than analyzing quantitative data.

While the benefits of using AI to support our research were notable, we both shared concerns about what we are "giving" ChatGPT and how it will be used in terms of thinking about data privacy and security echoing concerns of the technoskeptics in the field (Krutka et al., 2021; Krutka et al., 2019). These concerns intersect with fears that ChatGPT may be replicating or extending current inequities and bias (Lee et al., 2019; Kleiman, 2023; Mattas, 2023; Qadir, 2022; Sok & Heng, 2023; Trust et al., 2023).

We also both voiced concerns about the quality and reliability of ChatGPT outputs, and we identified limitations in using ChatGPT to support our research, such as access to databases and the common occurrence of misinformation (Sok & Heng, 2023). Qadir (2022) discusses the lack of reliability inherent in AI and the creation of hallucinative misinformation as ChatGPT creates content constrained by limitations of the language model itself, the quality of data it draws from, and the specific inputs and prompts we use. Qadir references these hallucinations as "a figment of generative imagination" (p. 7) which could have legal consequences (Athluri et al., 2023). Athluri et al.

(2023) noted that nearly 20% of references provided by ChatGPT in their study were hallucinations with another 20% described as “partial hallucinations” (i.e., the source articles existed, but the provided DOI were incorrect). Additionally, they noted ChatGPT bypassed scientific journal articles for lower quality or less easily vetted content, such as websites or textbooks.

ChatGPT often acknowledges limitations in its own output, cautioning users to engage in due diligence. The CEO of OpenAI tweeted that users should use caution when engaging with ChatGPT-created content noting “ChatGPT is incredibly limited, but good enough at some things to create a misleading impression of greatness. it’s a mistake to be relying on it for anything important right now. it’s a preview of progress; we have lots of work to do on robustness and truthfulness” (Altman, 2022). To this end, we wanted to provide a quote as guidance here. As Sok & Heng (2022) note,

It is essential to just use this tool for brainstorming and outlining, not to produce entire research articles, in order to prevent intentional or unintentional academic misconduct. That said, when using this tool for generating ideas, it is vital to ensure that all the information generated is accurate by checking and editing it, as well as requesting additional responses through follow-up prompts. Otherwise, the use of ChatGPT may be a curse rather than a blessing (p. 9)

Second, we focused on the importance of AI being a tool to support human researchers rather than replace them. We raised questions about maintaining the human aspects of research and the role of researchers in guiding and validating AI-generated content. This theme reflects the complex interplay between AI and human researchers in the context of academic research and the ethical and practical considerations associated with AI integration into the research process. We both shared concerns that AI would lead researchers to take shortcuts where we don’t do the hard work to really develop our depth of knowledge and define our voice. Specifically, we both concluded that our own depth of knowledge in our field and in the act of research supported our ability to use AI in research well and with integrity (Braun & Clarke, 2019; Christou, 2023a).

In terms of our work as teacher educators engaging in research, we did uncover a few takeaways we think are important to consider. As researchers, we need to have a clear understanding of the literature base and be able to define our research objectives clearly without support from AI, including specific questions or problems. While AI might enhance our language or help us brainstorm, it cannot replace the expertise we bring to our work. We did share concerns about how over-reliance on AI might lead to a decline in depth of knowledge and critical thinking skills if researchers take shortcuts or engage in careless ChatGPT use (Qadir, 2022).

In designing and implementing the study, AI can be used to refine (not define) the research objectives and questions. Researchers can be intentional about selecting AI platforms that are most relevant to supporting the research goals, keeping in mind the ethical complications and implications around the use of AI. As of yet, we have not identified how AI can replace data collection and the human element involved in engaging with participants in the research process. However, the potential for AI to support the analysis, interpretation, and writing of data are immense. Researchers can consider how to support their data analysis with support by AI in identifying appropriate statistical tests or analyzing large bodies of qualitative text (not ethical concerns above). Additionally, researchers can use AI to support their ability to communicate research findings clearly. Again, while AI can support this process, it cannot replace the human in the process.

CONCLUSION

This chapter generates new knowledge by exploring the potential of AI, specifically ChatGPT, to enhance efficiency in the research process by highlighting the benefits and limitations of using AI in research. We provide our insights gained regarding potential opportunities to use AI in conducting research with an eye toward ethical considerations as a serious concern in this work.

Our duoethnographic inquiry explores how ChatGPT impacts the generation of new knowledge and refinement of existing knowledge by offering potential efficiencies in support of research (e.g., idea generation, data analysis, writing support). However, the use of AI in research also holds concerns related to data privacy, reliability of provided information, and the risk of encountering (or generating) misinformation.

Through this work, we wish to call out new understandings around AI as a tool that can support researchers but cannot replace them. Researchers have a vast and highly developed expertise that cannot be replaced or supplanted by AI. Concerns here include researchers failing to develop their depth of knowledge, and we underscore

the need for researchers to maintain and deepen their expertise and to engage and nurture their critical thinking skills. This is crucial for using AI effectively and ethically in the research process.

Throughout this process, we feel our research epistemology has evolved based in our engagement in writing this duoethnography. Through this work, we affirm the nine tenets of duoethnography articulated by Norris and Sawyer (2012). This work for us has been generative because of those tenets that position our lived experience as the curriculum (or phenomenon) of interest best explored through polyvocal and dialogic deliberate juxtapositions. In our writing, we did not seek a universal truth but rather a praxis of our own theory and practice. Writing this study has been a process of articulating differences to interrupt and disrupt our own stories, to question meanings held about the past, to invite reconceptualization, and to engage in thinking about ethics at multiple levels.

Our collaboration has led us deeper and forced us to ask uncomfortable questions and pursue answers. We both leave this experience seeing the potential of AI to support our work, but also aware of a need to proceed with more caution, care, and critical thinking than when we entered our conversation. While AI can be a collaborator and a tool in generating knowledge, it is a means to an end that must be approached with ethical consciousness. The centering of the researcher as a human in this work is also critical to include here as we acknowledge that AI can be a valuable tool, but cannot replace the human as the arbiter of knowledge and generator of unique insights and perspectives.

EPILOGUE

After receiving reviewer feedback on our writing, Matthew and I engaged in additional reflection to further complicate and deepen our thinking. As Burleigh and Burm (2022) note, “duoethnography is not a practice with a static, final result” (para. 6). In duoethnography, and in qualitative research more broadly, it is not uncommon to use arts-based or creative writing conventions to make space for creativity and play (Savin-Baden & Major, 2013). Our reflection on the feedback we received led us to create this epilogue as our creative response seeking semi-closure to our introspection, critical reflexivity, and collaborative inquiry. In this section, we offer some final thoughts on our journey thus far.

Matthew: As someone relatively new to scholarly research and even newer to ChatGPT and similar AI tools, I appreciated the commonality that was found in this conversation. We shared realistic concerns about research quality and ethics, but we also had in common numerous ideas for how this tool could be used to improve and support the research process. Donna has been researching for many years, and despite being pragmatic and realistic, she still expresses a tangible excitement for research. This optimism and joy carry over into implementing AI in her work. Our theoretical framework for this study centered around how writing is a process of interconnected goals and activities orchestrated by the author. I do not think AI has to take away from that. In fact, I feel more confident that AI can improve every aspect of the research process while still leaving room for the human factor because, ultimately, that's what our research is all about.

Donna: I enjoyed the chance to look back over my 20+ years of experience doing research and sharing that journey with Matthew. I think the use of AI to support research is a critical and exciting conversation. I do have questions around ethics (e.g., data privacy, misinformation, bias, feeding the machine), but I am cautiously optimistic about the potential of AI to ease the workload that accompanies the research process at every stage of the model. I think this is particularly valuable for faculty working in teaching universities and with heavy teaching loads. I see AI as one means to perhaps provide equity in the field. Certainly, AI can help me polish my writing so that it is more succinct!

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Developing Frames for Change: The Impact Of Generative AI on the Broad Practices of Teacher Educators

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INTRODUCTION

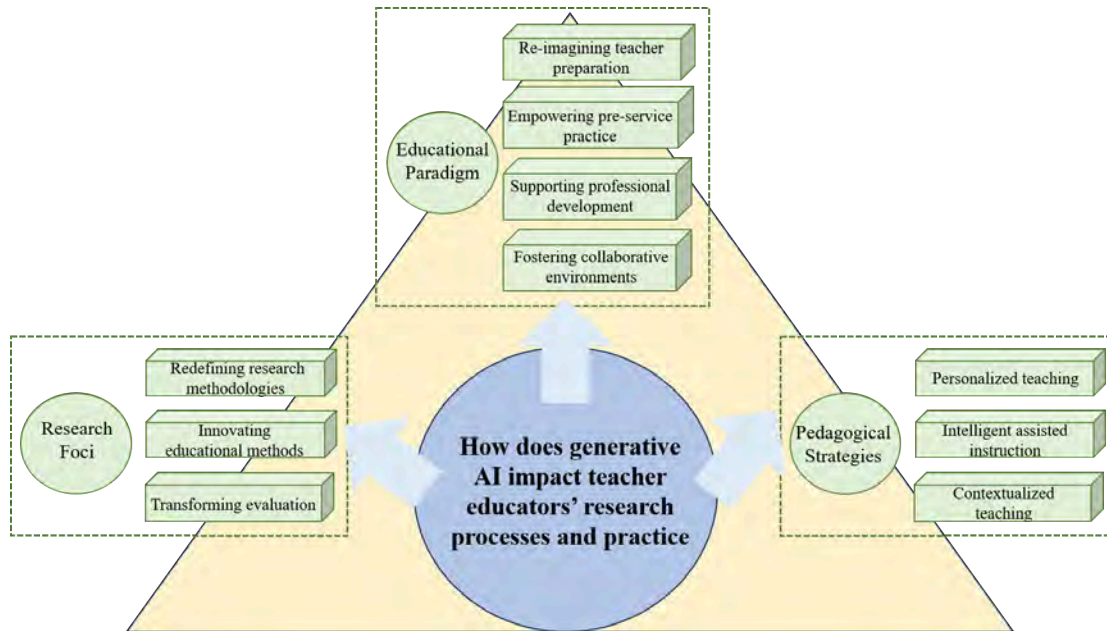
With the advent of machine learning and deep learning, a more refined and innovative technique of digital content generation has emerged—Generative Artificial Intelligence (GAI) (Ji et al., 2023). GAI utilizes artificial neural networks to generate human-like text, images, or other content based on patterns and data it has been trained on (Pataranutaporn et al., 2021). The potential value of GAI for teacher education includes personalized learning, more access to resources, time efficiency, flexible accessibility, and inclusivity (Kamruzzaman et al., 2023). As indicated in previous studies (Tlili et al., 2023), the impacts of GAI on teacher education can be both positive and negative, and they may vary depending on how generative AI is implemented and integrated into teacher training programs.

Exploring the impact of GAI on teacher education is significant due to its potential to revolutionize the field. GAI has the capacity to redefine the methods and tools used in teacher training, aligning them with the demands of a technology-driven educational landscape (Hwang & Chen, 2023). Firstly, it transforms the focus of teacher education, incorporating AI-driven tools into the curriculum to prepare educators for the digital era. In addition, GAI equips teachers with personalized learning experiences, abundant resources, and skill-enhancement opportunities, enabling them to excel in technologically advanced classrooms (Grassini, 2023). For instance, GAI can enhance learning experiences by tailoring content to individual student needs and preferences, thereby improving engagement and comprehension (Chan, 2023). The necessity of in-depth exploration stems from the fact that GAI's transformative impact can be realized most effectively when integrated responsibly and ethically. For example, GAI-powered content generators can provide teachers with a wealth of resources, but ethical considerations are crucial to avoid bias and ensure the diversity and accuracy of these resources (Glaser, 2023). Similarly, while virtual classroom simulations can aid in teacher preparation, their design must prioritize inclusivity and accessibility to cater to diverse learners (Rawas, 2023). In essence, delving into GAI's multifaceted role in teacher education is essential to unlock its potential fully while addressing the ethical and practical considerations that come with its implementation.

The purpose of this chapter is to explore the impact of GAI on teacher education, elucidating the opportunities and challenges that future educators will face. It aims to provide fundamental theoretical insights and practical guidance for educators in the era of artificial intelligence. In this book chapter, we examine how GAI impacts teacher educator's teaching strategies, research foci, and educational paradigms. Figure 1 displays the elements of each area we will investigate.

Figure 1

GAI Empowers Teacher Education



SHAPING PERSPECTIVES: HOW GENERATIVE AI INFLUENCES RESEARCH FOCI

Redefining Research Methodologies: From Data Analysis to GAI-Driven Insights

Traditional educational research usually relies on massive amounts of data collected manually; for example, teacher educators collect data through achievement tests or using questionnaires (Wilson & Dewaele, 2010) and analyze it quantitatively or qualitatively to understand general trends and correlations of educational phenomena. This process usually requires a great deal of time and human resources, and teachers face daunting challenges in dealing with the huge amount of student data and need to invest so much time and effort that they cannot provide deep insights to teacher educators. GAI makes data collection more efficient and comprehensive through its powerful data processing and pattern recognition capabilities (Pataranutaporn et al., 2021). It can identify potential relationships or meaningful information in teaching and learning from a large amount of data and generate brand new insights and research hypotheses by digging deeper into the underlying patterns and connections behind the data, which reduces the heavy workload of the teacher educators (Chen et al., 2023). Diverse data in the education context were collected, such as students' academic performance, learning behaviors, social interactions, and emotional states (Burman et al., 2020). The emergence of GAI not only enables intelligent collection of the above educational data but also significantly reduces the pressure on teacher educators to collect data manually, which helps them focus more time and resources on educational research. This process not only reduces the pressure on teacher educators to collect data manually but also helps them to focus more time and resources on education and teaching research. Moreover, through machine learning algorithms, huge data sets can be analyzed in time, and the mechanisms and relationships of educational problems can be expressed (Li et al., 2022). It enables teacher educators to better understand the diversity and complexity of educational environments and provide more innovative approaches to improve teaching and learning. Thus, it can provide personalized advice and guidance according to the needs of students and teachers (Chan, 2023), maximize the learning and educational needs of each individual, and improve students' learning performance and teachers' teaching effectiveness.

Adapting Pedagogies: Personalized and Adaptive Learning Through GAI

Traditional education methods usually use uniform teaching content, which often fails to meet the learning needs of different students. It is difficult to track students' learning progress during the teaching process, and it is not possible to make flexible adjustments according to students' actual needs (Gao & Latif, 2022). In addition, traditional teaching assessment mainly relies on a one-time test, and students tend to feel frustrated when they only receive limited feedback. With the continuous development of technology, the emergence of GAI provides innovative technological solutions for teaching and learning in the field of teacher education research and practice, such as personalized instructional guidance, adaptive learning content, and more interactive feedback mechanisms (Lockee, 2020). First, learners' data are comprehensively collected through GAI technology to build individual learner databases, such as learners' cognitive ability data, learning level data, cognitive style data, learning behavior data, learning evaluation data, etc. (Karabacak et al., 2023). Secondly, personalized analysis of learners' learning data is accomplished through data mining technology to understand learners' basic needs and learning styles, provide a more complete and accurate personal digital portrait, and automatically adjust the learning content and difficulty. Most importantly, continuous learning tracking services are provided for learners to help teachers better understand learning progress and problems, adjust teaching strategies in a timely manner, and provide intelligent learning resources (Jeon & Lee, 2023) to meet students' personalized needs and enhance learning effectiveness and engagement.

Transforming Assessment Practices: GAI-Enabled Automated Evaluation

Traditional assessment methods are mostly based on quizzes, exams, or one-way feedback from teachers, so it is difficult to meet the diverse learning needs of learners, and it is also difficult to ensure the accuracy, objectivity, and comprehensiveness of assessment (Ratten & Jones, 2023). Currently, in terms of accuracy, GAI provides more comprehensive and in-depth assessment results by analyzing students' thinking processes and problem-solving styles, documenting their learning performance, and automatically adjusting the difficulty of the assessment based on student learning (Cooper, 2023). For example, the GAI could help teachers better understand students' learning needs by analyzing their problem-solving processes and thinking patterns to gain insight into their learning abilities and thinking styles. In terms of fairness, assessment is not affected by individual differences, ensuring that each student can show his/her potential under a fair assessment system (Nikolic et al., 2023). In terms of time efficiency of feedback, situating GAI as a professional assessor according to the rubric provided by teachers, GAI can track learners' learning dynamics in real time to help teachers understand learners' learning progress and psychological state. Unlike traditional test-based assessment, GAI provides not only results-oriented feedback but also more detailed assessment content and improvement plans (de Laat et al., 2023). In addition, in terms of assessment diversity, GAI is capable of acting as a highly intelligent educational tutor based on the integration of interdisciplinary knowledge and the comprehensive assessment of learners in multiple dimensions, including text-based quizzes, programming questions, and skill assessments (Lozano et al., 2023). Moreover, as students interact with large language models, educators can assess the depth of students' grasp of knowledge based on their conversations and provide targeted feedback.

In conclusion, the rise of GAI in the field of teacher education has not only redefined the research methodology in theory but also revolutionized the pedagogical practice and overturned the traditional assessment methods. This change has brought more in-depth educational practices to the field of teacher education, advancing the field of teacher education research and providing more possibilities for improving educational reforms.

RETHINKING CURRICULUM: HOW GENERATIVE AI SHAPES PEDAGOGICAL STRATEGIES

GAI brings a range of intelligent tools to the education field that is redefining the teaching and learning process for teacher education programs (Ruiz-Rojas et al., 2023). Traditionally, training in teacher education tends to be dominated by lectures, case sharing, and work design by instructors, and learners usually learn instruction-related theories and methods in the process of accepting the training (Zagouras et al., 2022). With the arrival of GAI technology, learners can quickly and automatically generate the required course materials, such as syllabus, curriculum, and teaching activity design (Álvarez-Álvarez & Falcon, 2023). It can be seen that the curriculum design of teacher education needs to change to better adapt to the changing technological environment, not only to meet the learning needs of the learners but also to arm the learners to face the future needs of teaching better (Chiu

et al., 2023). For the automatic generation of learning content by learners in teacher training, for example, trainees of teacher education programs use ChatGPT to generate the instructional design, which is very efficient. Still, the quality is difficult to guarantee, and some researchers have pointed out that such a way of learning may negatively affect the active thinking and problem-solving ability of learners (Hsiao & Chang, 2023). Therefore, how to guide learners to make rational use of GAI tools, how to innovate the curriculum design of teacher education and training, and how to make learners better able to face the ever-changing technological environment are important issues that must be considered in the current teacher education research, from the curriculum innovation and pedagogy reform.

To have a better understanding of how teacher education trainees use GAI tools for learning, as well as the way they use GAI, this study invited 16 English teacher education majors from a public university in China to complete an informational, instructional design proposal using the GAI tool ChatGPT under the instructor's guidance. The instructor would guide the preservice teacher in training the GAI to generate the instructional design proposal that they needed using role-playing, style-setting, clarifying the task, and providing case studies in advance, as shown in Figure 2. Taking Unit 3, "What Color Is It?" of a middle school first-grade English class as an example, the pre-service teacher interacts with ChatGPT to generate teaching programs based on unit themes. Initially, the pre-service teacher may begin with general questions, such as "Please help me design a teaching plan." At this stage, the pre-service teacher's questions are broader and are used for one-way inquiries without involving specific details or in-depth content. Thus, ChatGPT's response was not satisfactory. Subsequently, the pre-service teacher will ask for more detailed questions about a particular aspect of teaching activities. For instance, they might ask, "I would like to add gamification to my teaching activities and keep the gamification to 20 minutes." During this stage, pre-service teachers increase the complexity of their inquiries and focus more on specific aspects of the teaching activities. Finally, pre-service teachers shift their focus towards delivering high-quality instruction, student development, and individual differences. They will carefully tailor their teaching methods to meet the needs of students with different learning styles based on the content of ChatGPT responses. As a result, pre-service teachers interact with ChatGPT in a more in-depth and specialized way by asking questions, for example, "While incorporating gamification elements into teaching activities, we should also take into account students with different learning styles." In the three stages mentioned above, through interaction with ChatGPT, pre-service teachers may gradually accumulate more knowledge and information. This enables them to pose more in-depth and specialized questions, better adapt, and gradually enhance their educational design and teaching methods.

To further explore how preservice teachers think and what they interact with when using the GAI, we used a qualitative approach to analyze the discourse between preservice teachers and ChatGPT.

Figure 2

Preservice Teachers Interact with GAI Tools in Reference to Tu & Hwang (2023)

General questioning	Further detailed questioning	Questioning in a more specialized way
<p>Q: 我想请你帮我做一个英语课的教学设计，我的题目是“What color is it?”</p> <p>A: 当然设计英语课的教学设计，题目“What color is it?”是一个很好的切入点，特别适合初学。以下是一个简单的教学设计，旨在帮助学生学习英语颜色的基本词汇和用法。</p> <p>课程标题: What Color is It?</p> <p>目标:</p> <ol style="list-style-type: none"> 1. 学习英语中基本的颜色词汇。 2. 能够用英语描述周围物体的颜色。 3. 发展听、说、读、写的技能。 <p>材料:</p> <ol style="list-style-type: none"> 1. 彩色图片或实物代表各种颜色的物品。 2. 白板或黑板用于呈现词汇和句子。 3. 录音设备或播放器用于听力活动。 4. 学生练习纸和彩色笔。 	<p>Q: 我想请你帮我做一个更详细的数字设计，我的题目是“What color is it?”要求：在前学活动中增加游戏环节，游戏时长在20分钟以内，课堂总时长在45分钟以内。</p> <p>A: 当然设计更详细的课时，以题目“What Color is it?”为基础，我们可以设计一些互动性强、趣味性强的游戏环节。以下是更详细的数字设计:</p> <p>课程标题: What Color is It? - Color Scavenger Hunt</p> <p>总时长: 45分钟</p> <p>目标:</p> <ol style="list-style-type: none"> 1. 学习基本的颜色词汇。 2. 能够用英语描述周围物体的颜色。 3. 发展听、说、读、写的综合性技能。 <p>材料:</p> <ol style="list-style-type: none"> 1. 彩色数字卡片 (可随机生成或学生自带)。 2. 白板或黑板用于展示词汇和例句。 3. 计时器。 4. 游戏道具、奖励贴纸或小奖品 (可选)。 <p>教学步骤:</p>	<p>Q: 我想请你帮我做一个更专业的教学设计，我的题目是“What color is it?”要求：要考虑不同学习风格的学生，并要在教学活动中增加游戏环节，游戏：团队合作、角色扮演、卡片游戏等元素。游戏时长在20分钟以内，课堂总时长在45分钟以内。</p> <p>A: 结合考虑不同学习风格的学生，以下是一个更专业的教学设计，题目为“What Color is It?”。时长在45分钟内，包括游戏时长在20分钟以内的教学互动。你可以选择其中一个游戏化元素，如团队合作、角色扮演或卡片游戏，无缝融入课程。</p> <p>课程标题: What Color is It?</p> <p>总时长: 45分钟</p> <p>目标:</p> <ol style="list-style-type: none"> 1. 学习基本的颜色词汇。 2. 能够用英语描述周围物体的颜色。 3. 发展听、说、读、写和团队合作的技能。 <p>材料:</p> <ol style="list-style-type: none"> 1. 彩色数字卡片、白板/黑板 (用于游戏)。 2. 白板或黑板用于展示词汇和例句。 3. 游戏道具和奖励、贴纸或小游戏。

The coding scheme was slightly modified based on the dimensions proposed by Murphy et al. (2017), with

a total of 10 codes, including authentic questions, uptake questions, exploratory talk, cumulative talk, challenge questions, speculation questions, generalization questions, analysis questions, high-level thinking questions, and shared knowledge questions. Based on research needs, the current study categorized the ten coding dimensions into three categories: low-level thinking styles, intermediate-level thinking styles, and high-level thinking styles. Low-level thinking styles refer to the perception and initial understanding of facts, information, or phenomena. Intermediate-level thinking styles refer to more in-depth processing of information and reasoning, such as integrating and speculating about information. Higher-level thinking styles refer to the ability to think more deeply, broadly, and creatively about information, involving deeper understanding, analysis, and creative application of knowledge.

As shown in Table 1, according to the results of the frequency statistics, the highest frequency of occurrence was in the low-level thinking style, followed by the general thinking style and the high-level thinking style. Among the low-level thinking styles, 74 data were collected; in the general level thinking styles, 68 data were collected; in the high-level thinking styles, 30 data were collected. This shows that most of the pre-service teachers are still at a low level of questioning; for example, one of the students at the low level of questioning was "Please provide an instructional design for the topic what color is it? " and "Can you give me some basic information about the topic of what color is it?" Students at the average level of thinking asked, "You can describe the application of the principles of instructional design to create an instructional design on the topic of what color is it?" Higher-level thinking students interacted with ChatGPT by asking, "Please create an instructional design that incorporates the PBL model on the topic of what color it is in order to stimulate students' interest in learning and deeper exploration of the content."

Table 1

Statistical Analysis of Learning Behavior Frequency

Levels of Thinking	Total	Percentage
Low-level thinking	74	0.41
Authentic Questions (AQ)	28	0.16
Cumulative Talk (CT)	24	0.13
Uptake Questions (UQ)	22	0.12
Intermediate-level thinking	68	0.39
Shared knowledge Questions (SkQ)	18	0.11
Speculation Questions (SQ)	20	0.11
Exploratory Talk (ET)	16	0.09
Challenge Questions (CQ)	14	0.08
High-level thinking	30	0.15
High-Level Thinking Questions (HLTQ)	12	0.06
Analysis Questions (AQ)	8	0.04
Generalization Questions (GQ)	10	0.05

EMPOWERING EDUCATION EDUCATORS: TRANSFORMATION OF THE TEACHER EDUCATION PARADIGM

Re-Imagining Teacher Preparation Programs With AI Infusion

Generally, lesson preparation is a time-consuming and laborious task for teachers, who need to understand the teaching objectives and content and collect the information needed for the teaching process, and then integrate it into the overall teaching process (Gimbert et al., 2007). GAI, with its powerful computational and content-generation capabilities, can quickly and accurately provide teachers with a complete set of instructional resources, including pre-course material preparation, instructional design outlines, instructional activity design, and instructional knowledge point displays (Rahman & Watanobe, 2023). GAI interventions offer significant opportunities to improve teacher preparation. Firstly, the application of GAI can significantly save time in lesson preparation, enabling educational practitioners to utilize their expertise more effectively (Aslan, 2021). In addition, GAI provides richer and more accurate educational resources and enables interdisciplinary integration of multiple domains of knowledge to better meet instructional needs. However, educators face the challenge of developing GAI to generate lesson preparation resources that meet their specific instructional needs (Liu et al., 2022). This includes effectively integrating large amounts of information, ensuring the originality and educational quality of generated content, and avoiding ethical issues such as knowledge plagiarism. These challenges require educational practitioners to actively explore and develop training models, develop appropriate ethical guidelines, and continually improve the performance of GAI to achieve a more personalized and efficient lesson preparation process.

Simulation-based training for pre-service educators

Teacher education is a systematic and planned learning process aimed at nurturing and developing the professional knowledge, skills, attitudes and reflective abilities of educational practitioners to enable them to perform their educational duties effectively and to promote student learning and development (Eßling et al., 2023). Simulation training plays an important role in teacher education as an educational strategy that provides educational practitioners with practical experiences and opportunities to develop their educational skills by simulating real educational scenarios. However, simulation training faces several problems, including the high cost of time, difficulty in developing higher-order thinking skills, and difficulty in mimicking emotional and social factors (Spector & Ma, 2019). GAI offers a potential opportunity for simulation training for teacher education. This opportunity includes, but is not limited to, simulating real teaching scenarios through virtual simulation environments to help educational practitioners develop educational skills and instructional strategies. The GAI can be used as a virtual tutor or tutee to provide situations similar to real classroom environments (Chen, 2022), allowing teachers to practice and improve their educational skills in the simulation. For example, GAI can play the role of virtual tutors to provide learning support, answer questions, and improve learning performance (Qiu et al., 2022). In addition, GAI can help students learn how to introduce themselves and answer the interviewer's questions through simulated interviews, laying a solid foundation for their future careers (Cabezas-González et al., 2021).

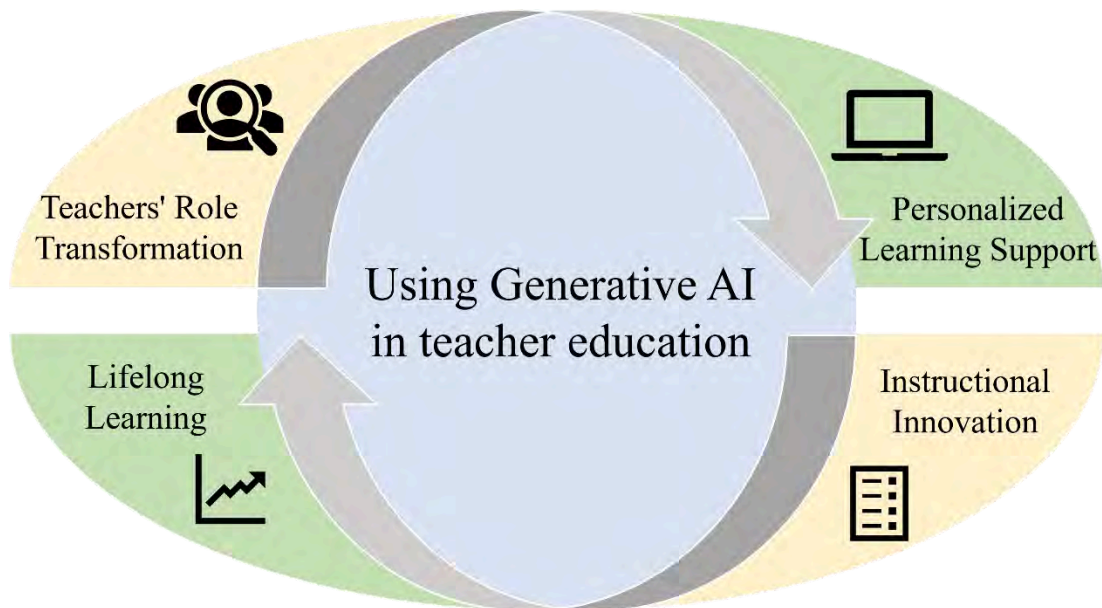
Continuous professional development empowered by generative AI

As shown in Figure 3, the technological context of GAI and future teachers' professional development needs to focus on several key aspects. First, teachers' professional roles will undergo a transformation, gradually evolving from traditional knowledge transmitters to more tutors and learning supporters. This means they will focus more on guiding students' self-directed learning and problem-solving skills, emphasizing student engagement and initiative rather than merely imparting factual knowledge (Lockee, 2020). Second, teachers will need to think deeply about how best to use GAI to improve instructional effectiveness and provide personalized learning support. The use of GAI technology will open up opportunities in the field of teacher education, such as automated task distribution, data analysis to personalize lesson design, and the provision of immediate feedback. Teachers will need to actively explore and incorporate these technologies to improve the quality of education and meet the needs of diverse students (Rospigliosi, 2023). Third, teachers will also need to think about how to use GAI to drive innovation in teaching and learning. This includes utilizing emerging technologies such as virtual reality, adaptive learning systems, and simulation experiences to improve student learning experiences and educational outcomes. Teachers will need to actively learn and adapt to these new approaches in order to stay on the cutting edge of the educational field (Bailey et al., 2020). Finally, educators will be faced with the need for lifelong learning to adapt to evolving educational technologies and GAI developments. This will require systems to support teachers' professional

development, including ongoing training, resource sharing, and interactive learning communities to ensure that they are able to keep up with technological advances and provide the best educational services to students (Lozano et al., 2023). Taken together, future teacher professional development will undergo an evolution of professional roles within the technological context of GAI, better use of technology to improve efficiency and personalized learning support, drive innovation in teaching and learning, and ongoing lifelong learning to keep pace with evolving educational technology and GAI.

Figure 3

Continuous Professional Development Empowered by GAI



Note. Figure depicts four aspects of teacher professional development.

Collaborative Learning Environments Facilitated By AI-Enhanced Tools

GAI can innovate collaborative learning models by providing personalized, virtualized, automated, and intelligent support to improve the effectiveness and quality of student collaboration, promote interdisciplinary cooperation, and foster collaboration among students in different locations and contexts. GAI offers multiple opportunities to innovate collaborative learning models in teacher education, covering several areas: First, GAI can improve the way teachers interact with AI systems through intelligent machine learning algorithms and natural language processing techniques. Such innovations can make it easier for teachers to interact with GAI by providing more natural and intelligent conversational interfaces for personalized educational support and feedback (Pérez-Segura et al., 2020). Second, GAI can facilitate the formation of virtual teacher communities, where teachers can share teaching experiences, materials, resources, and best practices on a virtual platform. At the same time, GAI can provide support for educational research by analyzing large amounts of educational data and generating insights that can help teachers conduct more in-depth educational research and improve educational practices (Mendez-Reguera & Cabrera, 2021). Third, GAI can facilitate collaborative learning among teachers through automated partner matching, task assignment, and progress tracking. It can facilitate more effective collaborative learning by connecting teachers with appropriate partners based on their areas of expertise and interests and monitoring the progress of collaborative projects to provide support and feedback (Wang et al., 2021). Finally, GAI can provide a virtual collaborative environment between teachers and students that encourages collaboration across ages and backgrounds. It can provide educators with tools and platforms to improve communication and collaboration with students, facilitating a more creative and interactive educational experience through online collaboration, virtual labs, and more (Bragg et al., 2021). Taken together, GAI has broad potential to innovate collaborative learning models in teacher education that can advance the field of education and support more

effective education by improving human-computer, teacher-teacher, student-student, and teacher-student collaborative learning models. These innovations will help meet evolving educational needs and improve the quality and efficiency of education (Ellis & Slade, 2023).

ETHICAL CONCERNS IN GENERATIVE AI INTEGRATION

Privacy and Data Security Considerations

GAI has had a tremendous impact in the field of teacher education, but its application has also raised a number of unavoidable ethical concerns (Duha, 2023). The first is that student data privacy is one of the key ethical concerns raised by GAI in the field of teacher education. The use of GAI for educational assessment and personalized learning involves large-scale collection and analysis of student data. This includes sensitive data such as academic performance, behavioral patterns, and personally identifiable information. There are potential threats to students' privacy rights, and if data are not properly protected, this can lead to inappropriate data access, misuse, or disclosure, which in turn raises issues of personal privacy violations and potential identity theft (Hill-Yardin et al., 2023). Second, educators' personal and professional data may also be at risk. When educators interact with GAI systems, they may share information about themselves, including educational background, teaching methods, and assessment data. In the same way that educators have no clear way of knowing how their data will be used, developers have no way of knowing whether they want it to be used. These data also need to be subject to appropriate privacy protections to prevent unauthorized access, misuse, or disclosure of the data in order to maintain educators' right to privacy (Enwald et al., 2022). Third, data misuse. Educational data collection and analysis may be misused for commercial purposes, advertising targeting, or other inappropriate uses. Educator and student data may be sold to third parties, triggering privacy invasions and inappropriate data use that can jeopardize individual privacy rights. Fourth, data security breaches are another potential ethical risk that GAI raises in the education sector. GAI systems may have security vulnerabilities that give hackers access to education data. This situation could lead to personal information leakage, data loss, or other security issues, further threatening the privacy and integrity of the data. To address these ethical risks, appropriate technical and legal measures must be taken to ensure that the privacy and security of educational data are adequately protected (Popenici & Kerr, 2017).

Addressing Algorithmic Bias and Fairness Issues

The application of GAI in the field of teacher education, despite its potential to improve the efficiency and quality of education, also poses many ethical risks, including algorithmic bias (Noble, 2018), inequality of educational resources, technological dependence, and knowledge plagiarism, which are ethical risks that pose a potential threat to educational equity. First, algorithmic bias may be one of the major risks. Because GAI algorithms are trained on unbalanced educational datasets, they may inherit biases from these data, leading to inequitable educational outcomes. This could mean that the needs of specific groups are given more attention (Eschenbach & Warren, 2021) while other groups are ignored. In addition, the algorithms themselves are potentially biased, depending on the training data and algorithm design. For example, gender or racial bias may be evident when generating educational content (Meyer et al., 2023). Second, the application of GAI may lead to the risk of unequal distribution of educational resources. If a GAI system allocates scholarships, educational support, or other resources based on individual data and characteristics, it may exclude some students or teachers, thus exacerbating inequalities within the educational field (Grassini, 2023) and hindering equity in education. Third, technology dependence is a potential ethical risk. If educators and students become overly reliant on GAI systems and no longer develop their own judgment and decision-making skills, they may become vulnerable to independent thinking about educational decision-making, thus diminishing their educational autonomy, which poses a potential risk to equity in education. Finally, knowledge plagiarism is also an important ethical issue. Teachers and students may misuse the GAI system to plagiarize the work or answers of others, thereby violating the principle of academic integrity and undermining the fairness and ethics of education.

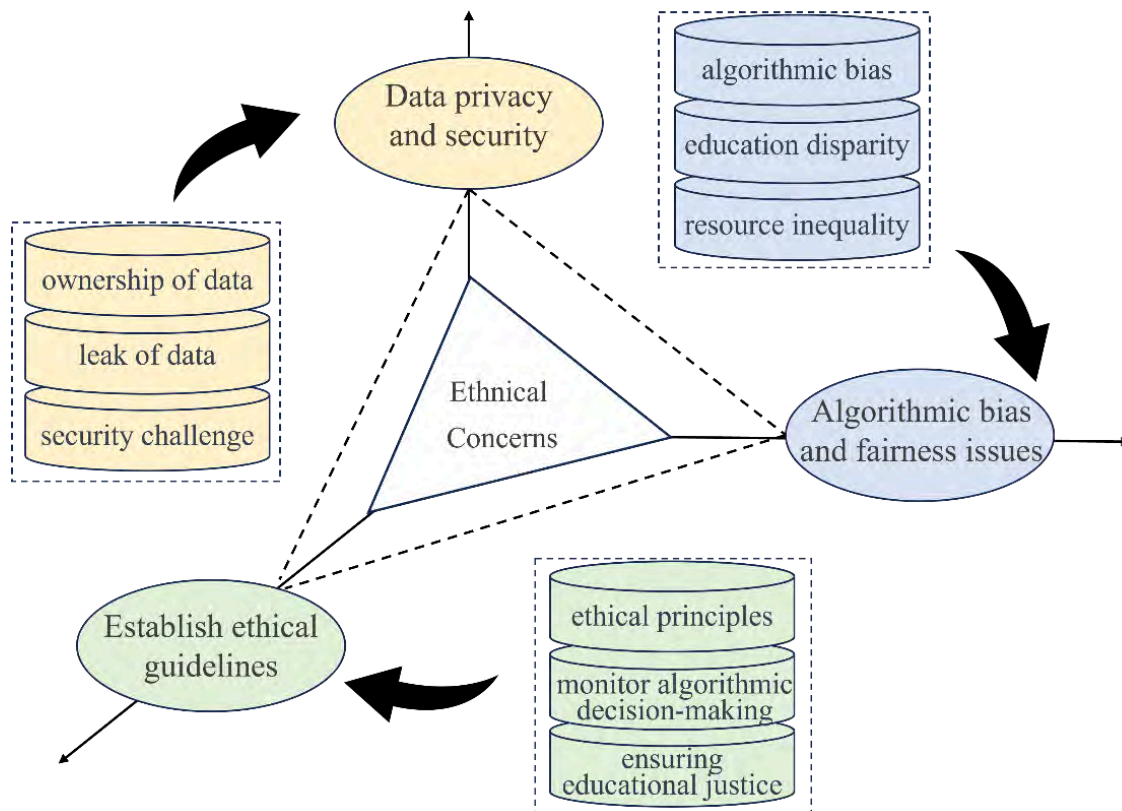
Establishing Ethical Guidelines for AI-Augmented Teacher Education

Establishing ethical guidelines for teacher education enhanced by AI is crucial to help ensure that ethical principles and best practices are followed in the use of technology in education. We have created a framework of

guidelines for teacher education for this purpose, as shown in Figure 4, to inform teacher educators to critically adopt GAI in teacher education based on the guidelines for GAI in education proposed by governments, international organizations, and universities. First, privacy and data protection guidelines are key to guaranteeing the privacy and security of students' and teachers' personal data. Second, guidelines should focus on fairness and equality in teacher education, requiring that the design and application of GAI tools should not introduce bias or discrimination to guarantee equal benefits for all students. In addition, transparency and interpretability are imperative, requiring educational institutions and developers to provide clear information so that teacher educators can understand how GAI works and the decision-making process (Chan, 2023). Teacher educators should avoid over-reliance when using GAI tools (Wang & Wang, 2019), monitor algorithmic decision-making, and correct inequities. Additionally, education and training are essential to help education practitioners better understand and address ethical challenges. Finally, mechanisms for continuous monitoring and improvement can ensure that these guidelines are effective and updated and improved as needed to ensure that GAI is properly managed in the application of teacher education and that equity and quality of education are maintained. The development of and adherence to these guidelines is critical to the establishment of a sustainable AI-enhanced teacher education system.

Figure 4

Ethical Concerns for Teacher Education with GA



Note. Figure depicts three key elements of “Ethical Concerns” for generative AI

A VISION OF THE FUTURE GAI FOR TEACHER EDUCATION

Anticipated advancements in generative AI technology were expected. The GAI of the future will have a higher level of comprehension and reasoning capabilities to better interpret the content it generates and reason based on understanding the context to generate more accurate and coherent content (Lee et al., 2023). GAI will be able to better understand information and generate content in multiple languages, which will play an even greater role in

cross-cultural communication. In order to train a better GAI to adhere to moral and ethical guidelines, moral and ethical improvement is also one of the future research focuses (Munn, 2022). The level of awareness of ethical guidelines can be gradually improved by, for example, providing GAI with ethical simulation data. In order to safeguard the personal information and privacy of students and faculty, appropriate data protection policies should also be developed to ensure that these data are adequately protected during transmission, storage, and processing.

It's worth mentioning that developing teacher educators' AI literacy in the era of GAI will help them effectively adapt to changes in education (Nedungadi et al., 2020). First, teacher educators and future teachers need to be data literate, which includes understanding how to capture, analyze, and interpret educational data to better personalize instruction and assess student performance. Second, they need to be AI ethically literate to be able to recognize and address the ethical and privacy issues associated with AI applications (Mello-Thoms, 2023) to ensure the safe and legal use of student and teacher data. In addition, educators need to be technologically literate and able to flexibly use educational technologies and GAI tools to enhance teaching and learning (Ng et al., 2021; Su et al., 2022) and improve the quality of education. Furthermore, interdisciplinary thinking and collaboration skills are important, as the application of GAI in teacher education involves multiple subject areas, and teacher educators and future teachers need to be able to collaborate across boundaries and work together to innovate pedagogy. Finally, the literacy of continuous learning and updating knowledge is crucial to keep up with the development of AI technology, and teacher educators need to maintain a keen sense of learning to adapt to new technologies and trends at any time. In conclusion, fostering AI literacy among teacher educators includes data literacy, ethical literacy, technological literacy (Wang et al., 2022), interdisciplinary thinking, and continuous learning, which will help them better guide their students to face an increasingly intelligent educational environment.

Promoting interdisciplinary research and collaboration for sustained innovation is not only important but necessary. GAI, supported by a powerful multidisciplinary knowledge database, can achieve higher precision data analysis, simulation, and prediction in different fields. For example, GPT-4 released by OpenAI, which is a multi-modal large model that can process and output text as well as process images and give text analysis, has shown obvious technical advantages in article generation, question answering, and code writing and has been habitually applied in various fields, including library services (Chen, 2013), healthcare (Chang et al., 2022), education, and so on. Therefore, the future research focus and teaching time in the field of teacher education emphasizes interdisciplinary knowledge sharing and communication, and with the support of technologies such as virtual reality and augmented reality, we expect more immersive virtual communities to promote interdisciplinary collaboration and knowledge integration and innovation to promote the sustainable development of teacher education.

CONCLUSION

This chapter provides a comprehensive exploration of the multifaceted impact of GAI on teacher educators' research endeavors and teaching practices. By examining teaching strategies, instructional systems, ethical considerations, and future possibilities, it aims to provide reflections on the transformative potential of GAI in the field of teacher education. From a broader perspective, GAI technologies are anticipated to persist in advancing on multiple fronts and assume an increasingly prominent role across diverse domains. However, we also need to note that the development of GAI has also brought about some challenges, such as data privacy and security, GAI bias, and other issues. While we promote the development of technology, we also need to pay attention to these issues and take corresponding measures to solve them. We propose distinct visual frameworks for using GAI in the professional practice of Teacher educators. We call for a comprehensive approach to integrating GAI into teacher education while encouraging ongoing exploration and adaptation in an evolving educational environment.

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Envisioning Generative AI in Teacher Education in Malawi: The Role of Teacher Educators as Researchers and Curriculum Developers

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INTRODUCTION

Generative Artificial Intelligence (AI), a subset of artificial intelligence, has garnered attention for its ability to generate text, images, and audio content. This powerful ability has profound implications for the educational sector, allowing for personalised learning, enhanced creativity, and improved accessibility. With Generative AI, it becomes possible to offer tailored learning experiences. Systems can generate specific content based on the student's learning style and pace (Chen et al., 2022). Generative AI models can collaborate with students in creative projects, offering suggestions and generating content, enhancing the creative process (Al-Shoqran & Shorman, 2021).

However, research from high-income countries, on the one hand, reveals a mixed response to AI's integration into education. Some scholars highlight its potential in addressing teacher shortages and personalising education (Alam, 2021). Others caution against over-reliance due to potential pitfalls such as bias and reduced human interaction (Borenstein & Howard, 2021). On the other hand, a literature search shows that despite the proliferation of AI research in high-income countries, the African context remains understudied. AI in the African continent is still understudied due to barriers, such as a lack of appropriate technological infrastructure and a shortage of well-trained personnel to work with AI (Okolo et al., 2023). Salas-Pilco et al. (2022) conducted a systematic review of the literature on the application and impact of AI in teacher education, and of the 30 papers included for review, only two were from Africa. Accordingly, Adams et al. (2023) recommend setting a research agenda for generative AI to generate insights into the risks and benefits of AI unique to the context of African societies. In education, some of the potential risks associated with generative AI in Africa can include students' exposure to biased or incorrect information or causing harm to people in terms of gender, religion, or race.

This situation presents a significant gap as African countries' educational challenges and socio-cultural context, such as Malawi, differ considerably from their counterparts in high-income countries. Furthermore, the capacity of Generative AI to produce content raises concerns about plagiarism, data privacy, and the potential for misinformation (Dien, 2023). Over-reliance on Generative AI is perceived to compromise fundamental human skills and critical thinking abilities (Fui-Hoon Nah et al., 2023). In addition, a one-size-fits-all approach to AI might not cater for the specific needs and sensibilities of diverse learner populations across the globe (Yang et al., 2021). Smakman et al. (2021) discuss the ethical considerations, emphasising the importance of ensuring that AI tools are used in ways that are transparent and do not inadvertently introduce biases into the learning environment. Thus, continued research and discourse, with sufficient attention to low-income countries, are necessary to navigate the evolving landscape of generative AI in education.

In this chapter, we focus on the future of generative AI and teacher education in Malawi, especially the role of teacher educators. We argue for the important role of teacher educators in enhancing AI integration into teacher education in Malawi, make clear why teacher educators must be prepared to utilise AI, and what this would require for the scholarship of teacher education in Malawi. We aim to provide insights into the development of productive use of generative AI in teacher education, such as theorising the evolution of current teacher education programmes in future, including questions around the role and relevance of teachers in teaching and learning in the context of AI.

The chapter is outlined as follows. First, we present the broader context of technology and teacher education. The following section highlights the roles of teacher educators in technology integration, followed by the roles of teacher educators as researchers and curriculum developers in shaping the future of AI in Malawi. The

conclusion is preceded by a discussion on teacher educators' preparation for an effective uptake of generative AI in Malawi.

CONTEXT OF TECHNOLOGY AND TEACHER EDUCATION IN MALAWI

The Malawi National Education Sector Implementation Plan (NESIP 2020-2030) recognises the need to integrate Information and Communication Technology (ICT) into all aspects of the education system to promote digital literacy and enhance the quality of education. The general objective for teacher education and development is to increase the number of qualified teachers who contribute to the quality of primary and secondary education (Ministry of Education, Malawi, 2022). ICT has the potential to increase access to teacher education in the country. The NESIP recommends digital literacy among teachers and a focus on developing digital content relevant to the Malawian context and aligned with the national curriculum. It is acknowledged that utilising technology to make teacher training more accessible, flexible, and affordable may help to increase the number of student teachers enrolled in teacher training institutions.

Accordingly, the Ministry of Education has focused on institutionalising alternative modes of teacher training, including the development of Learning Management Systems (LMS) and offering electronic Continuing Professional Development (CPD) for teachers (<https://ecpd.education.gov.mw>). The Ministry has also developed and implemented online and offline digital libraries (<https://library.tikwere.org/>), provided free WiFi connectivity, created radio lessons and programs for all primary school teachers and all teacher educators, and is developing an ICT in education policy. Further, teacher educators have had access to the Integration of Technology in Teaching and Learning (ITTL) course, which focuses on developing online learning materials for students and provides insights into developing content and interactive digital learning material (Ministry of Education, Malawi, 2023). These initiatives are in line with the Ministry's policy agenda of promoting virtual learning to provide access to high-quality education for all learners, even in hard-to-reach areas.

The other potential role of technology in education in Malawi is visible in research and development. Currently, training of lecturers in higher education institutions (which include teacher education institutions) to Masters and PhD levels and encouraging institutions of higher learning to publish their research work is recognised as one of the priority areas for enhancing quality and relevance of higher education in Malawi (Ministry of Education, 2022). To achieve this goal, the Ministry of Education has focused on harnessing the potential of digital technology in supporting research activities. For example, the Ministry has developed an online knowledge portal that provides content on the physical progress of implementing educational development activities related to the Ministry and its partner agencies (Ministry of Education, 2022). The platform also offers opportunities for research agencies to share research findings.

Despite numerous ICT-driven initiatives within teacher training institutions to harness ICT for learning support, not all institutions have access to the ICT infrastructure. Again, much of the digital education interventions in Malawi rely on external actors. Among others, international development partners have been working to equip teachers with digital skills. For example, in 2020, a training on Global Citizenship Education involving teachers in secondary and primary schools covered modern digital teaching methods (Saka, 2021). Furthermore, although it is claimed that ICT can play a pivotal role in addressing educational disparities and fostering a more equitable and inclusive educational landscape in Malawi (Chikasanda et al., 2018), little or no evidence exists to support such claims. According to Saka (2021), the lack of comprehensive data concerning the utilisation of ICT in education in Malawi is one major challenge. As such, most claims about the potential of ICT in teacher education are still speculative. This knowledge gap creates room for further research on technology integration (including AI) into teacher education.

Since little is known about the use of AI in teacher education in Malawi, we derive insights from the general technology use in teacher education. Unlike other technologies such as radio and media players (Carrier et al., 2012), the Internet and iPads, little is known about AI's real benefits and risks in education in general and teacher education in particular. Some AI interventions have focused on education in general or other sectors such as health and agriculture. In a related development, the Malawi University of Science and Technology (MUST) has established the Centre for Artificial Intelligence and STEAM to champion the Fourth Industrial Revolution (4IR) and promote humanistic Science, Technology, Engineering, Arts and Mathematics (Mphande, 2023). According to Mphande (2023), the Centre is expected to offer education, technical, policy and strategy products and services in emerging technologies, including Artificial Intelligence, Machine Learning and Deep Learning in the country. Apart from MUST, Frontier Technologies Hub has been exploring the potential impact of AI on development challenges

related to connectivity in education in Malawi and Kenya, with a primary focus on promoting skills development for jobs and life in the AI era (UNESCO, 2019).

Similarly, in terms of research, some studies have focused on AI in education in general. For example, Colak et al. (2023) applied machine learning to illustrate the potential of AI in predicting school dropouts in Malawi, considering that "data collection and management systems are relatively more prone to financial and technical constraints" (p. 1). For teacher education, it is only speculated that the adoption and effective utilisation of AI holds the potential for catalysing positive transformation in teacher education (Colak et al., 2023). Elsewhere, examples of AI applications in teacher education include scoring students' video presentations, identifying at-risk student teachers likely to drop out, or checking student's written reflections (Salas-Pilco et al., 2022). Heimans et al. (2023) add that AI allows us to rethink relations between the processes and the products of teacher education and related scholarship.

Building on the above interventions and insights from research, we can only speculate on the potential of AI in teacher education in Malawi. Among others, integrating AI can mark a shift from the current "basic, rudimentary and often obsolete technologies, which make delivery of teacher education via distance model cumbersome for both tutors and students" (Msiska, 2015, p. 1). Again, generative AI can also be beneficial in terms of personal tutoring to respond to the current growing student numbers in Malawi's teacher education. In this chapter, we envision the future of generative AI in teacher education in Malawi, especially the role of teacher educators in realising the potential of generative AI.

ROLES OF TEACHER EDUCATORS IN TECHNOLOGY INTEGRATION

Lunenberg et al. (2014, p.6) reviewed the literature to understand teacher educators' professional roles and behaviours. A professional role is "a personal interpretation of a position based on expectations from the environment and on a systematically organised and transferable knowledge base". The authors report that teacher educators perform one or more of the following roles: teacher of teachers, coach, broker, researcher, curriculum developer, and gatekeeper. As curriculum developers and researchers, they use these roles to make a case for the role of teacher educators in advancing the future of AI in teacher education in Malawi. The role of a researcher involves conducting and utilising research findings while curriculum development relates to teacher education curriculum.

For this chapter, we use the example of public teacher education institutions to illustrate the current roles of teacher educators in Malawi, where the Teaching Service Commission oversees the recruitment of teacher educators in all the public teacher training colleges. Teacher educators are recruited based on their previous teaching experience and minimum qualification of a Bachelor of Education degree. This expectation corroborates with Swennen et al. (2010) observation that prior school teaching experiences give teacher educators the credibility to be teachers of teachers. In all public TTCs, teacher educators are categorised in rank (e.g., head of department, principal lecturer, senior lecturer) or subject specialisation (e.g., languages, mathematics, etc.). Table 1 shows the roles of teacher educators according to one of the Ministry of Education's adverts.

Table 1*Roles of Teacher Educators in Malawi*

Rank/Grade	Roles and responsibilities
Senior Lecturer	Preparing lesson plans and lecturing. Assessing students' performance. Conducting tutorials. Supervising lecture sessions and projects. Supervising students in the field on attachment for teaching practice.
Head of a Department	Organising and arranging departmental meetings. Monitoring the performance of Lecturers and making recommendations for advancement or improvement. Participating in curriculum development activities. Lecturing in some subjects. Encouraging classroom research. Ordering for materials and equipment for the department.

Note. Based on the 2018 Vacancy for TTC Lecturers, Teaching Service Commission

Table 1 illustrates teacher educators' roles based on rank differences and similarities. Worth noting is that while the teaching role is familiar to all teacher educators, more roles are added as one rises the professional ranks. In this chapter, we are particularly interested in the roles of participating in curriculum development and encouraging classroom research. These roles align with the Ministry of Education's policy expectations and cut across other teacher education institutions, including Universities.

TEACHER EDUCATORS AS RESEARCHERS

In the absence of evidence showing the actual benefits of ICT in Malawi's teacher education, one gets the impression that the language of technology and education is exaggerated and "full of bullshit" (Selwyn, 2016, p. 1). The optimistic presentation of the role of technology in education in policy documents and the literature in general can be misleading. Meanwhile, the danger of this way of talking and thinking about technology must pay attention to the complexity of various educational contexts in Malawi (Selwyn, 2016). For instance, such language can obscure some real challenges that the country is facing, such as providing citizens with access to ICT equipment and the Internet, the low number of schools connected to the Internet (and the quality of that connection), and the lack of trained teachers to use ICT (Saka, 2021). Research about and with AI in teacher education is important for the context of Malawi to advance the productive use of AI in teacher education.

For teacher educators to contribute to the future of generative AI in teacher education in Malawi, they ought to be actively engaged in research about and with generative AI for teacher education. Kyaw (2022) highlights two perspectives of teacher educators' research engagement: engagement with research, which involves reading research-related materials, and engagement in research, which is about conducting research either as an individual teacher educator or a group of teacher educators. In Malawi, teacher educators' research engagement on and with AI can mean reading the literature on generative AI in teacher education or carrying out teacher education research supported by generative AI tools and techniques. One opportunity for teacher educators' research engagement in Malawi is that, at the policy level, research is also recognised as a professional development activity and for career progression. The Ministry of Education (2016) expects teacher educators to research and utilise the findings to inform their practice. Such a policy context is necessary for teacher educators' research engagement (Kyaw, 2022).

Furthermore, while there is little or no research on generative AI in teacher education in Malawi, Salas-Pilco et al. (2022) report that the international literature on AI in teacher education has focused on behaviours, perceptions, and digital competence of pre-and in-service teachers regarding the use of AI. Teacher educators can capitalise on the infancy of information technology and teacher education in Malawi to contribute to conversations on generative AI in teacher education. The following example illustrates the use of generative AI for teacher education research in Malawi.

When we were writing this chapter, we used ChatGPT to generate the literature related to the focus of the chapter. We started by asking for the literature on the cultural context of teacher education in Malawi. The following is an extract from our conversation with ChatGPT in response to the prompt “culture and teacher education in Malawi”:

Teacher education in Malawi takes into account the cultural context of the country. Effective teaching strategies often incorporate elements of local culture and traditions to make the learning experience more relatable and engaging for students. Malawi is linguistically diverse, with various indigenous languages spoken across the country. Teacher education programs may need to address language barriers and promote multilingual education to ensure effective learning (Open AI, 2023).

We also prompted ChatGPT to present the literature on “technology and teacher education in Malawi”.

In response, ChatGPT reported that, in recent years, technology had been increasingly recognised as a potential tool to enhance teacher education and improve the quality of instruction in Malawi. According to Open AI (2023), the following are some ways in which technology has been integrated into teacher education:

- Online Courses and Resources: Online courses and resources have provided training and professional development opportunities for teachers, especially those in remote areas. These resources cover pedagogical techniques, subject content, and educational technology integration.
- Digital Content: Digital educational materials, such as e-books, videos, and interactive lessons, can supplement traditional textbooks and help teachers explain complex concepts to students more effectively.
- Virtual Workshops and Webinars: Virtual workshops and webinars allow educators to participate in training sessions without needing physical travel. This approach can reach a wider audience and facilitate knowledge sharing.
- Education Management Systems: Technology can help streamline school administrative tasks, such as attendance tracking, student performance assessment, and resource allocation. Education management systems can enhance efficiency and data-driven decision-making.
- Collaborative Learning Platforms: Online platforms can facilitate collaboration and knowledge-sharing among teachers. Teachers can exchange ideas, share best practices, and discuss challenges they face in their classrooms.

Responding to our prompt “using AI in teacher education”, Open AI (2023) suggested as follows:

It is important to note that while AI has great potential in teacher education, it should complement rather than replace traditional pedagogical practices. The human touch, empathy, and critical thinking skills educators bring to the classroom are irreplaceable. Integrating AI should be done thoughtfully and ethically to ensure that it enhances the overall quality of teacher education and, by extension, students' learning experiences.

ChatGPT also shared some challenges in technology integration into teacher education in Malawi in response to our query “teacher education and technology in Malawi”. While the integration of technology in teacher education has the potential to bring about positive changes, some challenges need to be addressed:

- Digital Divide: Access to technology and the Internet remains uneven in Malawi, with rural and underserved areas facing limited connectivity and device access.
- Infrastructure: Adequate technology infrastructure, including reliable electricity and internet connectivity, is essential for effective technology integration.
- Teacher Training: Teachers need training to use technology in their teaching effectively. Without proper training, technology might not be utilised optimally.

- Content Localisation: To ensure effectiveness, digital content should be culturally relevant and aligned with the local curriculum.
- Sustainability: Ensuring the sustainability of technology initiatives requires long-term planning, including maintenance, updates, and addressing changing technological needs.

More importantly, ChatGPT advised us to consult more recent sources, such as government reports, educational organisations, and news articles, for the latest information on teacher education and technology in Malawi.

From the above conversation with ChatGPT, we see the potential of generative AI in supporting research on teacher education, especially in searching for literature sources and a possible outline of the write-up. The results of the literature search through ChatGPT partly helped us structure this chapter's narrative. We also appreciated that, by acknowledging that the currency of literature changes, ChatGPT demonstrates its limitation, which resembles human thinking when deciding the reliability of literature sources. Yet, considering that ChatGPT can generate citations for sources that do not exist, we referred to some published work on the subject to verify the reliability of the literature reported by ChatGPT. We observed that the above-reported practices and challenges of technology integration into teacher education in Malawi are in line with what is found in the existing literature and government reports (e.g., Ministry of Education, 2022; Saka, 2021; Gondwe, 2020; Mazolo, 2018). Moreover, the speculated potential and responsible use of AI in teacher education align with what has been published elsewhere (e.g., Salas-Pilco et al., 2022; UNESCO, 2019).

TEACHER EDUCATORS AS CURRICULUM DEVELOPERS

Teacher educators should actively undertake their role as curriculum implementors in championing the future of generative AI in Malawi. This involvement can be in the form of contributing to teacher education curriculum reform and preparing student teachers for their future role in contributing to curriculum reforms. Contributing to policy debates aligns with one of the core competencies that teacher educators are expected to meet. According to the Ministry of Education (2018), teacher educators should “demonstrate understanding and application of education policies and practices” and “demonstrate mastery of content area and approved curriculum” (p. 16). To achieve these aspirations, a curriculum that seeks to promote AI in teacher education in Malawi should consider teacher educators' professional needs (Mazolo, 2018). More importantly, such efforts should build upon the current teacher education curriculum.

To illustrate, instructional technology is currently offered as a separate subject and within different modules of the Initial Primary Teacher Education programme. For example, "teaching and learning resources for upper primary" is one of the topics in the Foundations of Education module (Malawi Institute of Education, 2017, p. 26). Student teachers learn about topics such as Teaching and Learning Using Locally Available Resources, abbreviated as TALULAR (Malawi Institute of Education, 2004). Training on TALULAR prepares student teachers to obtain, develop, and use local resources. The students practice using resources such as natural objects or anything improvised from their surroundings. The concept of TALULAR is significant across the education system in Malawi because the availability of instructional technology mainly relies on government funding and external donors. According to the Malawi Institute of Education (2004, p.1), "many teachers think of teaching and learning resources as commercially produced instructional materials only, such as printed charts, pupils' books, teachers' guides, globes, marker pens and radios".

In addition to TALULAR, ICT is recognised as a cross-cutting issue that can enhance teachers' life-long learning (Malawi Institute of Education, 2018). The inclusion of ICT in the IPTE course reflects the national teacher education policy's aspirations: to educate teachers who can continually develop their professionalism. ICT is also included so that students can acquire 21st-century skills (Ministry of Education, Malawi, 2016). For instance, ICT helps learners advance their learning, become inquisitive and develop manipulative skills (Malawi Institute of Education, 2018). A separate ICT training manual also focuses on guiding student teachers and teacher educators in developing the skills and knowledge needed to use educational technology to teach learners and develop their ICT competency. For example, teachers and students can use ICT for accessing, creating, sharing, and storing information. Accordingly, student teachers learn about computer packages, especially Microsoft Office and the use of tablet technology in the teaching and learning of primary school literacy and numeracy.

The above description presents the current vision of instructional technology to create more personalised, engaging and effective learning experiences in general, as well as methods and approaches for enhancing teachers' and educators' effective use of instructional technology in Malawi's primary teacher education. It is especially

important to note that the expectation to use instructional technology is already impacting primary teacher education's curriculum content and approach in teacher training institutions to incorporate diverse, up-to-date content and resources through personalised learning experiences. These changes in the teacher education curriculum present both opportunities and challenges related to the role of teacher educators in shaping the future of AI in teacher education. The current teacher education curriculum is an opportunity for teacher educators to ensure that the ability to harness the potential of generative AI is regarded as an important competence for pre-service teachers and teacher educators. Making generative AI visible in the teacher education curriculum would be necessary for teacher educators' practices and professional development (Instefjord & Munthe, 2016).

PREPARING TEACHER EDUCATORS FOR AI IN MALAWI

Building upon the preceding sections highlighting the roles of teacher educators in the productive use of generative AI in teacher education in Malawi, we now argue for teacher educator preparation for the effective integration of generative AI into teacher education in Malawi. The literature suggests varying degrees of tech-savviness among educators, often dependent on institutional support, infrastructure, and personal initiative (Spiteri & Chang Rundgren, 2020). Celik (2023) surveyed teacher educators and found that while many were aware of the term "generative AI," a majority lacked a deep understanding of its functionality and implications for teaching. Zawacki-Richter et al. (2019) note that educators often conflated generative AI with other forms of AI, indicating a need for more specialised training in this domain. The rapid evolution of generative AI and its potential applications in the classroom underscores the need for professional development. Xia et al. (2022) highlight that a structured professional development program on generative AI is crucial for current educators and those in teacher training programmes.

According to Casal-Otero et al. (2023), AI literacy is becoming a fundamental skill, much like digital literacy was in the early 2000s. Teachers should understand the basics of AI to prepare students for future careers and informed citizenship. Roll and Wylie (2016) emphasise the pedagogical shifts required when teaching in the context of AI. Since AI is dynamic, one-off orientation sessions are not sufficient. Gondwe (2021) recommends regular technology professional development activities to keep teacher educators updated through professional development frameworks. Gondwe's review on professional development in the context offers a pivotal starting point for educators to model effective AI integration to pre-service teachers. By understanding the unique needs of the South African educational landscape, Mangundu (2023) proposes an adaptable, relevant, and sustainable structure. Mangundu's study examined the intersection of experiences, attitudes and TPACK self-efficacy to determine their influence on the readiness of student teachers to use online multimodal teaching. The study recommends that teacher educators ensure coherence between teacher education curriculum and what is obtained during teaching practicum and "consider providing pre-service teachers with online multimodal teaching experiences to enhance pre-service teachers' e-readiness" (Mangundu, 2023, p. 13).

In the case of Malawi, some opportunities support the argument for preparing teacher educators in the domain of AI. To illustrate this, the organisation of technology professional development for teacher educators in all teacher training colleges is guided by the TTC Management Handbook and the CPD framework (Ministry of Education, 2018). At the national level, the CPD framework for teachers and teacher educators offers guidelines for planning, implementing, and evaluating CPDs. For instance, it suggests roles of different institutional stakeholders and structures such as CPD committees, college principals and heads of departments. These guidelines are then contextualised to suit the needs of each institution. CPD committees ensure that each department should benefit from resources to conduct their professional development activities. They get reports from different activities on professional development across the institutions. Some teacher training colleges have ICT committees that maintain technology resources and coordinate ICT-related training. Students and teacher educators access ICT services in computer laboratories, sometimes guided by rules regulating Internet use.

Building upon the preceding context of technology professional development of teacher educators in Malawi, we suggest the Technology Readiness Index (TRI) to illustrate the application of theory in understanding teacher educators' preparedness for integrating generative AI into their work. Chimbunde (2022) applied this framework to investigate the institutional needs necessitated by the sudden uptake of online teaching and ways of funding these needs in Zimbabwe. We replicate Chimbunde's application of the TRI to illustrate how it can also help understand teacher educators' preparedness for generative AI. For starters, since the TRI evaluates the preparedness of individuals to adopt and use technology (Parasuraman & Colby, 2015), it can be used to gauge teacher educators' readiness to integrate generative AI into their work. Through the framework, research can provide insights into challenges and opportunities posed by generative AI in teacher education in Malawi.

According to Parasuraman and Colby (2015), TRI measures an individual's state of mind through the following concepts: "optimism, innovativeness, discomfort, and insecurity" (p. 60). In the context of AI in teacher education, optimism can represent a positive mindset, that is, the belief that generative AI can help the individual teacher educator accomplish the envisioned goals of teacher education. Innovativeness would mean a teacher educator's initiative to become the first to acquire generative AI, demonstrating the teacher educator's preparedness to use AI and continuous learning about generative AI as it evolves. The concept of innovativeness can provide a lens for checking what teacher educators need to utilise generative AI in their work. The concept of discomfort can reveal barriers to teacher educators' adoption of generative AI, including struggles to understand how generative AI can be used in teacher education. Finally, insecurity can entail teacher educators' distrust of security, privacy and potential loss of control represented by adopting generative AI. Just like discomfort, insecurity can influence teacher educators' perceptions of generative AI and thus limit the transformative potential of generative AI in teacher education in Malawi. The four concepts at the core of TRI are related as the first two are enablers while the last two serve as inhibitors (Chimbunde, 2022). As such, the framework can generate insights into a broader picture of the competency needs of teacher educators to utilise generative AI in their work.

ENVISIONING ARTIFICIAL INTELLIGENCE IN TEACHER EDUCATION IN MALAWI AND THE ROLE OF TEACHER EDUCATORS

In concluding this chapter, we restate that the question of whether generative AI will do more harm than good to education continues to be of research interest globally. Answers to this question partly require attention to educators' current preparedness for the productive use of AI. This chapter aimed at generating insights into the role of teacher educators in shaping the future of AI in teacher education in Malawi. Specifically, we have focused on the role of teacher educators as curriculum implementors and researchers. For teacher educators to perform these roles, we recommend attention to their preparation that builds on the existing context of professional development of teacher educators in Malawi.

As a starting point, research is needed to assess teacher educators' current technology competencies and evaluate the technology components of teacher education programmes in Malawi. Some key questions to pursue include: What new teacher-educator competency needs are posed by generative AI in Malawi? How can teacher educators be supported to develop these competency needs? Such research can provide insights into further development of productive use of generative AI, such as personal tutoring, considering growing student numbers in Malawi's teacher education. The findings also offer an opportunity for theorising the evolution of current teacher education programmes in future, including questions about the role and relevance of teachers in teaching and learning in the context of AI.

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Closing

Setting Sail Toward New Horizons

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The horizon is that thin line that separates the earth from the sky. It symbolizes the future, potential opportunities, and challenges that lie ahead. Just as sailors set their course toward new horizons, sail into storms and rough seas, then eventually find harbor at their destination, we are at the dawn of our journey with generative AI (GenAI). It is sure to be a journey of discovery, struggle, growth, and transformation as society explores new possibilities. "Sailing toward new horizons" implies that we are moving forward with courage, curiosity, and a readiness to embrace change and innovation.

In the past year, there has not been a day that I (Jason) have not uttered the words generative AI or ChatGPT. In fact, it feels like OpenAI's product, launched in November of 2022, has become the Kleenex and Xerox of generative AI tools. As the Fall 2023 semester ended, I found myself reflecting on how I have used Large Language Models (LLM) and generative AI products in my practice and how I have seen my colleagues and students use these tools. I suspect that it is the same for the readers as well.

Now, nearly a calendar year into this book project, we are taking time to reflect on the changes, movements, and trends since we started this work. We approached this project with deep deliberation and care as we selected the chapters that would ultimately come together to examine this new phenomenon that is changing how humans think, interact, learn, grow, work, and exist. It seems we are shifting to a new age of AI (Gates, 2023).

This book proposes frameworks for integrating generative AI into the teacher education curriculum with forethought and fidelity. The authors also examine practices emerging in the past year that have already impacted the teacher education experience. Research and scholarship are primary elements of teacher educators' work, so our authors also discuss how GenAI influences this deeply human practice. As we wrap up this work that marks a single point when the introduction of generative AI is making waves through all industries, including education, we must acknowledge that we continue to have more questions than answers.

GENERATIVE DISCUSSION

Taking inspiration from Wake and White (Chapter 13), we recorded one of our final conversations a little over a year after ChatGPT 3.5 was released. In our conversation, we decided to have an open dialogue about topics and experiences we took away from working with each author for this work. After we recorded the conversation, we used the transcript to review our ideas, and then we asked ChatGPT4 to summarize our conversation (OpenAI, 2024).

1. Integration of Generative AI in Education: The discussion emphasized integrating generative AI into teacher education programs, highlighting the importance of incorporating AI understanding and critical thinking into curricula. It was suggested that students should be taught to analyze AI tools critically, understanding their algorithms and the underlying data that feeds these systems.

2. Adapting to Technological Advances: There was a consensus on the inevitability of technological advancements, including generative AI, in educational settings. The conversation touched upon the necessity for educators to adapt to these changes proactively rather than reactively, ensuring that future teachers are well-prepared to utilize and critically assess AI tools in their teaching practices.

3. Ethical and Societal Implications: The conversation delved into the ethical and societal implications of generative AI, including issues of bias, equity, and the potential for AI to influence or even control aspects of society. Concerns were raised about the digital divide and ensuring equitable access to AI technologies for all students.

4. Practical Applications and Concerns: Examples of generative AI applications were discussed, such as their use in creating lesson plans, assessing student work, and potentially replacing certain educational roles. However, there was also caution regarding over-reliance on AI for educational content and the need for a foundational understanding of subjects without undue dependence on technology.

5. Future of Education with AI: The conversation speculated on the future of education with the integration of AI technologies, stressing the importance of maintaining a balance between leveraging AI for educational benefits while also fostering critical thinking, creativity, and human-centered pedagogical approaches (OpenAI, 2024).

Throughout our discussion, we teetered back and forth between being hopeful and weary of the coming technological changes that will impact our profession and society in general. As we analyzed the GenAI summary of our conversation, we noticed that it did well in categorizing our conclusions. However, we could not help but notice the absence of a central worry posed in the conversation. “What will the nature of knowledge become?” Are our lives becoming increasingly mediated, often without our knowledge? Everyday experiences are now replete with AI-assisted interventions, ranging from automated writing and text tools in email compositions to having conversations with human-like but AI-generated customer service agents to taking photos that automatically filter the target image. Again, many of these mediated experiences occur outside the users' awareness. What effect will this have on the next generation of learners? To what extent will AI tools operating at a subconscious level impact formal education? Are we entering an age of uber Skinner-based (Skinner et al., 1961) teaching machines (Mintz et al., 2023)? As teacher educators, do we have a responsibility to address any of this with our students?

As teacher educators, we are tasked with inspiring future teachers to instill knowledge and skills, but we are beginning to question where that knowledge is held, who controls its dissemination, and who filters the knowledge that is disseminated. Since the onset of GenAI, we have seen teachers utilize the tools to create lesson plans, assessments, unit plans, and all other curricular documents. The production of what we teach is being offloaded to artificial minds rather than human minds. How can we make curriculum development a human endeavor? This curricular question is vital to the work of teachers and teacher educators. We are concerned about where knowledge resides and the evolving nature of information in the digital age, particularly with the invention of GenAI. Repositories of knowledge such as textbooks, academic journals, newspapers, art, and the entirety of the internet are fed into large language models, algorithmically dissected, and then mathematically reconstituted to predict a response that a GenAI user finds acceptable. This shift raises questions about the accessibility and credibility of knowledge sources. It challenges us to reconsider our roles in guiding students through these vast, uncharted informational terrains, terrains that are guarded by those who own and control generative AI machines.

The issue of who controls the dissemination of knowledge brings to light the power dynamics in educational systems and beyond. This issue is not new, but it is becoming increasingly less human. Schools purchase their curriculum from major publishers whose voices and biases are embedded in the instructional materials, guides, and assessments. GenAI expands the opportunity for bias as it is used to create curriculum materials. This issue compels us to examine the influences of governmental policies, institutions, and private corporations on curriculum design and content delivery. The act of filtering knowledge and deciding what is included in curricula and what is left out brings ethical considerations to the forefront of our practice. This process involves wise human academic judgments about what is essential for students' intellectual development and value judgments about what knowledge is deemed culturally and socially relevant. It requires us to engage with diverse perspectives and confront biases that may impact educational content.

Addressing these curricular questions is vital for developing competent educators and cultivating an educational environment that values critical inquiry, inclusivity, and adaptability. As teacher educators, our role in this endeavor is to seek answers and encourage a continuous dialogue among future teachers about the nature of

knowledge, the purposes of education, the use of technologies for good, and the human connections that are essential for a democratic society. This dialogue is essential for preparing knowledgeable, ethical, reflective educators committed to fostering learning environments that accommodate the needs of all students.

The influence of teacher educators extends far beyond mere instruction and training for daily life in a P-12 classroom; it embodies a profound responsibility to shape not only the pedagogical skills of future educators but also their ethos of learning. Curriculum design in teacher education should develop holistic critical thinking among aspiring teachers. As the first touchpoints for those who will later enact curriculum with young learners on a daily basis, teacher educators are tasked to influence the next generation of educators who not only deliver lessons but also instill in their students a deep understanding of the world and their place within it.

Amidst our swiftly evolving technological landscape, the integration of generative AI into education emerges as a pivotal frontier. Teacher educators, therefore, bear the responsibility of not only familiarizing future educators with these tools but also guiding them in their ethical and pedagogical utilization. Generative AI presents unprecedented opportunities to enrich learning experiences, engage learners in creative exploration, and support individual learning. However, its potential pitfalls, from perpetuating biases to eroding human creativity, demand vigilant stewardship.

Thus, our role as teacher educators extends beyond the transmission of knowledge; it is to promote a vision toward curriculum design and enactment that develops young minds, increases human faculties, and continues to elevate the human condition. This vision hopes to mold educators who are not merely proficient in their craft but also conscientious stewards of education. It is through their guidance that we navigate toward a future where young learners are not just recipients of information but active participants in shaping a world guided by empathy, understanding, and innovation.

CHARTING A FORWARD COURSE

Similar to early travelers and explorers, we are moving into new spaces, observing the details of this new environment, and taking note of all we see, hear, feel, and experience. This book is like the explorer's journal that shares discoveries, questions, and conflicts we have seen so far in our exploration of GenAI and teacher education. We recognize that a critical examination of process and product should be embedded in our practice as we engage with GenAI. Teacher educators bring a wealth of knowledge, experiences, frameworks, and theories to the important work of education. We must utilize each of these as guideposts and landmarks for our work with preservice and inservice teachers. It is imperative that we also consider the ethical and legal issues posed by various uses of these technologies, and we must lend our expertise to policy conversations that impact education. As we continually iterate and evolve our teacher education curriculum, we must shift practice toward equity with an eye on efficiency. Our assessment practices must also shift away from low-level assessments and toward evidence of excellent teaching practices in order to meet the needs of learners who are coming of age with GenAI (Weiss, 2024). Teacher educator researchers will grapple with ways to investigate unique questions and communicate novel conclusions as GenAI becomes embedded in our research practices.

We are embarking on new horizons. AI is influencing every area of our lives, and GenAI will impact the important work of teacher education. We continue to ask important questions that, when answered, will undoubtedly shift our course and require us to navigate rough waters. As we conclude this book, we are hauling in the anchor, releasing the mooring ropes, and raising the sails. Like the captain's whistle, we call all teacher educators to engage in the work, inquiry, and action presented in this book with a vision toward a just future as GenAI continues to impact our practice of teaching future and inservice teachers. We hope you are encouraged to design unique learning opportunities and craft innovative educational experiences for your future teachers.

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Chapter Abstracts

Transforming Teacher Education in the Age of Generative AI

Elizabeth Langran, Michael Searson, & Jason Trumble

This chapter positions the book as an important resource for educators, researchers, and practitioners examining the relationship among teacher education, generative artificial intelligence (Gen AI). Artificial intelligence has the potential to transform teaching practices, classroom dynamics, assessment, and more. The November 2022 release of ChatGPT is viewed as a seminal moment in society, with potential long-lasting impacts on culture, education, and teacher education. The authors contend that GenAI should enhance, not replace, teaching. The authors also believe that the examination of GenAI, in teacher education must be viewed critically. Short descriptions of the chapters are provided, highlighting the diversity of the contributions and contributors.

The (Neil) Postman Always Rings Twice: 5 Questions on AI and Education

Punya Mishra & Marie K. Heath

Generative Artificial intelligence (GenAI) technologies are rapidly reshaping our world, including the world of education. The dominant focus of much of the discourse around Gen AI and education has been either on plagiarism or on how educators could use these tools to be more efficient in their practices. In contrast, we frame this paper around a broader set of themes to argue that educators must think critically about AI's broad societal impacts, not just direct applications in classrooms. We build on five key ideas about technological change presented by Neil Postman. They are: (1) We always pay a price for technology; (2) When it comes to technology, there are always winners and losers; (3) Embedded in every technology, there are one or more powerful ideas—and biases; (4) Technological change is not additive, it is ecological; (5) Technologies are fictions. We then apply these ideas to the emerging world of Gen AI, questioning what this new technology will do and undo, as well as who will benefit from it and who will be harmed. In addition, we consider the biases inherent in this new technology and how this technological shift will transform societies. Finally, we argue that Gen AI technologies are human creations and that we have agency to question and redesign them towards humanistic goals. We believe these ideas offer insights into how educators and students can develop a critical awareness of AI's influences and thus support their ethical and responsible use in education.

Pedagogical Models and Generative AI Fluency: A Three-Tiered Empirical Framework Approach

Rebecca Blankenship

In considering the introduction of generative AI programs into traditional teaching and learning modalities, it is important to consider the intersection of theory and practice. In an era where emerging technologies profoundly influence teaching practices and learning spaces, educators find themselves at the crossroads of being innovative while at the same time maintaining instructional integrity. As traditional human-to-human classrooms are reimagined to include digital learning spaces, it is imperative to harmonize instructional spaces with a proven empirical framework or frameworks to scaffold successful implementation. Accordingly, in this chapter, the author explores the hermeneutical interplay between TPACK through the empirical lenses of the Johari Window and Hall, et al. Levels of Use (LoUs). Central to this exploration is the type of scaffolding and LoUs needed to facilitate learners navigating the complex terrain of generative AI learning modalities and spaces. Here, the awareness of the digital self and its proximity to the AI modality is essential for actualizing teaching and learning outcomes. Using a layered approach, the author curates an ensemble of theoretical frameworks to proffer a three-tiered scaffolded approach to inform best pedagogic practices in the evolving landscape of AI-enabled education. The Technological Pedagogical and Content Knowledge (TPACK) Framework, an established pedagogic framework, is the foundational scaffold for a comprehensive integration of technology, pedagogy, and content in AI-powered teaching modalities. In tandem with this, the Johari Self-Perception Window presents a lens through which the nuances of individual cognitive perceptions and hermeneutic cyclical interpretations merge, creating a synergistic interplay between learners, educators, and the AI-mediated learning environment. The Levels of Use (LoU) framework completes the third tier by capturing digital literacy and technical growth as educators and learners navigate the intricacies of AI-powered modalities.

Integrating AI in Teacher Education Using the Teacher Educator Technology Competencies

Torrey Trust, Robert W. Maloy, & Nanak Hikmatullah

Generative Artificial Intelligence (GenAI) technologies are generating amazing new learning opportunities and pressing complexities and risks for K-12 teachers, students, and teacher educators. The twelve Teacher Educator Technology Competencies (TETCs) developed by SITE (Society for Information Technology and Teacher Education) offer frameworks for educators to use as they successfully integrate these powerful new tools into their educational practices as AI-using educators. In this chapter, we describe how teacher educators can utilize each of the different TETC competencies to develop the AI literacy skills, knowledge, attitudes, and instructional practices of new teacher candidates. Expanding the TETCs to focus on learning with and learning about AI include how GenAI technologies teach content-specific information; critically evaluate the impact of AI on teachers and students; organize learning in face-to-face, hybrid, and fully online educational settings; differentiate instruction for diverse learners; create student-centered assessments; connect and support students from multiple cultural backgrounds; build opportunities for teacher-driven research and professional development about educational practices; and promote legal, ethical and socially responsible actions by students.

Generative AI and TPACK in Teacher Education: Pre-service Teachers' Perspectives

Aijuan Cun & Ting Huang

While using generative AI in education has become a trend, scholars have been concerned with generative AI in teacher education. Grounded in the literature on using AI in elementary education, this chapter describes pre-service teachers' perspectives on using generative AI tools, specifically ChatGPT, for teaching and learning. We also drew upon the Technological Pedagogical Content Knowledge (TPACK) framework to support our inquiry. The interviews with preservice teachers were utilized as the data sources. The findings show that the participants had different experiences and perspectives on using ChatGPT for teaching and learning. We designed a four-pathway model by drawing upon the findings and the TPACK framework. Implications and the model of the use of generative AI in teacher education are also discussed in this chapter.

Locked In Generative AI – The Impact of Large Language Models on Educational Freedom and Teacher Education

Roland Klemke & Halszka Jarodzka

This paper explores the potential of large language models (LLMs) in education and discusses the challenges and opportunities they pose with a specific focus on teacher education. LLMs, such as ChatGPT, have shown promising applications in creating learning content, assessing student work, and summarizing texts. However, they also have limitations, including issues with consistency, factuality, and lack of transparency. Furthermore, the commercial ownership of many LLMs raises concerns about control and accountability in education. The paper proposes strategies for mitigating these risks, including open-sourcing LLMs, ensuring transparency in their development and operation, and developing ethical guidelines for their use in education. It additionally outlines the potential impact of LLMs on teacher education along a number of open questions that arose with the introduction of LLM in education.

Toward a Conceptual Generative AI Ethical Framework in Teacher Education

Asmaa Radwan & Jacqueline McGinty

Amidst the transformative wave of Generative AI (GenAI) in education, reshaping paradigms, especially within teacher education, the need for an ethical framework becomes paramount. This chapter, "Toward a Conceptual Generative AI Ethical Framework in Teacher Education," delves into the transformative potential of GenAI, like ChatGPT, within education, emphasizing its role in enhancing productivity and quality. However, integrating GenAI brings forth ethical concerns, including bias, fairness, privacy, security, accountability, transparency, equity, and accessibility, necessitating a structured ethical approach. The chapter proposes the GENAIEF-TE framework, focusing on principles such as Transparent Accountability, Privacy and Secure Data Management, Culturally Sensitive and Inclusive Fairness, Community-Centered Design, Transparent Data and Algorithmic Literacy, and Pedagogy-Centered Design. By comparing GENAIEF-TE with existing ethical frameworks and emphasizing interdisciplinary approaches and community-centered designs, the chapter outlines how this framework can mitigate ethical challenges and pave the way for an ethically grounded AI-enhanced future in teacher education. It calls for educators, policymakers, and AI developers to prioritize ethical considerations, offering a visionary outlook on the impact of ethical GenAI integration in teaching and learning. This chapter serves as a guide for responsibly employing GenAI tools in teacher education, ensuring an ethical, inclusive, and equitable educational landscape.

Embracing ChatGPT in the Evolving Landscape of Mathematics Teacher Education and Assessment

Angie Hodge-Zickerman & Cindy S. York

The emergence of ChatGPT has prompted a reevaluation within the teacher education community regarding the instruction of pre-service and in-service teachers, particularly in the domain of mathematics education. Concerns have arisen regarding the potential impact of ChatGPT on student learning and assessment practices. Traditionally, mathematics instruction involves students learning a topic and answering related questions as an assessment. However, the worry is that students may now rely on ChatGPT to obtain answers and bypass the process of grappling with and deeply understanding mathematical concepts. This concern is especially significant for instructors of graduate classes for in-service teachers, where remote assessments (and take-home assignments) are common. This chapter explores how mathematics teacher educators can leverage ChatGPT as a tool to design alternative assessments that promote genuine learning rather than viewing it solely as a means for student cheating. The chapter provides sample questions, prompts, and answers, with a focus on interdisciplinary applicability for teacher educators across various disciplines. The goal of this chapter is to empower teacher educators to critically examine their role, navigate the evolving assessment landscape, and develop innovative assessment strategies that foster deep understanding, problem-solving skills, and effective communication of mathematical concepts. By embracing the potential of ChatGPT as a facilitative tool, this chapter aims to inspire teacher educators to rethink their assessment approaches and create meaningful mathematical learning experiences for their students while emphasizing the interdisciplinary applicability of these ideas.

Assessment and Instructional Decision Making: How AI Can Support Data Literacy Development for Preservice Teachers

Mary Jean Tecce DeCarlo, William Lynch, Vera Lee, Daniel Moix, & Valerie Klein

Artificial Intelligence (AI) is expected to impact education in many ways, and teacher educators need to begin preparing preservice teachers (PSTs) for its use now. One thing today's educators are expected to do effectively is use data to make instructional decisions (Schelling & Rubenstein, 2021). AI can support teachers as they work to improve student outcomes in our assessment-heavy educational climate. This chapter will illustrate AI's potential to enhance the critical data-driven decision-making abilities of PSTs, who are likely to collaborate with AI throughout their entire careers. The chapter includes examples of how generative AI can model small scale learning analytics and data analysis for educators along with descriptions of how generative AI can be employed to craft both simulated and authentic assessment tasks.

School Librarians as Collaborators in the Successful Use of GenAI

Elizabeth Gross & Holly Weimar

School librarians bring their proficiencies in educational technology and teaching into collaborative relationships developed with all classroom teachers. This includes novice teachers and all other educators in the school. Research has shown that a relationship with the school librarian fosters resilience in new teachers, which increases the chance for teacher retention and growth in expertise and self-efficacy (Soulen & Wine, 2018). In coursework and preparation, school librarians are charged with understanding and applying technology for learning and teaching. They are trained to think critically about the use of technology to teach and how best to apply technology. Generative Artificial Intelligence (GenAI), such as Dall-E and ChatGPT, is a new technology that has the potential to change the educational landscape in ways that are still being investigated. Because school librarians work with teachers as instructional partners and have an understanding of technology, they can demonstrate how GenAI is beneficial support and how best to use it in the classroom and as an instructional tool. School librarians can show novice teachers as well as experienced colleagues how to create prompts that elicit useful information, such as lesson plans with modifications for all learners. While GenAI will not take the place of a teacher, school librarians can help novice teachers by modeling the creation of innovative, personalized prompts for use with GenAI and by offering guidance on the products it creates. As well, there is an opportunity for school librarians to create and utilize their own LLM to support learning and teaching in their schools.

Generative AI to Improve Special Education Teacher Preparation for Inclusive Classrooms

Rashmi Khazanchi & Pankaj Khazanchi

Emerging technologies, such as artificial intelligence (AI), machine learning, and data mining, have ushered in disruptive Generative AI, revolutionizing various domains, including education. The advent of AI-based chatbots like ChatGPT has led to the widespread adoption of Generative AI tools in educational settings. These tools enable the creation of new content, including text, images, and videos, potentially transforming teaching and learning processes. This book chapter highlights the benefits of using Generative AI tools to generate accessible learning materials to enhance the teaching and learning processes. This book chapter aims to explore the application of Generative AI in creating an inclusive educational environment, overcoming barriers, and promoting equitable learning opportunities, with a particular focus on the preparation of special education teachers for inclusive classrooms. This book chapter also discusses ethical concerns in using Generative AI tools in the preparation of special education teachers.

Social, Cultural and Political Perspectives of Generative AI in Teacher Education: Lesson Planning in Japanese Teacher Education

Masanobu Sakamoto, Shirley Tan, & Stephane Clivaz

In this chapter, after reviewing previous studies on instructional design, we mention the possibilities and challenges of using Generative AI to create instructional plans. In particular, we sought to create a detailed draft of a Japanese instructional plan, and to create prompts that make students think not only about procedures but also about teacher activities and expected student reactions. We followed these steps in the chapter: select a lesson, analyze the lesson, use the results of the lesson analysis to create prompts in generative AI, ask the generative AI to make a lesson plan using the prompt, and discuss the possibilities and limitations of the lesson plan. The lesson analyzed was a second-grade elementary school math class, and the results of the lesson analysis were used to determine where students make mistakes, what elements students focus on, and why students focus on certain terms. Based on these results, the team came up with prompts for creating instructional plans and had the AI generate the plans. When the generated instructional plans were presented to teachers in Japan and Canada for comments, the foreign teachers were generally satisfied with the results, while the Japanese teachers acknowledged the work to some extent, but pointed out the inadequacy of the description of teaching knowledge and the lack of depth of the lesson content. Because of differences in teacher culture, the degree of satisfaction with the generated instructional plans is likely to vary from country to country and region to region.

Examining Generative AI and Teacher Educators Research Practice: A Duoethnographic Dialogue

Donna Wake & Matthew White

This article explores the potential role of generative artificial intelligence (AI), specifically ChatGPT, in supporting faculty research in teacher education. The authors, a veteran and novice researcher, engage in a duoethnographic dialogue to share their experiences and perspectives on using ChatGPT to facilitate the research process. Guided by Flower and Hayes' cognitive process theory of writing, they discuss AI's applications across planning, translating, and reviewing research. Benefits include efficiency in brainstorming, finding sources, and drafting text. However, reliance on AI risks plagiarism, bias, and lack of depth. The authors conclude AI is a supplemental tool requiring human expertise. Through thematic analysis, additional findings indicate AI may enhance productivity but cannot wholly replace researchers' critical thinking. Concerns include data privacy, information reliability, and over-reliance limiting researcher knowledge. Ultimately, AI supports but does not supplant researchers' skills and voices. Researchers must maintain expertise to use AI effectively and ethically. This introspective study provides insights on AI's promise and perils in research. Key takeaways underscore the continued primacy of human researchers in producing quality scholarship.

Developing Frames for Change: How Generative AI Impacts the Broad Practices of Teacher Educators

Chen-Chen Liu & Xiao-Qing Gu

This chapter delves into the transformative influence of Generative Artificial Intelligence (GAI) on teacher education practices. Through a multidimensional lens, the chapter explores the redefinition of research methodologies, pedagogical strategies, and ethical considerations, and envisions the future landscape of GAI integration in teacher education. From redefining research methodologies to shaping pedagogical strategies, it provides a comprehensive analysis of GAI integration in teacher education, including GAI's role in data analysis, personalized learning, and automated assessment underscores the evolution of research foci and pedagogical practices. Ethical considerations regarding GAI integration are critically examined, emphasizing the necessity of ethical frameworks. The chapter concludes by presenting a visionary perspective on the impacts of GAI in teacher education, envisioning its potential for innovation and excellence.

Envisioning Generative AI in Teacher Education in Malawi: The Role of Teacher Educators as Researchers and Curriculum Developers

Foster Gondwe & Frank Mtemang'ombe

The question of whether generative AI will do more harm than good to education continues to be of research interest globally. Answers to this question partly require attention to educators' current preparedness for the productive use of AI now and in the future. Meanwhile, there is a growing body of knowledge on AI and education in high-income country contexts, but research on AI in the developing world, especially in Africa is lacking. In this chapter, we focus on the future of AI and teacher education in Malawi, especially the role of teacher educators, who are critical to the preparation of teachers. We argue for the important role of teacher educators in enhancing AI integration into teacher education in Malawi, make clear why teacher educators must be prepared to utilize AI, and what this would require for the scholarship of teacher education in Malawi.

Setting Sail Toward New Horizons

Jason Trumble, Elizabeth Langran, & Michael Searson

Using the imagery of the horizon and sailing into uncharted waters, we explore what we have learned, and what is lingering. We report the conclusions from concluding conversations then discuss how GenAI influences curriculum. We continue to ask important questions that, when answered, will undoubtedly shift our course and require us to navigate rough waters. As we conclude this book, we are hauling in the anchor, releasing the mooring ropes, and raising the sails. Like the captain's whistle, we call all teacher educators to engage in the work, inquiry, and action presented in this book with a vision toward a just future as GenAI continues to impact our practice of teaching future and in-service teachers. We hope you are encouraged to design unique learning opportunities and craft innovative educational experiences for your future teachers.

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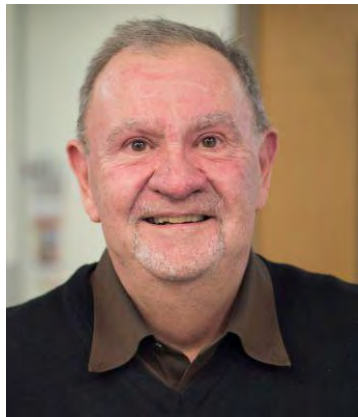
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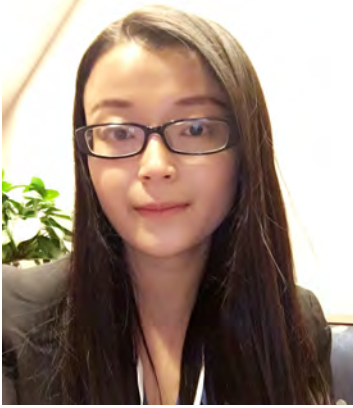
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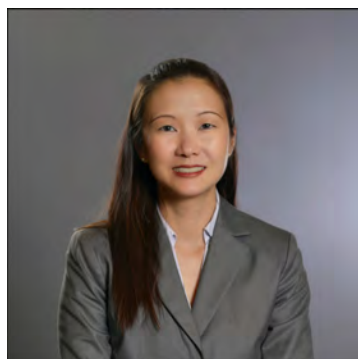
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