ChangeMaker K-12 + AI: AI-Enhanced Processes for Preparing Teacher Candidates to Teach Engineering

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Abstract[75-150 words]: This paper explores the addition of AI into ChangeMaker K-12, a set of experiences and materials designed to support teacher candidates (TC) in learning to teach engineering design. The ChangeMaker K-12 model and materials consist of four progressive stages: design awareness, design for function, design with empathy, and design for change. This new research explores the introduction of AI assistance into these four stages.

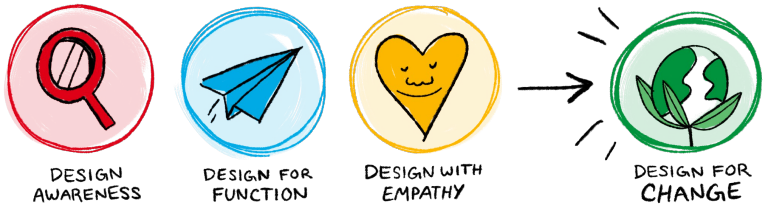
Introduction

Between 2021-2023, a team of university-based researchers developed ChangeMaker K-12 to improve the preparation of undergraduate teacher candidates (TCs) in the effective teaching of engineering design and human-centered design (National Science Foundation, award # 2044358). That effort resulted in the creation of materials that are accessible at ChangeMakerK12.org for use in teacher education programs to (1) support elementary (K-5) education undergraduate TCs in teaching engineering and human-centered design and (2) engage TCs in employing systems thinking and change processes to improve their practice. Building on the ChangeMaker K-12 model and materials (Williams, 2023; Williams, Barber, Sheppard, 2023a; Williams, Barber, Sheppard, 2023b), this paper focuses on adding AI technology to the ChangeMaker K-12 process.

Overview of the ChangeMaker K12 Model and Materials

The *ChangeMaker K-12* model and materials, freely accessible on the project website, were developed through six design and testing cycles with three TCs cohorts (N=102). The *ChangeMaker K-12* model and materials consist of four progressive stages: design awareness, design for function, design with empathy, and design for change (see Figure 1). The first three stages focus on design fundamentals. Knowledge and practice of these three fundamentals are then brought together in the fourth stage to practice the more complex process of creating change through design.

Figure 1: ChangeMaker K-12 Stages



- ***Design Awareness:*** This stage offers hands-on activities that emphasize the development of systems thinking and seeing objects as designed. Participants learn to look closely at objects to identify parts, purposes, and how the parts work together to get something done. Next, we zoom out to see how people connect to these systems and then imagine how we can make these systems more effective, efficient, ethical, and/or beautiful.
- ***Design for Function:*** With a foundation in design awareness, participants can then engage with engineering design challenges to experience processes for designing a functional system. These activities guide TCs and students through the engineering design process: define a challenge, ideate, prototype, test, and refine solutions.
- ***Design with Empathy:*** With knowledge of design awareness and experience in designing for function, next TCs and students learn how to infuse empathy into design when designing for others. This stage offers a set of human-centered design challenges that begin with identifying the needs of specific people. TCs and students develop solutions through empathy, defining a challenge, ideating, prototyping, testing, and refining. During these activities, students gain experience developing solutions to real-world problems by first seeking to understand the point-of-view of the individuals for whom they are designing.
- ***Design for Change:*** Once TCs and students have developed skills and experience in systems thinking (design awareness), in designing for function (i.e. engineering design process), and in human-centered design, TCs and students are guided through developing a solution to a real-world problem. This progression begins with creating a list of problems that matter to them. Students then empathize and learn, define the problem, ideate, prototype, test, refine, and communicate their solution at the ChangeMaker Faire event.

The TC interactive hands-on, course-embedded materials were designed to help TCs learn and implement protocols and practices of human-centered design (in year 3 of undergraduate programs) and practitioner inquiry for improved implementation (during year 4 / residency). These professional learning modules were designed with the following characteristics to improve effectiveness and increase adoption:

- *High-Quality Professional Learning:* The professional learning experiences were designed (1) to *build TCs' confidence and preparedness* in engineering and human-centered design while *simultaneously focusing on the relationship between context-specific student achievement and one's own teaching practice* (Borko, 2004; Desimone, 2009; Guskey, 2000) (2) so TCs are viewed as professionals where they have *voice in their own learning* and opportunities to actively contribute to a larger vision or goal (Borko, 2004; Webster-Wright, 2009), (3) to be *social*, ensuring TCs have opportunities to learn from one another and contribute to the learning experience rather than sitting and listening to video lectures (Putnam & Borko, 2000), and 4) to be *open-ended*, allowing *flexibility* in implementation and providing TCs with opportunities to think about how *learning affects practice* (Desimone, 2009; Webster-Wright, 2009).
- *Scaffolded Inquiry:* In this project's fifth and final semester, the *ChangeMaker K-12* platform scaffolded TCs as they linked passions and powerful investigations to their classroom teaching. *ChangeMaker K-12* scaffolded an inquiry process designed to continuously reflect on and improve solutions and designs as TCs developed the courage to act on student-centered issues within classrooms and schools. The open-ended style, with connected vision and contextual application, has shown increased feelings of professionalism as one is empowered to shape the life of a school and as an agent for instructional improvements (Cochran-Smith & Lytle, 2009).

- *Designed to Increase Adoption and Diffusion:* Research suggests that the perceived characteristics of an innovation account for 49% to 87% of the variance in the rate of adoption (Rogers, 2003). To increase the likelihood of adoption and diffusion, the following characteristics were explicitly considered in the design of *ChangeMaker K-12*: (a) *Relative advantage:* The design of the platform and materials reduced the complexity and friction for implementing high-quality engineering experiences thus TCs saw *ChangeMaker K-12* is better than current solutions. (b) *Compatibility:* design of *ChangeMaker K-12* fits with the values of TCs / teachers, the realities of typical classroom contexts, and the need to support hybrid/online teaching. (c) *Complexity: ChangeMaker K-12* is perceived as easy to use and understand. (d) *Trialability: ChangeMaker K-12* is easy to try out with limited commitment. (e) *Observability:* TCs and teachers quickly "get" the platform's value.

The clinical experience materials for design awareness, design for function, design with empathy, and design for change consist of slide decks, protocol materials, children's books, and videos. The materials designed to scaffold TCs knowledge and lesson facilitation included:

- *Series of Maker-centered Learning Activities:* Maker-centered learning, an infusing of many of the practices and ethos of the maker movement into education, provides a framework for designing activities that are accessible to diverse populations and can develop in TCs and students the mindsets, habits of mind, and processes of innovation that are foundational in engineering (Clapp, Ross, Ryan, Tishman, 2016).
- *Based in Literacy Framework:* For each ChangeMaker K-12 stage, children's storybooks were identified for each lesson. Examples include *Rosie Revere Engineer* (Beaty, 2013) and *Empathy is Your Superpower* (Bussolari & Grzeszkowiak, 2021). This approach is more familiar to elementary teachers and connects to literature in ways that could be infused into language arts instruction, provides an accessible way to communicate engineering design and careers to children and teachers, and may provide a more effective way to reach underserved and underrepresented children with engineering design opportunities.
- *Videos of Practicing Professionals:* Videos were developed to introduce key concepts of design awareness, design for function, design with empathy and design for change. These videos highlight how engineering and human-centered design are used in different fields. For example, Collin Cormier, a chef and restaurateur, describes how he looks closely at the parts and purposes of food (design awareness) and how the creation of a new dish involves many iterations of design, testing and redesign (design for function), while considering the needs of the customer (design with empathy).
- *Activity Series Leads to Annual ChangeMaker Faire:* Activities in design awareness, design for function, and design with empathy prepare children and TCs with the skills to become changemakers by developing their own solutions to share with the world. Children shared solutions at the conclusion of summer programs. Similarly, TCs shared their solutions on stage at the *ChangeMaker K-12* Faire.
- *Designed to Increase Adoption and Diffusion:* The clinical experience materials were designed with features to increase adoption and diffusion (Rogers, 2003): maker activities that are simple and appealing to adults and kids (relative advantage, observability), literacy framework (relative advantage, observability, complexity), sequence of content and video of practitioners illuminating protocols and processes (compatibility, relative advantage, observability, complexity), and simplicity in design (complexity, trialability).
- *Accessible and Free:* All materials are web-based and free to ensure they are widely available and work on Chromebooks, laptops, tablets, and smartphones to help increase accessibility.

Prior Changemaker K-12 Findings

In previous iterations of the *ChangeMaker K-12,* key findings from the external evaluation show TCs grew significantly in key areas. For Cohort 1 (N=14), data showed significantly higher confidence in teaching engineering design, $t(14) = 2.80$, $p < .05$, and systems thinking, $t(14) = 2.24$, $p < .05$. Confidence in teaching human-centered design increased, but not significantly, $t(14) = 0.94$. Cohort 2 (N=9) showed statistically significantly higher confidence in teaching engineering design, systems thinking, and human-centered design. On measures of efficacy in teaching problem-solving and engineering design, Cohort 1 increased, but not significantly while Cohort 2 showed a statistically significant increase. Over 90% of TCs in Cohorts 1 and 2 placed moderate to high value on students engaging with engineering design, maker-centered learning, and human-centered design topics. And over 94% indicated they were likely or very likely to engage children in engineering design, systems thinking, and human-centered design. A major revision of TC materials, such as adding additional hands-on lessons and refined field experience materials (e.g., slide decks), took place before the start of Cohorts 3 and 4. Research findings for these cohorts resulted in more positive TC experiences. Cohort 3 (N=31) and Cohort 4 (N=19) showed significantly higher confidence in teaching key aspects addressed in ChangeMaker K-12, at the significance level of $p < .001$

(e.g., engineering design, systems thinking, human-centered design, creativity thinking routines, design, creative problem solving), significantly increased in efficacy for teaching problem solving and engineering design (at the significance level of $p < .001$), showed significantly higher value in engaging students with engineering design, maker-centered learning, and human-centered design (at the significance level of $p<.001$), and showed a significant increase in likelihood to engage children in engineering design, systems thinking, and human-centered design in their future classrooms.

Building on the promising findings regarding increased confidence and added value in the design process, the authors aimed to further enhance the TCs' experience with ChangeMaker K-12 by leveraging the benefits of AI. With the current focus on AI technology in society, researchers sought to investigate how AI could further enhance and support TCs' learning. This paper explores how TCs felt AI improved their understanding and potential implementation across each phase of the ChangeMaker K-12 process: design awareness, design for function, design with empathy, and design for change.

Research on the Use of AI in K-12 Education

Research on AI in education is still emerging. A current focus is on the benefits of using AI to support education and teachers' acceptance of AI as a tool for teaching and learning. Literature on teacher acceptance of technology is largely shaped by the Technology Acceptance Model (TAM), introduced by Davis (1989). Subsequent iterations and meta-analyses have solidified the TAM as a powerful framework that outlines both direct and indirect pathways to teachers' technology adoption, applying to both pre-service and in-service educators (Scherer, Siddiq, & Tondeur, 2019; Davis, 1989). Gurer and Akkaya (2022) emphasized that TAM illustrates the relationship between perceived ease of use, perceived usefulness, and attitudes toward technology, which, in turn, directly influence behavioral intentions to use technology. They also argued that TAM should be expanded to include the influence of pedagogical beliefs. Their findings suggested that pre-service mathematics teachers' pedagogical beliefs were more constructivist-oriented than traditional, and these constructivist beliefs significantly impacted technology acceptance.

Zhang's (2023) study further highlighted the role of teachers' beliefs in adopting AI technologies in the classroom, influencing their future development in education. The research found that perceived usefulness and ease of use were the most significant factors affecting pre-service teachers' intentions to use AI, with perceived usefulness having a stronger impact than ease of use. Choi et al. (2022) identified key human factors that encourage or limit teachers' acceptance of educational AI tools. Their study revealed that teachers with constructivist beliefs are more likely to integrate educational AI tools, compared to those with more traditional teaching orientations. They also emphasized that perceived usefulness, ease of use, and trust in AI tools are critical factors influencing teachers' acceptance of these technologies.

A systematic literature review by Zhang & Aslan (2021) noted several benefits of AI for learners, including increased engagement, adaptive learning materials, meta-cognitive prompts, and improved learning outcomes. For educators, the authors found that AI can assist in identifying gifted or at-risk students, monitoring learning progress, creating personalized learning materials, and instantly analyzing data at scale. Bryant, Heitz, Sanghvi, & Wagle (2020) estimated that teachers spend approximately 11 hours per week preparing activities. They suggested that AI technologies could reduce this time to around six hours, allowing teachers to focus more on tasks that AI cannot replicate, such as inspiring students, building positive school and class climates, fostering connections and belonging, seeing the world from individual students' perspectives, and mentoring and coaching students. By saving teachers time, AI can help reduce educational inequalities and allow educators to shift from instructors to facilitators (Bryant et al., 2020). Wilder, Peercy, Orland-Barak, & Wilson (2024) argued that AI integration can enhance personalized learning and provide real-time feedback. However, they emphasized the need for teacher preparation to engage educators, students, and stakeholders in shaping and utilizing AI technologies to enhance—not replace—human judgment and oversight. Additionally, the authors deduced that AI can complement human expertise, promote critical thinking, and support meaningful educator-student interactions when appropriately implemented.

To investigate the integration of AI into the Changemaker K-12 process, the following research question guided this study:

1. What do TCs perceive as the benefits of using AI as a teaching assistant in preparing to teach design awareness, design for function, design with empathy, and design for change?

Methodology

In the Fall 2024 semester at a mid-sized university in southern Louisiana, TCs enrolled in PK-3 and Grades 1-5 certification coursework about educational technology and innovation participated in *Becoming a Changemaker* learning modules and field experience activities. As part of the learning experience, the instructor asked the TCs to use Khan Academy's AI tool Khanmigo, to understand the four progressive stages of the Changemaker process. For example, in *Design Awareness*, TCs used AI to learn about systems, systems thinking, and applications to K-12 classrooms. Prompting questions TCs asked included: *What is a system? Why should children learn systems thinking? How can I add design awareness activities into my busy classroom?* In *Design for Function,* TCs used AI to learn about the engineering design process (define a challenge, ideate, prototype, test, and refine) and ideas for classroom implementation. Prompts included: *What is design for function? Why should children learn design for function? What are several design challenges I can use in 2nd grade? As my students use the engineering design process, how can I help them ideate?* And for *Design with Empathy,* TCs engaged in human-centered design with the AI, and asked for ideas related to facilitation in the classroom. Example prompts include: *What is design with empathy? Why should children learn design with empathy? What are the most important parts of teaching design with empathy? As my students engage in design with empathy, how can I help them empathize?*

Due to the exploratory nature of this research, qualitative inquiry methods guided data collection and analysis (Braun & Clark, 2006; Creswell, 2004; Merriam & Saldaña, 2016; Saldaña, 2021; Smith & Osborn, 2007). At the beginning of the semester, a researcher who was not teaching the course invited the TCs to participate in the study. Involvement included allowing the course instructor to collect coursework and reflection surveys and agreeing to be invited to an interview or focus group. Thirty-seven (N=37) TCs consented to participate in the study. The course instructor did not know who participated in the study until final grades were submitted.

Data Collection

For this paper, we focused our analysis on TC reflection surveys. TCs were asked to reflect and respond to several prompts on how the learning activities might be integrated into a classroom setting. Next, the instructor asked the TCs to use the Khan Academy AI to explore the same prompts and reflect on the responses.

Twenty-nine participants (n=29) completed the AI assistance-specific survey, reflecting on the perceived benefits of utilizing AI assistance in understanding varying design areas. The survey consisted of nine questions with *Yes, No*, or *Somewhat* selective responses and 11 open-ended questions following up or expanding upon the *Yes, No*, or *Somewhat* response.

Respondents could select *Yes, No,* or *Somewhat* to the questions: *Did the Kahnmigo AI help deepen your understanding of the topic?, Did the AI help you learn new ideas of how to implement this strategy in your future classroom?* related to stages of Design Awareness, Design for Function, and Design with Empathy. Participants could also select *Yes, No,* or *Somewhat* to questions related to each stage of Design for Change, including: *During the wonder stage, I asked you to generate a list of problems worth solving, first alone and then with AI. Did the Kahnmigo AI help you generate ideas?, During the empathize and learn, did the AI help you in your research and empathy work?, During the ideate phase, where your team developed a list of solution ideas. Did the AI help you generate solution ideas?*

To further answer the research question, *What do TCs perceive as the benefits of using AI as a teaching assistant in preparing to teach design awareness, design for function, design with empathy, and design for change?,* participants were invited to expand upon their selection of Yes, No, or Somewhat to the questions above with 11 open-ended prompts. These included responding to *How, Why, or Why Not?* Following each *yes, no,* or *somewhat* response and the additional open-ended questions, *Reflect on your experience interviewing the AI as it pretended to be the spy fairy. How well did the AI serve as an effective interview partner? How well did the AI character help you understand their needs as you empathized with them?,* and *What was your final topic, and how did AI help you identify your topic?*

Data Analysis

Qualitative data collected through the end-of-project survey were analyzed using a structured yet flexible approach, emphasizing thematic analysis (Merriam & Saldaña, 2016) as the focus was on understanding pre-service teachers'

experiences using new technology tools in the Changemaker process. Basic percentages were calculated for the close-ended questions (i.e., what percent said yes, somewhat, or no). Three research team members began the analysis for the open-ended questions by thoroughly reviewing the data to identify patterns and recurring ideas. After the initial read, significant statements were highlighted, and a combination of in vivo and descriptive codes were developed (Saldaña, 2021). These codes were then grouped into broader categories, refining thematic analysis as themes emerged naturally (Merriam & Saldaña, 2016). As new data was analyzed, it was continuously compared with previous codes and categories, using a constant comparative method to ensure consistency and depth in interpretation. Members of the research team engaged in memo writing to document emerging insights before synthesizing themes after reviewing each others' codes to determine agreement.

Findings

For each of the four design areas, participants were asked to identify if the AI deepened their understanding of the topic and if the AI helped them learn new ideas of how to implement this strategy in their future classroom responding "Yes", "Somewhat", "Not at all". Table 1 provides a summary of TC responses.

Table 1: Descriptive Statistics of TC Perception of the Benefits of AI in Each Part of ChangeMaker K12

Res-pons e	**Design Awareness**		**Design for Function**		**Design with Empathy**		**Design for Change**		
	Understand-ing	Class-room Use	Understand - ing	Class-room Use	Understan d-ing	Class - room Use	Topic Idea Genera-tion	Research and Empathy	Solution Idea Generation
	%	%	%	%	%	%	%	%	%
Yes	92.86	92.86	89.66	96.55	82.76	93.1	82.14	71.4	42.86
Some - what	3.57	3.57	10.34	3.45	17.24	3.45	14.29	10.7	35.71
Not at all	3.57	3.57	0	0	0	3.45	3.57	17.8	21.43

Each yes, not at all, or somewhat response was followed by an open-ended question asking for further insight into these initial responses. The following sections present thematic findings based on these and additional open-ended survey responses.

AI Assistance Contributed to Participants' Selection and Deepened Understanding of Topics

Across all four design areas, participants explained how using the AI assistant deepened their understanding.

For the *Design Awareness* stage, most TCs reported that AI helped deepen their understanding (92.86% Yes, 3.57% Somewhat, 3.57% No). The few participants who did not report benefits felt they encountered generic suggestions, but the overall feedback highlighted Khanmigo's potential as a valuable resource for educators seeking to enhance their teaching of design awareness and systems thinking. Several TCs stated that they found the interactive and dynamic nature of the technology helpful in deepening their understanding. TCs could ask questions and follow up with more questions to dig deeper. One TC stated, "It helped deepen my understanding because it offered personalized explanations with the questions asked and it provided immediate feedback." Other TCs mentioned that the tool's structure led to quick, clear, and concise responses that helped explain the concept of design awareness. A TC explained, "Khanmigo AI offered a structured approach to systems thinking by breaking down complex ideas into digestible components."

Another benefit of Khanmigo for deepening TCs' understanding was its ability to generate ideas and help the TCs think outside the box. Several TCs stated that they could be more creative, and the tool gave them ideas they never thought about using before. Many said that the AI technology provided examples that helped them expand their thinking and perspectives. For example, one participant stated, "Khanmigo helped me see aspects of the process that

I would have never realized or considered before. I have a much better understanding of these topics than I would have without using AI."

TCs discussed how the AI assistant helped solidify their understanding of *Design for Function* (89.66% Yes, 10.34% Somewhat, 0% No), including broadening their perspectives and offering comprehensive and practical examples.
A participant explained, "The AI effectively clarified each stage of the engineering design process. It supported comprehension by providing relevant examples and encouraging reflection on design challenges, enhancing my grasp of how to apply these concepts practically." Other participants commented on how the AI assistant clarified their thinking and helped to break down the process into meaningful steps and provided immediate assistance. One TC explained, "it gave great solutions and helped with the process. It helped with the process when I was getting 'stuck' in my thinking."

For the *Design with Empathy* component, participants felt that using the AI assistant deepened their understanding (82.76 Yes, 17.24% Somewhat, 0% Not at all) by providing interactive, engaging experiences such as role-playing with characters, which made the complex concept more relatable and easier to grasp. The AI introduced new ideas and offered strategies for applying these concepts in authentic education contexts. TCs felt AI assistance encouraged critical thinking by presenting different perspectives, emphasizing the importance of considering user needs in the design process. While some participants already understood the basics, AI broadened their view, clarified key concepts, and highlighted additional benefits, such as fostering creativity and problem-solving skills. However, a few noted that AI support was less impactful for straightforward topics.

AI also played a significant role in helping participants identify and refine their final project topics for *Design for Change*. Participants reported AI played a valuable role in brainstorming and refining ideas. Many found it helpful for generating a broad range of possible solutions, often providing logical and implementable ideas. While some participants did not use AI-generated suggestions directly, they acknowledged that AI provided insightful and creative ideas, sometimes introducing problems they hadn't considered. For some, AI played a key role in expanding upon existing ideas rather than generating entirely new concepts. While many teams had a general direction in mind, AI helped refine details, suggest additional components, or introduce new perspectives that may not have been considered initially. AI helped participants dig deeper into issues, refine broad topics, and view problems from multiple perspectives. It particularly benefited those who struggled with idea generation, as it guided their thinking and expanded their understanding of educational challenges.

Additionally, AI contributed to framing problems in more specific, actionable ways and helped teams empathize with different stakeholders affected by the issues they explored. While some groups found AI less useful because they relied more on human input, others used AI to generate initial ideas, narrow, broad topics, or pinpoint specific issues within a larger theme. AI was particularly helpful in refining topics like new teacher support, mental health in schools, digital literacy, and community involvement by breaking them into more manageable components. Additionally, it helped clarify key factors, identify underlying causes, and provide structured approaches to research. However, some found its suggestions more general or basic, requiring further refinement through discussion and external input.

AI Assistance Provided Clear Examples of how to apply the Topics in Elementary Classrooms
Participants often noted how the AI assistant provided clear examples of how they could apply *Design Awareness*, *Design for Function*, and *Design with Empathy* in K-12 classrooms.

When TCs explained the usefulness of the AI assistant for *Design Awareness*, they stated their appreciation of the practical suggestions provided by Khanmigo. "Khanmigo was able to provide direct examples of how an activity could benefit a classroom. It was also able to provide different steps and materials to complete these activities in class."

For *Design for Function*, participants appreciated the support Khanmigo provided to develop new ideas. One TC explained, "I struggle with developing ideas for implementing these types of things into my future classroom, so Khanmigo really helped make that difficult part easier. In the future, I can see this helping me get baseline ideas [so] that I can use my energy to improve rather than come up with [ideas]." Other participants explained the tool helped

to give "step-by-step, simplified descriptions" and understand how to implement Design for Function activities in elementary classrooms.

Participants generally felt Khanmigo provided creative and interactive ways to teach *Design with Empathy*, including role-playing, storytelling, and discussion-based activities that help students understand different perspectives. Many respondents found the AI suggestions helpful in developing engaging lesson plans, empathy mapping, and designing fictional characters, which make abstract concepts more tangible for students. The tool helped teacher candidates feel more confident in implementing empathy-focused strategies in their classrooms by offering actionable ideas, specific examples, and a structured approach to fostering human-centered design thinking in practical contexts.

AI Assistance Provided Depth in Understanding and Experiencing Empathy

Reflecting on experiences engaging in an interview with AI as part of the design with empathy activities, participants reported AI served as an effective interview partner by staying in character, providing detailed and engaging responses, and encouraging deeper inquiry. While some users felt the AI initially provided similar answers, asking more specific questions led to more personalized and insightful responses, enhancing their understanding of the Spy Fairy's needs. By offering opportunities for teacher candidates to engage in dialogue with AI, they began to construct their own knowledge of how to refine prompts for more meaningful responses. Overall, participants reported that AI's role-playing helped them empathize with the character, think critically about problem-solving, and explore the importance of perspective-taking in the design process.

Participants also found AI useful in identifying key stakeholders affected by the topics chosen for *Design for Change*. AI reportedly aided in generating ideas for interviews and gathering supporting research. AI provided fresh perspectives on problems, suggested solutions, and helped pinpoint key concerns, such as the importance of parental involvement or specific teacher support needs. Some teams relied heavily on personal experiences and interviews, using AI mainly to supplement their findings. Others found AI helpful in identifying affected groups, guiding research efforts, and refining their empathy work by considering multiple viewpoints.

Balancing AI Insights with Human Experience: Navigating the Limitations of Technology in Problem-Solving

Most participants explained how the AI tool aided their understanding of and development of design-focused activities they could use with elementary-aged students. However, a few students consistently noted that the AI tool did not necessarily give them new ideas. For the *Design for Functio*n section, one respondent explained, "I found my original answers to most of the questions were almost identical (at least in content) to the answers that Khanmigo was giving for them." The respondent did note that this helped to reinforce their original ideas.

Some participants felt AI was not particularly useful in the empathize and learn stage of *Design for Change*, as they either relied on firsthand experiences or found AI's responses limited. Some reported feeling like AI often suggested problems and solutions that participants had already identified on their own, making it feel unnecessary. Some responses described AI's contributions as "basic" or "elementary," not offering new insights beyond what participants already knew. Some teams gathered AI responses but ultimately relied on their own experiences, interviews, or other research methods instead.

Participants had mixed experiences with AI during the ideation phase of *Design for Change*. Although AI played a role in the brainstorming process, its impact varied. For some, it served as an initial guide, while for others, it was largely secondary to human collaboration and expertise. Some participants encountered restrictions where AI responses did not fully align with the specific focus of their projects. AI suggestions were typically refined or altered after discussions with instructors, experts, or other real-world stakeholders. AI was a useful starting point, but human conversations and deeper research primarily shaped the final solutions. Several participants noted that real-world discussions with educators and professionals proved more valuable in developing practical solutions. In many cases, the most effective ideas emerged through meaningful conversations rather than AI-generated suggestions.

Participant responses highlight a clear need for balancing AI insights with human experiences, as both play essential roles in problem-solving. While AI provided valuable starting points, such as suggesting possible solutions, generating ideas, and offering new perspectives, many participants emphasized that their lived experiences and interactions were crucial in refining and implementing those ideas. AI often helped expand the scope of potential

solutions and provided creative prompts. Still, it was the real-world input—through interviews, conversations with experts, and personal experiences—that grounded the solutions in practical, context-specific ways.

Additionally, participants noted AI sometimes lacked the emotional nuance and deeper understanding that human empathy and lived experience bring, particularly when considering issues like teacher burnout, community involvement, and student well-being. Ultimately, responses suggest that AI is a helpful tool to augment the ideation process, but human interaction and insights are necessary to ensure that solutions are relevant, meaningful, and feasible.

Discussion and Implications

This project aimed to improve the preparation of TCs to confidently engage K-5 students in engineering processes and employ systems thinking processes in their own practice with a free and user-friendly online platform. As the project has continued to refine and adjust how candidates engage and develop the skills to teach engineering lessons, an AI assistant has been added to support the current cohort's understanding of the design areas. Data from this study suggests that TCs found AI useful and easy to use in developing domain content knowledge and in generating ideas for classroom integration (Zhang, 2023), and supports the use of AI in teacher preparation to develop skill in using AI to "enhance--not replace--human judgment and oversight" (Wilder et al., 2024). These data suggest that how the AI was integrated into the ChangeMaker K12 materials, emphasizing its use as an AI teaching assistant, aligns with the research on the Technology Acceptance Model (TAM) (Davis, 1989; Scherer et al., 1989; Gurer and Akkaya, 2022; Choi et al., 2022) and improves TCs content knowledge and pedagogical content knowledge. Yet, these data suggest a number of areas for further research. TCs noted that the AI responses were sometimes limited, providing no deepening of their understanding of the topics. And often, during ideation, AI-generated ideas were outside the scope of the project, or only provided a starting point. Further research can explore whether better training on AI prompting may help TCs have more productive experiences with the AI teaching assistant. Research can also explore how to expand the benefits of TCs using an AI teaching assistant, blending the strengths of AI with TCs' lived experience and interactions with experts and teachers to refine and implement practical and contextually relevant ideas.

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