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Navigating the Terrain:

Emerging Frontiers in Learning Spaces, Pedagogies, and Technologies

AI-Teacher Teaching Task Spectrum in Action

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The AI-Teacher Teaching Tasks Spectrum (AITTTS) was conceived as a way to understand the relationship between human teachers and the ever-evolving AI technologies in education. This study demonstrates how the AITTTS framework can be operationalised into a tangible intervention, showcasing the design models and practical applications of the AITTTS in real-world educational settings. By categorising teaching tasks into a spectrum, the AITTTS delineates the roles that AI and human teachers can play, providing a structured and nuanced understanding of their collaboration. As a result of the practical application of the AITTTS, a design model was birthed in this study. It highlights various aspects of holistic student outcomes such as positive electronic nonverbal communication (eNVC) cues, adaptive learning paths, and interactive learning responses as elements by which AI should be designed. By providing a structured approach for educators to incorporate AI tools and interventions in their learning environments, this research lays the groundwork for further exploration of the synergistic relationship between AI and human teachers in modern education. This framework can serve as a guide for educators to develop and implement AI-enhanced teaching strategies, fostering a more dynamic and responsive educational landscape.

Keywords: AI in Education, AI-Teacher Teaching Tasks Spectrum, AI design

Introduction

"The End of High-School English" was one of the headlines splashed across The Atlantic barely a week after the public release of ChatGPT (an artificial intelligence backed large language model) (Herman, 2022). The provocative title only serves to underscore the impact that Artificial Intelligence (AI) has had on the educational landscape. As AI continues to permeate every aspect of education (Aled), there is a growing need to have a good understanding of the diverse roles that AI can play and the roles that human teachers now play in this modern-day classroom.

To make sense of these various roles that AI and teachers play, the AI-Teacher Teaching Tasks Spectrum (AITTTS) was proposed. First proposed and conceptualised in 2022 (Koh et al., 2022), prior to the release of ChatGPT in November 2022, and further expounded upon in 2023 (Koh et al., 2023), this theoretical model aims to provide a more structured and nuanced understanding of the multifaceted ways in which AI can augment and enhance teaching practices. The AITTTS framework recognizes that AI systems can assume varying degrees of responsibility and autonomy in executing different teaching tasks, ranging from simple, repetitive administrative activities to support the teachers in more complex, higher-order cognitive functions. Hence, this study seeks to translate the AITTTS framework into a tangible intervention and investigate its practical utility and outcomes by answering these two questions:

RQ1: How can the AITTTS framework be translated practically into a tangible intervention?

RQ2: What impact does this AITTTS based intervention have on holistic student outcomes?

Background

The AITTTS was built on the premise of trying to provide a framework to better understand the different roles that AI and human teachers can play in the classroom. This was done by categorising teaching tasks into a spectrum of categories, ranging from administrative to pastoral care activities. Each category of tasks can be

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performed by performed by AI, teachers, or a combination of both in the context of education. Building on from Bloom's Taxonomy (Bloom,1956), the AITTTs helps to clarify the roles of AI and teachers by delineating the various teaching tasks based on the cognitive demands and the level of human interaction needed. This will allow teachers to leverage on AI whilst maintaining the essential human elements of teaching and learning more effectively. In Figure 1 below, the spectrum was divided into 9 categories.

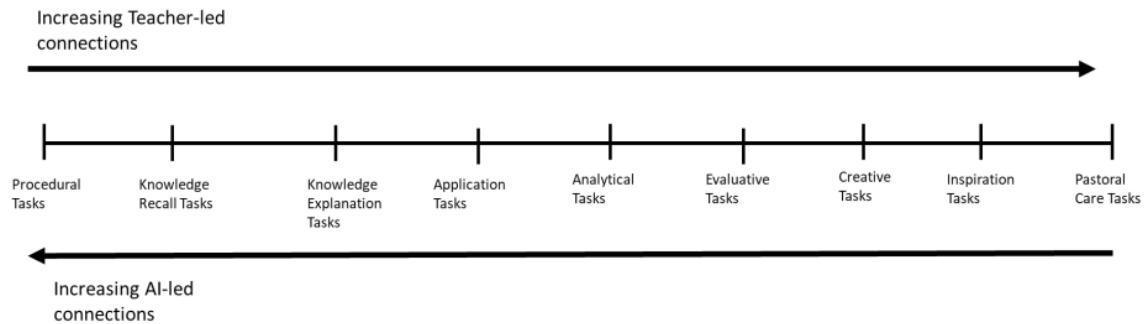


Figure 1. AI-Teacher Teaching Tasks Spectrum

The AITTTs can be understood to consist of the following elements: procedural tasks involve administrative work such as answering assessment deadline extension requests or providing information. Knowledge recall tasks test the ability to remember information, while knowledge explanation tasks require students to re-present or paraphrase recalled knowledge. Application tasks involve using information to solve problems or demonstrate understanding practically. Analytical and evaluative tasks require students to interpret information and present opinions based on their interpretations. Creative tasks involve making something new or applying knowledge in novel ways, extending beyond artistic endeavors to problem-solving and inventions. Inspirational tasks aim to motivate and inspire students, focusing on both intrinsic and extrinsic motivation to encourage personal growth. Pastoral care tasks, requiring a human touch, address the personal and emotional needs of students, ensuring their individual needs are understood and met.

Research Methodology

Evaluation of the AITTTs

An evaluation of the AI-Teacher Teaching Tasks Spectrum (AITTTs) was conducted in Dec 2023 using a methodology that incorporated the use of a literature review and practitioner evaluation. That evaluation is currently in the peer review process. The aim of the literature review was to situate the AITTTs within the broader literature, using the existing literature to establish the relevance of the AITTTs and its alignment with existing knowledge in the field. The practitioner evaluation was aimed at seeing if there were consensus amongst practitioners about the validation of the framework, based on their personal expertise and lived experience.

The practitioner evaluation played a crucial role in validating the AITTTs framework, as they recognised the applicability and accuracy of the AITTTs in representing the range of teaching roles that AI can fulfill in conjunction with human teachers. Whilst there are some differences in opinion regarding AI's role in creative or inspirational tasks, the overall consensus among the practitioners bred confidence in the AITTTs' suitability for understanding AI's role in teaching. By analysing the responses of the practitioners via statistical measures such as Fleiss' κ , an element of objectivity was inserted into the framework evaluation, on top of its alignment with existing literature, bolstering the study's rigor and credibility.

This evaluation of the AITTTs concluded that the AITTTs was accurate and relevant, underscoring the importance of collaboration between AI and human teachers, whilst also emphasizing the potential for AI to

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support teachers and the necessity for teachers to develop technological pedagogical and content knowledge (TPACK) to effectively work with AI.

Theoretical Underpinning

The AITTTTS is underpinned theoretically by two main theories, namely Bloom's taxonomy and the Technology Acceptance Model (TAM). Bloom's Taxonomy categorises educational objectives into a hierarchy of cognitive skills, ranging from simple recall of facts to complex evaluation and creation tasks. The taxonomy is divided into six major categories:

- Knowledge: The ability to recall data or information.
- Comprehension: Understanding the meaning of informational materials.
- Application: The ability to use learned material in new and concrete situations.
- Analysis: The ability to break down material into its component parts and understand its structure.
- Synthesis: The ability to put parts together to form a new whole.
- Evaluation: The ability to judge the value of material based on criteria and standards.

The AITTTTS framework builds on Bloom's Taxonomy by categorizing teaching tasks according to the cognitive demands they place on students and the level of human interaction required. This alignment helps in clarifying the roles AI and human teachers can play, ensuring that AI systems support rather than replace human educators.

The other theoretical model underpinning the AITTTTS is the adapted Technology Acceptance Model (TAM) (Koh et al., 2022). The TAM is traditionally defined by Perceived Usefulness (The degree to which a person believes that using a particular technology will enhance their job performance.) and Perceived Ease of Use (The degree to which a person believes that using the technology will be free from effort.). This hybrid approach is particularly suited for contexts where the focus isn't solely on technology acceptance, but also on the intersection between technology and educational pedagogy. Unlike newer versions of the TAM such as the UTAUT2 (Venkatesh et al., 2012), which is more specifically tailored to understanding technology adoption in a general sense, this modified TAM-COI model offers a nuanced perspective that better captures the complexities of integrating technology within educational frameworks.

The COI framework focuses on creating a meaningful educational experience through three interdependent elements: social presence, cognitive presence, and teaching presence. Similarly, the COI model is defined by Social Presence (Ability of participants to identify with the community, communicate purposefully, and develop interpersonal relationships.), Cognitive Presence (Extent to which learners can construct and confirm meaning through sustained reflection and discourse.) and Teaching Presence (Design, facilitation, and direction of cognitive and social processes to achieve learning outcomes.)

The TAM and COI provides a comprehensive approach to understanding and enhancing the use of technology (AI in this case) in education. This integrated framework when mapped on Bloom's taxonomy, allows a categorisation of the educational tasks in light of the roles of human teachers and AI. By leveraging the strengths of each model, the AITTTTS is birthed.

Translating the AITTTTS to a Design Model - Interview with practitioners

Interviews with educators about their perspectives on the incorporation of AI in teaching were done. A qualitative pilot study was conducted among teachers who were interviewed on what deems a holistic student outcome and which features they would prefer to be there in the hypothetical chatbot. These questions were based on an educational chatbot (EC) and was underpinned theoretically by the AITTTTS. In this study, educators focused on the transformative possibilities offered by ECs in regard to personalisation, real time

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responses to questions, and AI's role in the classroom, especially in light of what these practitioners view as holistic student outcomes. This reflects educators' worries over a failure of students to apply classroom concepts practically thus illustrating the existence of a gap between knowledge acquisition and everyday life experiences. Teachers conceptualized holistic student outcomes as covering resilience, adaptability, enjoyable learning moments, job readiness, high emotional involvement when studying, practical application of knowledge acquired from school settings and career aspirations.

From this interview, a design model for ECs (Fig 2) was proposed. This model aligns with educators' desired features, such as serving as a coach rather than a player, offering multi-faceted engagement, and easing teaching and administrative workloads, and is underpinned by the AITTS. The model emphasizes guided reflection to build students' confidence in problem-solving, positive reinforcement in responses to enhance motivation, and adaptive learning paths for tailored responses to individual student needs. By incorporating these features, chatbots can support students in developing resilience, adaptive mindset, and readiness for future challenges, ultimately enhancing their overall learning experiences and outcomes.

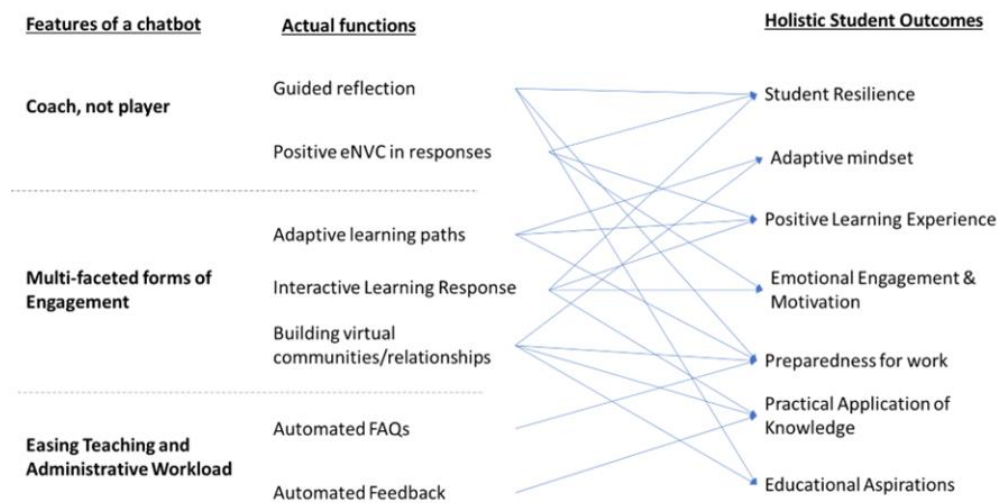


Figure 2. Design model for AI chatbot to enhance holistic student outcomes

Results & Discussion

Translating the Design Model to an AI tool

Based on the design model, these design principles were established. In the conversation flow, the chatbot's responses are carefully crafted to be couched in a warm, friendly and engaging tone. This helps foster an inviting environment that is conducive to learning. Expressive language and punctuation, such as exclamation marks, are strategically employed to convey a tone of excitement and encouragement. For instance, phrases like "Well done on nailing that one!" and "Keep up the great work!" convey positive eNVC cues to the learners, motivating and celebrating their progress, which in turn helps instil a sense of accomplishment and achievement. Maintaining an appropriate tone throughout the conversation is important, as eNVC has a positive correlation with motivation and engagement levels in educational settings (Koh & Hulbert, 2022). Positive eNVC cues aligns closely with the 'coach, not player' aspect of the design model.

Warm, engaging and friendly responses also encourage students to build a virtual relationship with the EC. The increased perceived authenticity of the responses of the chatbot will help itself in the virtual relationship building process (Pentina et al., 2023) and may enhance learner well-being (Skjuve et al., 2021). On top of that,

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there are some studies that suggest a positive virtual relationship with ECs has a positive impact on student learning outcomes, including academic outcomes (Huang et al., 2023), engagement & motivation levels (Huang et al., 2023; Liang et al., 2023) and self-efficacy (Liang et al., 2023).

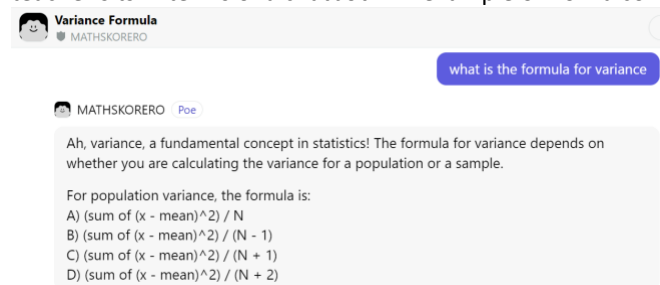
Adaptive Learning Paths

In the same conversation flow, the AI can be seen to maintain a fairly strong context handling capabilities and can follow the conversational logic better. This is important as for adaptive learning paths to occur, the AI must be able to recognise that the learner understands the concept or otherwise. In the example above, the AI chose to break down the question about variance into smaller, more easily digestible portions, looking first at the variance formula for a population and thereafter for a sample. The AI would only proceed after the answer for the variance formula of a population was correctly selected, ensuring that there has been some basis for progressing. Having a good conversation logic allows for a more adaptive path of learning, giving the students a chance to learn in a manner more consistent with them. Adaptive learning paths have been shown to have a positive impact on learner outcomes (Kabudi et al., 2021), showing an alternative route to traditional learning methods.

Interactive Learning Response and Guided Reflection

Using a gamified response to answer questions has traditionally been a good way to engage with learners (Smiderle et al., 2020). This AI tool, incorporating the 'coach, not player' as well as the 'multi-faceted forms of engagement' aspects of the design model, uses a specially crafted system of responses that are created in the form of a multi-choice question, allowing students to have a semi-gamified learning experience. This will also answer one of the primary concerns brought up by educators about the use of AI in education, which was the possibility of a cognitive 'off-loading' of learning to the AI (Essien et al., 2024). By not blindly giving students the answers, gamified responses give students a chance to carry a higher cognitive learning load (Khaleghi et al., 2021), whilst engaging in a fun and no-pressure environment (Çavuş et al., 2023). Interactive learning responses, not only helps with the learning process and experience, it also lends itself to higher levels of engagement and interest (Alsawaier, 2018).

Guided reflection is also a critical aspect of the design model. By structuring the learning in more bite sized forms, it not only follows the principles from the eNVC model (Koh & Hulbert, 2022), it also incorporates the pedagogical concepts of scaffolding into the delivery of the knowledge. Unsurprisingly, this also works well with the AITTTs, as it breaks a request/query down, first interpreting it as a knowledge recall task, and expands it, bringing it up the AITTTs, to the knowledge explanation area. This also shows the role of where the teacher sits in terms of a chatbot. An example of how a conversation flow is as follows:



The screenshot shows a chatbot interface. At the top, the chatbot is identified as 'Variance Formula' with a profile picture of a person with glasses and the name 'MATHSKORERO'. A blue input box contains the question 'what is the formula for variance'. The chatbot's response is: 'Ah, variance, a fundamental concept in statistics! The formula for variance depends on whether you are calculating the variance for a population or a sample. For population variance, the formula is: A) (sum of (x - mean)^2) / N B) (sum of (x - mean)^2) / (N - 1) C) (sum of (x - mean)^2) / (N + 1) D) (sum of (x - mean)^2) / (N + 2)'. The chatbot's name 'MATHSKORERO' and the name 'Poe' are visible in the bottom left corner of the chat window.

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 MATHSKORERO Poe

Ah, variance, a fundamental concept in statistics! The formula for variance depends on whether you are calculating the variance for a population or a sample.

For population variance, the formula is:

- A) $(\text{sum of } (x - \text{mean})^2) / N$
- B) $(\text{sum of } (x - \text{mean})^2) / (N - 1)$
- C) $(\text{sum of } (x - \text{mean})^2) / (N + 1)$
- D) $(\text{sum of } (x - \text{mean})^2) / (N + 2)$

d)

 MATHSKORERO Poe

Ah, I'm sorry, but that's not the correct answer. The formula you selected, $(\text{sum of } (x - \text{mean})^2) / (N + 2)$, is not the correct formula for calculating the variance.

Let me give you another chance to try. Would you like to try again or would you like a hint?

b)

 MATHSKORERO Poe

Absolutely right! You've got it! The formula for sample variance is indeed $(\text{sum of } (x - \text{mean})^2) / (N - 1)$.

Well done on nailing that one! Keep up the great work! Is there anything else I can help you with?

a)

 MATHSKORERO Poe

That's correct! Well done! The formula for population variance is indeed $(\text{sum of } (x - \text{mean})^2) / N$.

Now, if you're interested, I have another question for you. Can you tell me what the formula for sample variance is?

- A) $(\text{sum of } (x - \text{mean})^2) / N$
- B) $(\text{sum of } (x - \text{mean})^2) / (N - 1)$
- C) $(\text{sum of } (x - \text{mean})^2) / (N + 1)$
- D) $(\text{sum of } (x - \text{mean})^2) / (N + 2)$

Impact of the AITTS based intervention on Holistic student outcomes

A total of 93 valid responses garnered in the pre-intervention exposure of the study, comprising 41 respondents from a New Zealand institution and 52 respondents from various higher education institutions in Australia. Notably, the age demographics of the New Zealand cohort displayed a broader spectrum, with participants ranging in age from 18 to 65 years. This indicates a diverse sample, likely capturing a wide array of perspectives and experiences. In contrast, the age distribution of respondents from the Australian higher education institutions was more concentrated, with ages ranging from 17 to 23 years. This narrower age range suggests a predominantly younger demographic, likely reflecting the traditional age bracket of undergraduate

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students within these institutions. A closed survey was conducted to understand the students perspectives measured across seven metrics, in line with the design model. The seven metrics are namely:

- Student Experience: encompasses the overall perception and satisfaction of students with their educational environment and activities.
- Student Self Efficacy: refers to the confidence students have in their own abilities to accomplish tasks and succeed in their educational endeavours
- Response Experience: describes the quality and nature of interactions between students and teachers, particularly focusing on how teachers respond to student inquiries, feedback, and participation
- Perceived Engagement: is the degree to which students feel actively involved and interested in their learning process.
- Effectiveness of Instruction: refers to how well easily understood and clear the instructions are received and experienced by students.
- Experience from Answers refers to the experience from receiving responses and feedback to their inquiries, enquires and questions.
- Openness to AI implementation: measures the willingness and receptiveness of students and educators to integrate artificial intelligence technologies into the educational process.
- Perceived Cognitive Learning: refers to the mental effort required to process and understand information during learning activities.

A two sample t-test is used to determine whether there is a statistically significant difference between the means of the pre and post intervention exposure. A p-value of lower than 0.05 is considered statistically significant. Cohen's d is a measure of effect size, indicating the magnitude of the difference between the two groups in terms of standard deviations. It complements the t-test by quantifying the size of the difference, regardless of sample size. Cohen's d values are typically interpreted as follows: 0.2 (small effect), 0.5 (medium effect), and 0.8 (large effect).

The results of the pre and post intervention exposure survey have shown in Table 1 below:

Table 1

Results of the Pre and post intervention exposure survey

	Pre-Intervention Exposure Score	Post-Intervention Exposure Score	t-statistic	p-value	Cohen's d
Student Experience	2.753	3.962	-8.082	2.02×10^{-12}	1.074
Student Self Efficacy	2.279	3.711	-13.135	3.81×10^{-18}	2.516
Response Experience	2.289	3.885	-8.002	1.26×10^{-10}	1.533
Perceived Engagement	3.065	4.096	-7.614	5.21×10^{-10}	1.458
Effectiveness of Instruction	2.667	3.827	-13.423	1.58×10^{-18}	2.573
Experience from answers	2.720	3.865	-6.663	1.71×10^{-8}	1.305
Openness to AI implementation	3.441	4.231	-2.663	0.0103	0.541
Perceived Cognitive Learning	3.043	4.038	-3.261	0.0020	0.937

Table 1. Study Results from the pre and post intervention exposure surveys

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1. **Student Experience:** The extremely low p-value and large effect size indicates that there is a statistically significant difference between the pre-test and post-test scores. This suggests that the intervention or change between the pre-test and post-test periods had a significant effect on the scores
2. **Student Self Efficacy:** The intervention had a substantial positive impact on student confidence, evidenced by a very large effect size (2.516). The extremely low p-value indicates that this improvement is highly statistically significant, suggesting that the observed changes are unlikely to be due to random chance.
3. **Response Experience:** The intervention significantly improved teaching responses, with a large effect size (1.533). The p-value is extremely low, demonstrating strong statistical significance and confirming that the improvement is not due to random variation.
4. **Perceived Engagement:** Engagement levels showed a notable improvement post-intervention, as indicated by a large effect size (1.458). The very low p-value further supports the statistical significance of this change.
5. **Effectiveness of Instruction:** The effectiveness of instruction saw the largest effect size (2.573), indicating a significant enhancement post-intervention. The extremely low p-value confirms the statistical significance of this improvement, highlighting the strong impact of the intervention on instructional effectiveness.
6. **Experience from answers:** Experience based on answers improved significantly, with a large effect size (1.305). The low p-value indicates strong statistical significance, suggesting that the intervention positively affected students' experiences based on their answers.
7. **Openness to AI Implementation:** Openness to the chatbot showed a moderate improvement with an effect size of 0.541. The p-value indicates statistical significance, although it is less strong compared to other metrics. This suggests a moderate but meaningful impact of the intervention on students' openness to using chatbots.
8. **Perceived Cognitive Learning:** Cognitive learning experienced a noticeable improvement with a medium to large effect size (0.937). The p-value confirms the statistical significance of this improvement, indicating that the intervention had a positive effect on cognitive learning outcomes.

Overall, the intervention had a significant and positive impact on all measured metrics. This was a positive direction, indicating that the students did find the chatbot useful and novel. This is also in line with other research stating that students have indeed found AI tools helpful.

Discussion

The intervention showing a statistically significant positive impact across all eight metrics is a positive indication that the design model is at the very least, accurate. It also suggests that the AITTS is practically applicable, and with positive results. Attitudes towards chatbots have the least amount of change, suggesting that the underlying technology acceptance plays a smaller role compared to the other pedagogical aspects. It also suggests that there is a greater need to place the pedagogy before the technology, echoing what the AITTS suggests, namely that there is a role for both the human teacher and the AI technology in enhancing holistic student outcomes. Student self-efficacy showing a significant change also suggests that by allowing AI to handle more lower-level teaching tasks, students feel more confident in their learning and trying out future concepts. This further solidifies the idea that teachers can now play a more encouraging and inspirational role in the classroom, allowing AI to handle knowledge recall and knowledge explanation tasks.

However, the AITTS is not without its challenges, specifically around the changing nature of the human-AI relationship, in terms of pastoral and inspirational tasks. Recent studies have explored the potential of AI chatbots in providing social and therapeutic support. Research suggests that people can derive social connection from interacting with supportive chatbots, sometimes even more than with less supportive

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humans (Folk et al., 2024). However, AI is still unable to replicate the 'human touch' aspects of human interaction (Sonawane, 2023). Generative models like GPT may have shown some promise in therapy contexts, but they also produce more negative outputs than human therapists (Wang et al., 2021). These findings suggest that while AI may show promise in pastoral and inspirational tasks, careful consideration of its limitations and ethical implications is necessary.

Conclusion and Future Research

In summary, this study has demonstrated how the AITTS can be operationalised in an intervention to enhance educational outcomes. The AI intervention is currently being developed in a study involving first year undergraduate statistics students. The practical implications of this study are significant, demonstrating a possible method of applying the AITTS in a way that can be aligned with contemporary educational needs, addressing gaps in knowledge application and fostering holistic student outcomes such as resilience, adaptability, and job readiness.

While this study provides a foundational understanding of the practical utility of the AITTS framework, there are several avenues for future research:

Further Iterative Studies: Conducting further iterations in short-medium term studies to assess the sustained impact of the AITTS-based intervention on student outcomes and teacher practices.

Diverse Educational Settings: Exploring the applicability and effectiveness of the AITTS framework across diverse educational contexts, including different age groups, subjects, and cultural backgrounds.

Technological Advancements: Investigating the integration of emerging technologies, such as augmented reality and advanced natural language processing, to further enhance the capabilities of AI in education.

The AITTS offers a promising method for integrating AI in education. By continually exploring and refining this approach, we will have a better understanding of the relationship between human teachers and AI and how to best utilise this synergistic relationship to enrich educational experiences and improve holistic student outcomes.

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