Nicole S. Flanagan

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Annotated Bibliography

Hannan, B., & Eynon, R. (2025). Widening the digital divide: The mediating role of intelligent tutoring systems in the relationship between rurality, socioeducational advantage, and mathematics learning outcomes. *Computers & Education,* 233, Article 105312. https://doi.org/10.1016/j.compedu.2025.105312

Brody Hannan and Rebecca Eynon conducted a quantitative study examining how socioeducational advantage and rurality influence student usage of an intelligent tutoring system (ITS) and related learning outcomes, drawing on data from 66,451 students across 304 schools in years 7–10. The Australian study pulled demographic data from a single public database and raw activity log metrics from the AdaptiveMath program used by all participants.

Findings regarding rurality were not clear. Students in major cities were found to have completed more modules overall, but had lower mastery compared to students in inner regional areas, while students in the more rural, outer regional areas, completed and mastered more modules than students in major cities. In contrast, students in the most remote areas completed and mastered fewer modules than their major city peers. These nonlinear patterns highlight the complexity of technology usage across levels of rurality and underscore the need for further, in-depth investigation.

Findings regarding socioeducational advantage were linear and clear. Students with higher socioeducational advantage benefited more from the intelligent tutoring system than their less advantaged peers. This finding is significant as it indicates usage of ITS may in fact,

heighten educational inequalities, which should be considered when employing ITS in schools with disadvantaged students.

The quantitative secondary datasets had a tendency to use validated measures, heightening the reliability and accuracy of the results. Furthermore, the large sample size and single ITS platform were relatively unique among other related studies, creating a sense of credibility and reliability for policy makers, administrators, and ITS developers.

The study supported the notion that ITS alone cannot close learning gaps and suggests that the effectiveness is highly dependent upon context. Building on previous research in the field, the challenges surrounding technology usage and the digital divide are shown to be more nuanced and multifaceted than previously thought. Although methods were dissimilar, findings were not consistent with similar large-scale studies conducted in the United States (US). Further studies evaluating the impact of socioeducational advantage and rurality amongst students in the US would support national policy makers and administrators in creating equitable educational experiences.

Khazanchi, R., Di Mitri, D., & Drachsler, H. (2024). The effect of AI-based systems on mathematics achievement in rural context: A quantitative study. *Journal of Computer Assisted Learning, 41*(1), Article e13098. https://doi.org/10.1111/jcal.13098

This study focused on students in rural areas from economically disadvantaged backgrounds, aiming to measure the impact of artificial intelligence (AI) based systems, specifically Edmentum, on student achievement and engagement. The quantitative design compared three groups: one experimental group and two control groups. The experimental group was not chosen at random to ensure students had access to the potentially beneficial program.

Control group 1 was comprised solely of students with economically disadvantaged backgrounds, and control group 2 was comprised of students with a mix of backgrounds.

The study results were mixed, showing significant improvement for students with economic disadvantages, while traditional instruction was shown to be more effective for students with mixed backgrounds. This is significant because many students from rural areas lack resources and experienced teachers. Leaders looking to supplement math instruction in rural areas may want to consider this as a potential option for supplementing math instruction. Further studies controlling the backgrounds of students would be beneficial in determining if AI-based systems disproportionately affect students based on socioeconomic status. Studies comparing the achievement of students while isolating teacher experience and the use of AI-based systems would also be helpful for leaders looking to implement AI-based programs in underachieving schools.

The study also found students in teacher-led groups showed a higher level of cognitive engagement. This is important for decision makers to note when planning, as this program should be used as a supplement to traditional instruction rather than replacing it. Further studies looking at the achievement across grade levels would be beneficial for those looking to deploy this resource on a broader scale.

Kim, J., & Wargo, E. (2025). Empowering educational leaders for AI integration in rural STEM education: Challenges and strategies. *Frontiers in Education, 10,* Article 1567698. https://doi.org/10.3389/feduc.2025.1567698

A mixed-methods approach utilizing surveys and interviews investigated administrators' perceptions of the opportunities and barriers associated with artificial intelligence (AI) in rural

K–12 schools. The study found that most leaders viewed AI as a positive opportunity for their school districts, citing benefits such as personalized learning experiences, streamlined administrative tasks, and dynamic tools for content development. Yet, only 6.8% of administrators surveyed reported active AI use in their schools, while 51.9% acknowledged it was on their radar but lacked concrete plans for adoption. Additionally, just 22.7% of administrators recognized the need to teach students how to use AI as part of preparing for the future workforce. Leaders also raised ethical concerns related to privacy, data usage, and integrity. Further research into the foundations of these perceptions could help address and overcome such concerns.

Participants indicated unreliable broadband internet access, outdated technological infrastructure, and limited professional development opportunities as barriers to AI adoption. This is in alignment with similar studies exploring the digital divide and may be useful for policymakers and administrators looking to overcome these barriers in the implementation of AI.

The study claimed the success of AI in rural schools will largely depend on the tenacity of leaders. Strategies for successful incorporation included having a clear and strategic plan, collaborative professional development, securing high-speed internet, and improving the technological infrastructure. Some participants noted success in leveraging partnerships with private equity and securing grant funding as ways to finance implementation. Other participants noted the need for leaders to lobby for policy change on a broader level to bring about more equitable access to technology and broadband access. These insights, while powerful, came about through the qualitative branch of the study, which was notably small. Leaders looking to employ these strategies would benefit from further studies regarding the feasibility of said endeavors.

Given the exponential rate of change within the technology sector, it would be helpful to know when the data in this study was collected. While the study was published in January 2025, the technology world evolves quickly, and the data collected is limited by the perceptions having been collected at a single point in time. Further studies can collect data at multiple points in time to analyze trends and shifts in perception. This study would be helpful to educational leaders and policy makers looking to integrate AI into rural K-12 school systems, but also companies looking to foster good public relations by partnering with K-12 schools to close the digital divide.

Li, Z., Wang, C., & Bonk, C. J. (2025). Generative AI for teachers' self-directed professional development: A mixed-methods study. *TechTrends.* Advance online publication. https://doi.org/10.1007/s11528-025-01123-8

Utilizing a Likert survey, researchers evaluated 298 K-12 school teachers to explore the impact of generative artificial intelligence (AI), specifically ChatGPT, on their self-directed professional development (SDPD). Following the survey, participants were invited to take part in semi-structured interviews; however, only five teachers agreed to partake, raising concerns regarding the generalizability of qualitative responses. The study sought to determine how teachers use ChatGPT within their instructional practices, how they engage with it during their developmental process, and to ascertain their perception of its functionality.

The study concluded that teachers using ChatGPT experienced an increase in time management and organizational skills, highlighting the AI's ability to increase efficiency. Qualitative responses indicated faster, more specific resources, as well as an ease in the burden of entry point. Motivation for use was variable, with some users noting a lack of motivation due to limited availability for advancement in their careers. Administrators and change makers

considering implementing AI-driven supports may want to consider incorporating motivational supports into professional development.

While the study was conducted using teachers with a wide breadth of experience, researchers noted a level of criticism would be needed to employ ChatGPT ethically and efficiently, noting novice teachers may benefit from structured professional development on using ChatGPT as an SDPD. Additionally, researchers found that teachers were less likely to collaborate, share lessons, and acknowledge their use of AI, attributing the reluctance to a lack of institutional support and negative connotation surrounding the technology. Findings may be valuable for administrators and policymakers as knowledge sharing is a crucial aspect of professional development. Efforts to improve perceptions surrounding AI should be made prior to broad implementation.

Future research examining the impact of ChatGPT-generated lessons compared to teacher-created lessons on student performance would be valuable for educators seeking to integrate AI into their SDPD. Such studies could also explore strategies to help teachers generate and critically evaluate the quality of AI-generated instructional materials.

Lee, S., Mott, B., Ottenbreit-Leftwich, A., Scribner, A., Taylor, S., Park, K., Rowe, J., Glazewski, K., Hmelo-Silver, C. E., & Lester, J. (2021). AI-Infused collaborative inquiry in upper elementary school: A game-based learning approach. *Proceedings of the AAAI Conference on Artificial Intelligence*, *35*(17), 15591-15599. https://doi.org/10.1609/aaai.v35i17.17836

Conducted with grant funding from the National Science Foundation, researchers set out on a two-part mission: to discover how to integrate artificial intelligence (AI) with life science,

utilizing game-based learning experiences for upper elementary students (ages 8-11), and to determine which supports teachers would need for this. The study employed PRIMARY AI, a game-based learning program seeking to incorporate AI education with inquiry-based science scenarios. Next Generation Science Standards (NGSS) and the K-12 Computer Science Framework were used as a foundational framework for the lesson designs, which were co-designed by teachers, ensuring they aligned with teacher needs and school constraints.

The study took three teachers through the co-design and implementation process and concluded with semi-structured interviews. The interviews revealed that teachers believe computer science will be important to students in the future, but feel ill-prepared to teach it. Participants did not have concerns about teaching AI because they were unfamiliar with it. AI has increased in popularity since the publication of this study in 2021, and new data regarding the preparedness of teachers to teach AI is available and should be referenced by those interested in implementing AI in schools. Additionally, with such a small pool of participants, it is difficult to make any generalizations about the data.

This study is, however, valuable for those looking to design curriculum. While no quantifiable data was produced, and qualitative data cannot be generalized, the design of the program itself is compelling. The program allows students to utilize block-based program design to learn about AI concepts, including image recognition, machine learning and semi-autonomous navigation, while simultaneously engaging in a problem-based learning approach to natural science. Given the strong pedagogy and lesson design, this provides a high-quality model for how computer science, AI and natural science lessons can be integrated. Furthermore, lessons were characterized by many aspects of global competencies and deep learning; additional studies

examining the impact of these lessons on student performance should be conducted on a larger scale as they could hold great promise as a model for future science instruction.

van den Berg, G., & du Plessis, E. (2023). ChatGPT and generative AI: Possibilities for its contribution to lesson planning, critical thinking and openness in teacher education. *Education Sciences*, 13, 998. https://doi.org/10.3390/educsci13100998

The article seeks to explore the usage opportunities for generative artificial intelligence (AI), specifically Generative Pretrained Transformer (ChatGPT), in schoolteacher education and training through a document analysis of generated texts.

Researchers prompted ChatGPT for a lesson on prepositions for English language learners in 6th grade. Utilizing a single lesson, subject, and grade level, the scope of the research was acknowledged to be quite narrow. A series of follow-up questions were asked to generate a worksheet as well as a visual presentation. According to researchers, the lesson generated had the components of a basic lesson with the potential for individualization; however, they noted that some teachers found the lesson rudimentary. While the study defined the terms for the document analysis, they did not discuss who conducted the analysis. Information, including how many people reviewed the document and the credentials of those people, would be beneficial in determining the credibility of their claims.

The article argues that ChatGPT-generated lessons could save teachers time and reduce teacher workload by generating specified content, with the caveat that premade lessons are commonly available in teacher curriculum books. While claiming to maximize teacher efficiency, no quantifiable measures were taken, and there were no qualitative comparisons made. The data could be meaningful if quantifiable measures were made comparing the amount

of time teachers spend creating a lesson plan using generative AI vs. traditional methods. The skill level of the teacher would need to be accounted for, as a more seasoned teacher may be able to design a lesson of higher quality in a similar amount of time, especially when accounting for the time teachers would need to spend evaluating the accuracy of the AI-generated lesson.

The authors claimed generative AI could make education more equitable through providing open access to lesson plans and reducing the cost of textbooks. There is no evidence that these generated lesson plans could replace the use of textbooks, and authors acknowledge that some teachers are bound by prescriptive curriculum.

This study could be useful for a teacher looking to incorporate AI into their personal lesson planning; however, those looking to enact change on a broader level may benefit from more detailed studies utilizing a variety of grade levels, subjects, and varied prompts. Especially useful would be a comparative analysis of AI-generated lesson plans and teacher-generated plans, as well as their impacts on student learning. Generative AI models are notorious for producing illogical responses; therefore, research regarding the implementation and efficacy of generated lessons is needed.