ARTIFICIAL INTELLIGENCE READINESS AMONG ARCHITECTURE STUDENTS: A COMPUTER-AIDED QUALITATIVE ANALYSIS USING ORANGE DATA MINING AND VADER SENTIMENT ANALYSIS

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ABSTRACT. *Rapid advancements in Artificial Intelligence have significantly transformed higher education, particularly in architecture, where design, visualization, and research are fundamental. This study explored architecture students' perceptions regarding AI integration in architectural education and identified the curriculum enhancements necessary to prepare future practitioners. Employing a qualitative research design, we analyzed textual responses using Orange Data Mining software, including VADER sentiment analysis, word cloud visualization, and thematic analysis. Findings reveal predominantly positive sentiment toward AI, with students viewing it as a valuable support for research, creativity, and productivity. Notably, students emphasized the continued necessity of critical thinking, ethical reasoning, and professional judgment alongside AI literacy. We suggest that architecture curricula adopt a balanced approach that integrates AI technologies while reinforcing the essential human competencies that define the profession.*

Key Words: Architecture Students,CAD software,Sentiment Analysis,Vader

1. INTRODUCTION

Artificial Intelligence has emerged as a disruptive force, fundamentally reshaping the paradigms of education, industry, and professional architectural practice. The rapid proliferation of generative AI—including platforms such as ChatGPT, Midjourney, and Gemini—has revolutionized how students acquire knowledge, conduct research, ideate, and resolve complex design problems. In architectural education, these technologies are no longer peripheral; they have become central, offering unprecedented capabilities in conceptual design, visualization, computational modeling, environmental analysis, and informed design decision-making. However, the integration of these tools into academic workflows necessitates a critical examination of how they influence creative exploration and goal-directed design processes [19].

Architecture has consistently demonstrated an affinity for technological adaptation, transitioning historically from manual drafting to Computer-Aided Design, Building Information Modeling, and parametric modeling. Today, AI represents a paradigm shift of greater magnitude. Unlike its predecessors, which functioned primarily as drafting or documentation utilities, contemporary AI systems offer cognitive enhancements that extend beyond visual output. By augmenting students' capacities in research, writing, programming, and analytical data processing, AI functions as a collaborative agent in the design process rather than merely a production tool. This transformative potential necessitates the development of comprehensive AI literacy, enabling students to navigate the intersection of algorithmic outputs and professional judgment [4, 30].

This technological ascendancy brings significant challenges. Concerns regarding over-reliance on automated systems, the potential erosion of original thought, compromised academic integrity, and ethical ambiguities necessitate a critical examination of AI's role in the design studio. Furthermore, there is a legitimate apprehension regarding the potential displacement of uniquely human creative faculties. Consequently, architectural pedagogy faces a vital imperative: to integrate AI technologies into the curriculum while concurrently fortifying the core competencies that define the discipline—namely, creativity, critical thinking, ethical reasoning, and the professional judgment required to navigate an increasingly algorithmic landscape. To address these challenges, current educational frameworks should evolve to incorporate multidisciplinary design teams that oversee the integration of ethical principles, digital literacy, and machine learning into core studio work [4].

Understanding students' perceptions is therefore paramount, as they constitute the nascent workforce destined to operate within this evolving, AI-integrated milieu. Capturing their experiences and recommendations provides the foundational empirical evidence necessary for curriculum developers, educators, and policymakers to navigate the complexities of modernizing architectural education effectively. By elucidating these perspectives, this study bridges the existing research gap regarding the intersection of student sentiment and pedagogical innovation [8]. Furthermore, the integration of specialized, human-in-the-loop AI systems ensures that technological tools remain responsive to the unique cognitive and emotional requirements of the learner. By fostering interactive, scaffolding-based design workflows, these systems reinforce student agency and mitigate the risks of over-reliance, ultimately underscoring the necessity of a human-centric approach in the evolution of architectural education.

2. RESEARCH QUESTIONS

To address the objectives of this investigation, this study sought to answer the following research questions:

1. What are the perceptions and sentiments of architecture students regarding the use of Artificial Intelligence in architectural education?
2. What competencies and curriculum enhancements do architecture students recommend to prepare future architects for the integration of Artificial Intelligence into

professional practice?

3. SIGNIFICANCE OF THE STUDY

The results of this study contribute to the extant literature regarding Artificial Intelligence in higher education by offering empirical insights derived from the perspectives of architecture students. Furthermore, this research delineates actionable recommendations for curriculum enhancement, providing a framework for academic institutions to establish AI-integrated architectural programs that effectively harmonize technological innovation with essential human-centric competencies. Specifically, this research emphasizes that institutional adoption of AI must be guided by ethical principles such as transparency, justice, and fairness to ensure that technological integration fosters a robust and trustworthy learning environment [11].

4. REVIEW OF RELATED LITERATURE

The integration of Artificial Intelligence into higher education has accelerated, necessitating evidence-informed curricula that prioritize ethical and digital literacy [3]. Furthermore, research indicates that AI enhances personalized learning and engagement when systematically incorporated into academic environments. Students frequently highlight the responsiveness and interactivity of these tools as critical drivers of a positive learning experience, acknowledging their profound impact on future career trajectories [5]. Nonetheless, practitioners emphasize that while AI tools streamline complex design workflows, they must be balanced by pedagogical approaches that foster human creativity and critical assessment to mitigate the risks of over-reliance on generative outputs [6. 18].Within architecture, AI applications in conceptual design, simulation, and visualization are transforming the studio experience. In this context, recent studies suggest that AI functions as a collaborative agent or "provocateur" in the design process rather than a replacement for professional architects [19]. While AI significantly improves efficiency and supports exploratory design, scholars maintain that creativity, ethical reasoning, and professional judgment remain uniquely human competencies [4]. Consequently, institutions must develop comprehensive frameworks that address not only technical proficiency but also the pedagogical and ethical implications of these technologies [10 32]. Moreover, addressing these concerns requires interdisciplinary strategies that bridge the gap between technical tool proficiency and the development of critical thinking, ensuring that AI-enhanced learning activities sustain long-term student engagement [23].Consequently, emerging literature emphasizes the critical need for comprehensive AI literacy among future professionals. This literacy encompasses technical understanding, prompt engineering, and the ability to critically evaluate algorithmic outputs [30]. Furthermore, institutional adoption must be grounded in ethical principles such as transparency, justice, and fairness, ensuring that technological integration fosters a trustworthy learning environment [11]. Ultimately, these competencies are essential for transforming higher education to produce "future-ready" graduates capable of navigating an evolving, technology-integrated architectural landscape.[9] Importantly, the implementation of these pedagogical frameworks requires a rigorous adherence to data privacy and security standards, as the collection of student information during AI interactions presents significant ethical and confidentiality risks [15]. To mitigate these risks, educators should implement "friction-by-design" strategies, such as mandating provenance logs that document the transition from initial AI generation to human-led verification and synthesis [1]. Such measures ensure that AI tools function as catalysts for student agency rather than automated shortcuts that bypass critical inquiry [12, 24]/.

5. METHODOLOGY

5.1 Research Design

This study employed a qualitative descriptive research design to comprehensively explore student perceptions regarding the integration of Artificial Intelligence into architectural education. By utilizing Computer-Aided Qualitative Data Analysis through Orange Data Mining software, the research ensured a rigorous and systematic processing of the textual responses collected via Google Forms. This methodological framework facilitated the objective identification of sentiment trends and thematic patterns, providing a robust empirical basis for interpreting how students navigate the evolving landscape of technology-enhanced architectural pedagogy. The study purposively engaged all fourth-year Bachelor of Science in Architecture students enrolled in the Research Methods course during the Mid-Year Term. This cohort was selected due to their advanced standing in the program and their imminent transition into professional internships, which necessitates a nuanced understanding of AI-driven tools within practice-based environments [24].

5.2 Participants

The study purposively engaged all fourth-year Bachelor of Science in Architecture students enrolled in the Research Methods course during the Mid-Year Term. This demographic was strategically selected due to their advanced academic standing, which ensures a level of disciplinary maturity and practical experience necessary for providing informed, critical perspectives on the role of AI within the architectural curriculum. These participants possess the requisite exposure to design software and studio workflows to reflect on the balance between algorithmic automation and human creativity, particularly as they prepare for the transition into professional practice [17].

5.3 Research Instrument

Data collection was facilitated through a researcher-developed, structured Google Forms questionnaire designed to elicit nuanced qualitative insights into students' perceptions of Artificial Intelligence, specifically focusing on perceived benefits, operational challenges, and strategic recommendations for curriculum enhancement. To establish content validity and ensure the instrument’s alignment with core research objectives, the questionnaire was subjected to a rigorous expert review process prior to dissemination. This validation step was critical in ensuring the robust capture of qualitative data, thereby providing a comprehensive empirical basis for the subsequent thematic and sentiment analysis.

5.4 Data Analysis

The collected responses were systematically processed using Orange Data Mining, employing the following analytical techniques:

- Word Cloud Analysis
- VADER Sentiment Analysis
- Keyword Frequency Analysis
- Thematic Analysis

Among these methods, the VADER Sentiment Analysis was specifically utilized to classify textual responses into positive, neutral, and negative categories, generating compound sentiment scores ranging from -1 to +1. This quantitative classification was complemented by thematic analysis, which identified key concerns and pedagogical opportunities by coding qualitative narratives into overarching categories [21]. This approach allowed for a granular examination of participant feedback, ensuring that the internal consistency and reliability of the identified themes were adequately maintained [2]. To ensure the validity of these findings, inter-rater reliability was assessed by comparing independently coded thematic subsets, thereby minimizing subjective bias in the interpretation of student narratives [27].

6. RESULTS AND DISCUSSION

6.1 Research Question 1

What are the perceptions and sentiments of architecture students regarding the use of Artificial Intelligence in architectural education?

Figure-1: Research Question 1 Word Cloud/

6.2 Word Cloud Analysis

The generated word cloud reveals that architecture students generally perceive Artificial Intelligence as a valuable educational tool that enhances learning and understanding. Specifically, frequently occurring terms such as helpful, learning, understand, education, architecture, design, efficient, information, and research suggest that students associate AI with improved comprehension, increased productivity, and enhanced academic performance. Collectively, these keywords reflect a broader recognition of AI's potential to optimize educational workflows and support academic development. Furthermore, the VADER sentiment scores corroborate these findings, indicating a predominantly positive orientation toward AI-integrated tasks, likely due to the perceived reduction in cognitive load during complex design iterations [15].

Students likewise emphasized the role of AI in facilitating brainstorming, visualization, conceptual development, and research activities, suggesting that AI has become an important component of their educational experience. Although positive concepts dominated the responses, words including **verify**, **concerns**, **replacement**, and **relying** indicate that students remain cautious regarding the responsible use of AI and the necessity of validating AI-generated information. These critical reflections highlight a sophisticated awareness of potential biases and the erosion of original creative autonomy that can accompany over-dependence on automated systems [29].

6.3 VADER Sentiment Analysis

Table-1: RQ1 Sentiment Table (VADER RESULTS)

Respondent	Positive	Negative	Neutral	Compound
1	0.282	0	0.718	0.9863
2	0.149	0.16	0.691	-0.0534
3	0	1	0	-0.25
4	0.212	0	0.788	0.827
5	0.296	0	0.704	0.8439
6	0.111	0	0.889	0.5569
7	0	0	1	0
8	0.141	0.089	0.771	0.2819
9	0.118	0	0.882	0.4854
10	0	0	1	0
11	0.118	0	0.882	0.4703
12	0.153	0	0.847	0.4404
13	0.265	0	0.735	0.6597
14	0.114	0	0.886	0.734
15	0	0	1	0

The sentiment analysis revealed predominantly positive perceptions toward AI integration. Most responses obtained positive compound sentiment scores, indicating favorable attitudes regarding the educational value of Artificial Intelligence. Only a small number of responses reflected neutral or negative sentiments, suggesting isolated concerns regarding overdependence, ethical considerations, and information reliability. This trend aligns with broader findings in educational technology, where students prioritize the efficiency and convenience of AI-supported workflows while maintaining a critical awareness of potential technical inaccuracies [7. 28].

The convergence between the word cloud and sentiment analysis strengthens the interpretation that students generally perceive AI as a beneficial educational technology while recognizing the importance of maintaining critical evaluation and responsible use. Such nuanced perspectives reflect an underlying enthusiasm for leveraging AI to streamline academic tasks, echoing findings that highlight how these tools improve research efficiency and bolster self-confidence in complex disciplinary writing [33].

6.4 Research Question 2

What competencies and curriculum enhancements do architecture students recommend to prepare future architects for AI integration?

Figure-2: Research Question 2 Word Cloud

6.5 Word Cloud Analysis

Building upon the previous analysis, the second word cloud highlights the competencies that students consider essential for future architectural practice. Dominant keywords include skills, critical thinking, creativity, future, design, architecture, ethical, communication, curriculum, learning, and Artificial Intelligence. These terms underscore a pedagogical necessity to emphasize human-centric design and intellectual autonomy, as students explicitly caution against the detrimental impacts of over-reliance, such as restricted problem-solving abilities and diminished independent judgment [34].

The prominence of these terms suggests that respondents advocate for an educational model that integrates AI technologies without compromising the uniquely human competencies required of architects. Specifically, students emphasized creativity, professional judgment, ethical responsibility, and communication as indispensable qualities that AI should complement rather than replace. Furthermore, the data indicates that students view AI literacy as a dual-faceted requirement, necessitating both technical proficiency and an understanding of the inherent limitations within algorithmic outputs [12].

Furthermore, respondents recommended the integration of AI across diverse architectural subjects, particularly in design studios, visualization, research methods, computational design, and Building Information Modeling. In parallel, students stressed the importance of responsible AI use, highlighting the necessity of verifying AI-generated information, maintaining awareness of algorithmic biases, and engaging in ethical decision-making. These recommendations align with emerging frameworks that position AI literacy as a foundational competence for the modern workforce, requiring educators to foster environments where students develop the discernment to evaluate algorithmic outputs within their disciplinary contexts [26, 31].

Consistent with the initial findings, the sentiment analysis demonstrated overwhelmingly positive attitudes toward curriculum enhancement through AI integration.

6.6 VADER Sentiment Analysis

Table-2: RQ2 Sentiment Table (VADER RESULTS)

Respondent	Positive	Negative	Neutral	Compound
1	0.216	0.032	0.752	0.9976
2	0.192	0	0.808	0.9756
3	0.142	0.07	0.788	0.8276
4	0.18	0.03	0.791	0.9571
5	0.204	0.043	0.752	0.9405
6	0.233	0.019	0.749	0.9931
7	0.07	0.062	0.867	0.0772
8	0.155	0	0.845	0.8816
9	0.234	0	0.766	0.9413
10	0	0	1	0
11	0.159	0.045	0.796	0.9441
12	0.213	0.024	0.763	0.9524
13	0.194	0.032	0.774	0.8883
14	0.204	0.064	0.732	0,7863
15	0	0.057	0.953	-0.3182

The majority of responses yielded highly positive compound scores, reflecting students' enthusiasm for preparing future architects through AI-supported learning. While a few respondents expressed reservations concerning over-dependence on AI and the preservation of originality, these concerns represented a minority perspective. Ultimately, these findings reinforce the necessity of implementing structured AI literacy programs that prioritize technical prompt engineering competencies while simultaneously grounding students in the ethical and regulatory frameworks essential for professional practice [14, 22].

Ultimately, students recommended an educational framework that seamlessly combines AI literacy with creativity, critical thinking, ethical reasoning, communication, and lifelong learning. Such a holistic pedagogical approach ensures that students do not merely learn to operate tools, but instead develop the self-reflective mindsets necessary to apply these technologies in demonstrably beneficial and responsible ways [8].

7.0 DISCUSSION

The findings demonstrate that architecture students perceive Artificial Intelligence as a transformative technology capable of enhancing architectural education. Rather than advocating for AI to replace traditional instruction, students consistently recommend its integration as a complementary tool, reflecting a sophisticated awareness of the need to balance technological efficiency with the preservation of creative autonomy [29].

The word cloud analysis for Research Question 2 reinforces this, placing greater emphasis on essential human competencies—specifically skills, critical thinking, creativity, and professional development—rather than AI technologies in isolation. This prioritization suggests that students do not view AI as the primary objective of architectural education; instead, they frame it as an instrument that supports human-centered design. Students explicitly caution against over-reliance on automated systems, highlighting concerns about restricted independent judgment and problem-solving abilities [34].

These findings align with contemporary educational frameworks that emphasize AI literacy, responsible

innovation, and the strategic augmentation of human intelligence rather than the automation of professional judgment [8. 26]. By advocating for an educational model that integrates AI without compromising uniquely human competencies, students underscore a dual-faceted requirement for technical proficiency paired with a critical understanding of algorithmic limitations [12]. This consensus highlights the urgent need for a structured competency framework in architectural curricula to guide didactic proposals and ensure academic continuity in the face of rapid technological evolution [20].

8.0 CONCLUSION

Architecture students generally exhibit positive perceptions regarding the integration of Artificial Intelligence into architectural education. They recognize AI as an effective learning support tool that enhances research, creativity, visualization, and academic productivity. However, students also acknowledge the importance of maintaining ethical responsibility, originality, and critical thinking when utilizing AI **technologies.**

The findings further indicate that future architecture curricula should emphasize AI literacy alongside creativity, professional judgment, communication, and ethical decision-making. Such an approach ensures that graduates are equipped to collaborate effectively with AI while preserving the human competencies that define architectural practice.

9.0 Recommendations

The following recommendations are proposed to enhance the integration of artificial intelligence within the architectural curriculum:

1. Primarily, integrate AI literacy into the Bachelor of Science in Architecture curriculum through dedicated modules and practical applications.
2. In tandem, incorporate AI-assisted design exercises into architectural design studios while maintaining a strong emphasis on manual and conceptual design foundations.
3. Furthermore, strengthen instruction regarding ethical AI use, the critical evaluation of AI-generated outputs, and the principles of academic integrity.
4. Concurrently, expand instruction to cover computational design, BIM, generative design, and advanced visualization technologies.
5. Finally, conduct longitudinal studies to examine the long-term impact of these pedagogical shifts on architectural education and the development of professional competencies.

10.0 REFERENCES

[1] Banerjee, A., & Pathak, R. (2026). From Algorithmic Adherence to Cognitive Autonomy: Mitigating Automation Bias in Student Decision-Making Workflows. *International Journal of Innovative Science and Research Technology (IJISRT)*, 1088–1088. https://doi.org/10.38124/ijisrt/26jun803

[2] Barrett, A., & Pack, A. (2023). Not quite eye to A.I.: student and teacher perspectives on the use of generative artificial intelligence in the writing process. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00427-0

[3] Bond, M., Khosravi, H., Laat, M. de, Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S. W., & Siemens, G. (2024). A meta systematic review of artificial intelligence in higher education: a call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-023-00436-z

[4] Chan, C. K. Y. (2023). A comprehensive AI policy education framework for university teaching and learning. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00408-3

[5] Chan, C. K. Y., & Hu, W. (2023). Students' voices on generative AI: perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00411-8

[6] Chan, C. K. Y., & Lee, K. K. W. (2023). The AI generation gap: Are Gen Z students more interested in adopting generative AI such as ChatGPT in teaching and learning than their Gen X and millennial generation teachers? *Smart Learning Environments*, *10*(1). https://doi.org/10.1186/s40561-023-00269-3

[7] Chan, C. K. Y., & Zhou, W. (2023). An expectancy value theory (EVT) based instrument for measuring student perceptions of generative AI. *Smart Learning Environments*, *10*(1). https://doi.org/10.1186/s40561-023-00284-4

[8] Chiu, T. K. F. (2023). Future research recommendations for transforming higher education with generative AI. *Computers and Education Artificial Intelligence*, *6*, 100197–100197. https://doi.org/10.1016/j.caeai.2023.100197

[9] Chiu, T. K. F., Ahmad, Z., Ismailov, M., & Sanusi, I. T. (2024). What are artificial intelligence literacy and competency? A comprehensive framework to support them. *Computers and Education Open*, *6*, 100171–100171. https://doi.org/10.1016/j.caeo.2024.100171

[10] Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: the state of the field. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00392-8

[11] Delcker, J., Heil, J., Ifenthaler, D., Seufert, S., & Spirgi, L. (2024). First-year students AI-competence as a predictor for intended and de facto use of AI-tools for supporting learning processes in higher education. *International Journal of Educational*

Technology in Higher Education, *21*(1). https://doi.org/10.1186/s41239-024-00452-7

[12] Ding, L., Li, T., Jiang, S., & Gapud, A. A. (2023). Students' perceptions of using ChatGPT in a physics class as a virtual tutor. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00434-1

[13] Familoni, B. T., & Onyebuchi, N. C. (2024). ADVANCEMENTS AND CHALLENGES IN AI INTEGRATION FOR TECHNICAL LITERACY: A SYSTEMATIC REVIEW. *Engineering Science & Technology Journal*, *5*(4), 1415–1430. https://doi.org/10.51594/estj.v5i4.1042

[14] Hackl, V., Müller, A. E., & Sailer, M. (2026). The AI literacy heptagon: A structured approach to AI literacy in higher education. *ArXiv.Org*, *10*, 100540–100540. https://doi.org/10.1016/j.caeai.2026.100540

[15] Jin, S.-H., Im, K., Yoo, M., Roll, I., & Seo, K. (2023). Supporting students' self-regulated learning in online learning using artificial intelligence applications. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00406-5

[16] Kerimbayev, N., Umirzakova, Z., Shadiev, R., & Jotsov, V. (2023). A student-centered approach using modern technologies in distance learning: a systematic review of the literature. *Smart Learning Environments*, *10*(1). https://doi.org/10.1186/s40561-023-00280-8

[17] Khader, S. M. A., & Khalil, M. (2025). A Comprehensive Qualitative Analysis of Artificial Intelligence's Potential to Improve Higher Education Students' Learning in Comparison to Current Research (2019–2025). *International Journal of Innovative Science and Research Technology (IJISRT)*, 285–285. https://doi.org/10.38124/ijisrt/25dec334

[18] Labadze, L., Grigolia, M., & Machaidze, L. (2023). Role of AI chatbots in education: systematic literature review. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00426-1

[19] Medel-Vera, C., Britton, S., & Gates, W. (2025). An exploration of the role of generative AI in fostering creativity in architectural learning environments. *Computers and Education Artificial Intelligence*, *9*, 100501–100501. https://doi.org/10.1016/j.caeai.2025.100501

[20] Otero, L. C., Catalá, A., Fernández-Morante, C., Taboada, M., López, B. C., & Barro, S. (2023). AI literacy in K-12: a systematic literature review. *International Journal of STEM Education*, *10*(1). https://doi.org/10.1186/s40594-023-00418-7

[21] Özçelik, N. P., & Ekşi, G. Y. (2024). Cultivating writing skills: the role of ChatGPT as a learning assistant—a case study. *Smart Learning Environments*, *11*(1). https://doi.org/10.1186/s40561-024-00296-8

[22] Pangestu, F. N. N., Hamidah, I., Widaningsih, L., Abdullah, A. G., & Saputra, N. A. (2026). A scoping literature review of prompt engineering for bridging students AI literacy in higher education. *Computers and Education Artificial Intelligence*, *10*, 100581–100581. https://doi.org/10.1016/j.caeai.2026.100581

[23] Qu, Y., Tan, M., & Wang, J. (2024). Disciplinary differences in undergraduate students' engagement with generative artificial intelligence. *Smart Learning Environments*, *11*(1). https://doi.org/10.1186/s40561-024-00341-6

[24] Schmidt, D. A., AlBloushi, B., Thomas, A., & Magalhães, R. (2025). Integrating artificial intelligence in higher education: perceptions, challenges, and strategies for academic innovation. *Computers and Education Open*, *9*, 100274–100274. https://doi.org/10.1016/j.caeo.2025.100274

[25] Seo, K., Tang, J., Roll, I., Fels, S., & Yoon, D. (2021). The impact of artificial intelligence on learner–instructor interaction in online learning. *International Journal of Educational Technology in Higher Education*, *18*(1), 54–54. https://doi.org/10.1186/s41239-021-00292-9

[26] Southworth, J., Migliaccio, K. W., Glover, J., Glover, J., Reed, D. M., McCarty, C., Brendemuhl, J. H., & Thomas, A. (2023). Developing a model for AI Across the curriculum: Transforming the higher education landscape via innovation in AI literacy. *Computers and Education Artificial Intelligence*, *4*, 100127–100127. https://doi.org/10.1016/j.caeai.2023.100127

[27] Stöhr, C., Ou, A. W., & Malmström, H. (2024). Perceptions and usage of AI chatbots among students in higher education across genders, academic levels and fields of study. *Chalmers Research (Chalmers University of Technology)*, *7*, 100259–100259. https://doi.org/10.1016/j.caeai.2024.100259

[28] Sun, D., Boudouaia, A., Zhu, C., & Li, Y. (2024). Would ChatGPT-facilitated programming mode impact college students' programming behaviors, performances, and perceptions? An empirical study. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-024-00446-5

[29] Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart Learning*

Environments, *10*(1). https://doi.org/10.1186/s40561-023-00237-x

[30] Walter, Y. (2024). Embracing the future of Artificial Intelligence in the classroom: the relevance of AI literacy, prompt engineering, and critical thinking in modern education. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-024-00448-3

[31] Wang, F., King, R. B., Chai, C. S., & Zhou, Y. (2023). University students' intentions to learn artificial intelligence: the roles of supportive environments and expectancy–value beliefs. *International Journal of Educational Technology in Higher Education*, *20*(1). https://doi.org/10.1186/s41239-023-00417-2

[32] Xia, Q., Weng, X., Ouyang, F., Lin, T., & Chiu, T. K. F. (2024). A scoping review on how generative artificial intelligence transforms assessment in higher education. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-024-00468-z

[33] Zhai, C., Wibowo, S., & Li, L. D. (2024). The effects of over-reliance on AI dialogue systems on students' cognitive abilities: a systematic review. *Smart Learning Environments*, *11*(1). https://doi.org/10.1186/s40561-024-00316-7

[34] Zhang, S., Zhao, X., Zhou, T., & Kim, J. H. (2024). Do you have AI dependency? The roles of academic self-efficacy, academic stress, and performance expectations on problematic AI usage behavior. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-024-00467-0