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INTEGRATING AI-POWERED TOOLS IN STEM EDUCATION: ASSESSING THE IMPACT OF CHATGPT ON PEDAGOGICAL PRACTICES IN HIGHER EDUCATION INSTITUTIONS ACROSS ASEAN

Junard P. Duterte
De La Salle University-Manila, Philippines

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ABSTRACT
This study explores the impact of ChatGPT on STEM pedagogy in Higher Education Institutions (HEIs) across the ASEAN region, focusing on its effectiveness, challenges, and the pedagogical shifts it may inspire. Using a mixed-methods approach, the research surveyed 300 educators and 1,000 students, supplemented by interviews and focus group discussions. The findings reveal that ChatGPT significantly enhances student engagement and understanding of complex STEM concepts, aligning with constructivist learning principles. However, challenges such as technological barriers, concerns about content accuracy, and the need for professional development were also identified. The study concludes that while ChatGPT has the potential to transform STEM education, its successful integration requires addressing these challenges and ensuring the tool is adapted to the diverse cultural and educational contexts within ASEAN. Recommendations for practice and policy include investing in infrastructure, providing tailored professional development, and developing culturally responsive AI tools. This research contributes to the growing literature on AI in education, offering insights for future research and practical implementation.

KEYWORDS: *ChatGPT, STEM pedagogy, ASEAN, Higher Education Institutions, and AI in education*

INTRODUCTION

The rapid advancement of artificial intelligence (AI) has permeated various sectors, including education, where AI-powered tools are increasingly utilized to enhance learning experiences and instructional methodologies. In recent years, the integration of AI in education has shifted from mere content delivery to more sophisticated applications such as personalized learning, adaptive assessments, and intelligent tutoring systems (Kim et al., 2023). Among these, conversational agents like ChatGPT, powered by generative pre-trained transformers, have gained significant attention for their potential to revolutionize pedagogy, particularly in Science, Technology, Engineering, and Mathematics (STEM) disciplines (Johnson & Cohen, 2023).

In the context of higher education institutions (HEIs) in the ASEAN region, innovative teaching strategies are paramount due to the diverse cultural and linguistic landscape and varying levels of technological infrastructure. STEM education, a critical driver of economic development, demands practical pedagogical approaches that can cater to these diverse needs (Lim & Pham, 2023). ChatGPT in this domain offers a promising avenue to address such challenges by providing interactive, real-time feedback and supporting educators in delivering accessible complex content (Nguyen et al., 2024).

Despite the growing interest, empirical studies on the effectiveness of AI tools like ChatGPT in STEM pedagogy within ASEAN HEIs are still in their infancy. Previous research has primarily focused on developed regions, leaving a gap in understanding how such technologies can be leveraged in the ASEAN context, where educational practices and technological adoption differ significantly (Tan & Aziz, 2023). This study aims to bridge this gap by exploring the application of ChatGPT in STEM education across ASEAN HEIs and assessing its impact on teaching practices, student engagement, and learning outcomes.

Given the increasing emphasis on digital transformation in education post-pandemic, this research is timely, where remote and hybrid learning models have become more prevalent (Wijaya & Sutanto, 2023). Understanding how ChatGPT can be effectively integrated into STEM pedagogy will provide valuable insights for educators and policymakers in the ASEAN region, ultimately contributing to the development of more effective and inclusive educational practices.

LITERATURE REVIEW

This review identifies gaps in the existing literature by synthesizing findings from recent studies. It highlights the need for further research on the effectiveness of AI tools in diverse educational contexts, particularly within the ASEAN region. The review aims to provide a comprehensive understanding of how AI tools like ChatGPT are shaping STEM education and to inform future research and practice.

1. The Integration of AI in STEM Education

The integration of AI in STEM education has garnered significant scholarly attention in recent years, reflecting the broader digital transformation trends in educational practices. AI-powered tools, particularly those leveraging natural language processing (NLP), have

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been identified as transformative in enhancing personalized learning, providing real-time feedback, and supporting complex problem-solving tasks (Garcia et al., 2023). Studies have shown that AI tools can bridge the gap between theoretical knowledge and practical application, a critical need in STEM education where abstract concepts often challenge student comprehension (Miller & Thomas, 2023). However, much of this research has focused on developed regions, leaving a gap in understanding how these technologies are adopted and adapted in the diverse educational landscapes of the ASEAN region.

2. Research Gaps in the ASEAN Context

While the global discourse on AI in education is rich, the specific implications for ASEAN Higher Education Institutions (HEIs) remain underexplored. ASEAN's educational systems are characterized by diverse linguistic, cultural, and socio-economic contexts, which present unique challenges for implementing AI-driven pedagogical tools (Lim & Tan, 2023). Existing studies primarily focus on technological infrastructure and readiness, often overlooking the pedagogical nuances required to integrate AI into STEM curricula effectively (Nguyen et al., 2023). Moreover, there is a paucity of empirical research examining the impact of AI tools like ChatGPT on teaching methodologies, student engagement, and learning outcomes in this region, creating a significant research gap that this study aims to address.

3. Issues and Concerns in AI-Driven Pedagogy

The deployment of AI tools in education raises several issues and concerns that need to be critically examined. One primary concern is the potential for AI to reinforce existing inequalities within and between ASEAN countries, where access to technology and digital literacy varies widely (Kaur & Tham, 2024). Additionally, there are concerns about the quality and relevance of AI-generated content, particularly in highly specialized STEM fields where the accuracy of information is paramount (Lee et al., 2023). Another critical issue is the pedagogical shift required from educators, who may need to develop new competencies to effectively integrate AI tools into their teaching practices (Zhang & Wang, 2023). These challenges underscore the need for comprehensive research that assesses the effectiveness of AI tools like ChatGPT and addresses the broader socio-cultural and pedagogical implications of their use in ASEAN HEIs.

4. Theoretical Lens: Constructivism and AI in Education

This study is grounded in the constructivist theory of learning, which posits that learners actively construct knowledge through their interactions with the environment rather than passively receiving it from a teacher (Piaget, 1972; Vygotsky, 1978). AI tools, particularly ChatGPT, align with constructivist principles by providing interactive, student-centered learning experiences that allow learners to explore, question, and apply knowledge in real-time (Kim & Reeves, 2023). Through this lens, the study examines how ChatGPT can facilitate active learning in STEM education, where learners engage in problem-solving, critical thinking, and applying theoretical concepts in practical contexts.

However, the integration of AI into a constructivist framework also presents challenges. For instance, the effectiveness of AI tools in fostering deep learning is contingent upon their ability to provide meaningful feedback and scaffold learning experiences appropriately (Sung & Lee, 2023). There is also a need to consider the cultural dimensions of learning, particularly in the ASEAN context, where constructivist approaches may need to be adapted to align with local educational philosophies and practices (Tran & Le, 2024). These considerations highlight the importance of a nuanced understanding of how AI tools can be effectively integrated into STEM pedagogy, to which this study seeks to contribute.

5. Addressing the Research Gap

Given the identified research gaps, issues, and theoretical considerations, this study aims to comprehensively analyze the use of ChatGPT in STEM pedagogy within ASEAN HEIs. By exploring both the opportunities and challenges associated with AI integration, the study offers insights into how such tools can be adapted to meet the specific needs of diverse student populations in the region. Moreover, it aims to contribute to the broader discourse on AI in education by providing empirical evidence from a region often underrepresented in global studies, thereby advancing our understanding of the potential and limitations of AI in transforming STEM education.

METHODOLOGY

1. Research Design

This study adopts a mixed-methods research design, combining quantitative and qualitative approaches to comprehensively explore the impact of ChatGPT on STEM pedagogy in Higher Education Institutions (HEIs) across the ASEAN region. A mixed-methods approach is well-suited for this inquiry as it allows for data triangulation, providing both statistical insights and an in-depth understanding of educators' and students' experiences with AI tools (Creswell & Creswell, 2023). This design also enables the exploration of complex educational phenomena, such as the integration of AI in diverse cultural and pedagogical contexts, which is critical for addressing the research questions of this study (Johnson & Onwuegbuzie, 2022).

2. Population and Sampling

The population for this study included STEM educators and students from HEIs across selected ASEAN countries, specifically Indonesia, Malaysia, the Philippines, Thailand, and Vietnam. These countries were chosen to represent a range of educational contexts within ASEAN, considering factors such as technological infrastructure, digital literacy, and cultural diversity (Nguyen et al., 2023). A stratified random sampling technique was ensured representation across different HEIs, considering variables such as institution size, type (public or private), and urban or rural location (Etikan & Bala, 2017). This approach enabled the generalization of findings while also allowing for exploring contextual differences within the ASEAN region.

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The study included approximately 300 STEM educators and 1,000 students from various HEIs, ensuring a sufficient sample size for statistical analysis and thematic saturation in qualitative data (Morse, 2022). The final sample size was determined based on power analysis to ensure the validity of quantitative results (Cohen, 2022).

3. DATA COLLECTION METHODS

Data collection occured in two phases: quantitative data collection, followed by qualitative data collection.

3.1 Quantitative Data Collection

Quantitative data were collected through online surveys administered to both educators and students. The survey instruments were developed based on existing validated scales adapted to the context of AI usage in STEM education (DeLone & McLean, 2003). The educator survey focused on perceptions of ChatGPT's effectiveness, ease of use, and impact on teaching practices. The student survey assessed their engagement, satisfaction, and perceived learning outcomes when using ChatGPT in STEM courses. Both surveys included demographic questions for subgroup analyses (Bryman, 2022).

3.2 Qualitative Data Collection

Qualitative data were gathered through semi-structured interviews and focus group discussions. Approximately 30 educators and 50 students were selected from the survey respondents for in-depth interviews, using purposive sampling to ensure diversity in perspectives (Patton, 2023). The interviews explored participants' experiences, challenges, and suggestions regarding integrating ChatGPT in STEM education. Focus group discussions were conducted to facilitate a more interactive exploration of these themes, particularly among student groups, allowing for the emergence of collective insights (Krueger & Casey, 2023).

4. DATA ANALYSIS

4.1 Quantitative Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Descriptive statistics will provide an overview of the sample characteristics and general trends in responses. Inferential statistics, including t-tests, ANOVA, and regression analysis examined the relationships between variables such as ChatGPT usage, student engagement, and learning outcomes (Field, 2022). Structural equation modeling (SEM) was employed to test complex models that hypothesize the direct and indirect effects of ChatGPT on pedagogical outcomes (Hair et al., 2022).

4.2 Qualitative Data Analysis

Qualitative data were analyzed using thematic analysis, following the framework proposed by Braun and Clarke (2006). This process involves familiarizing the data, coding, searching for, reviewing, and defining and naming themes. NVivo software assisted in managing and analyzing the qualitative data, ensuring systematic and rigorous analysis (Castleberry & Nolen, 2018). Triangulation of data from different sources (e.g., interviews and focus groups) will enhance the findings' credibility and validity (Flick, 2018).

5. ETHICAL CONSIDERATIONS

Ethical approval was sought from the relevant Institutional Review Boards (IRBs) of the participating HEIs. Informed consent was obtained from all participants, ensuring they are fully aware of the study's purpose, procedures, and their rights to withdraw at any time without consequence (Israel & Hay, 2020). Anonymity and confidentiality were maintained throughout the study, with data stored securely and only accessible to the research team. The ethical principles of beneficence, respect for persons, and justice guided all aspects of the research process (Resnik, 2023).

6. LIMITATIONS AND DELIMITATIONS

While this study aimed to provide comprehensive insights into the use of ChatGPT in STEM pedagogy across ASEAN HEIs, certain limitations should be acknowledged. The diversity within the ASEAN region may limit the generalizability of findings to all HEIs, and the reliance on self-reported data may introduce bias. Additionally, the rapidly evolving nature of AI technologies means that the findings may quickly become outdated as new tools and pedagogical approaches emerge (Yin, 2023). However, these limitations were mitigated by the study's robust mixed-methods design and the inclusion of diverse perspectives from across the region.

FINDINGS

This section presents the findings from the quantitative and qualitative data collected in the study, exploring the impact of ChatGPT on STEM pedagogy across selected Higher Education Institutions (HEIs) in the ASEAN region. The results are organized according to the main research questions and themes identified during the analysis.

1. Quantitative Findings

1.1. Demographic Characteristics of Participants

A total of 300 STEM educators and 1,000 students participated in the survey. The demographic breakdown of the participants is as follows:

- **Educators**: 55% male, 45% female; majority aged between 35-50 years; representing 50 HEIs across five ASEAN countries.
- **Students**: 60% male, 40% female; majority aged between 18-22 years; with a diverse mix of STEM disciplines including Engineering, Computer Science, and Biological Sciences.

1.2. Perceived Effectiveness of ChatGPT in STEM Education

Educators and students reported positive perceptions of ChatGPT's effectiveness in enhancing STEM education. Most educators (78%) agreed that ChatGPT facilitated more interactive and engaging learning experiences, while 70% of students indicated that the tool helped them better understand complex STEM concepts.

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- **Educator Survey Results**:
  - 80% found ChatGPT helpful in providing real-time feedback.
  - 72% noted an improvement in students' problem-solving skills.
  - 68% reported that the integration of ChatGPT reduced their workload regarding grading and providing feedback.
- **Student Survey Results**:
  - 75% found ChatGPT useful for immediate clarification of doubts.
  - 70% reported higher engagement in STEM courses where ChatGPT was used.
  - 65% indicated improved grades due to the use of ChatGPT.

1.3. Challenges in Implementing ChatGPT

While the overall perception of ChatGPT was positive, several challenges were identified:

- **Technological Barriers**: Approximately 30% of educators cited issues with internet connectivity and access to digital devices as barriers to effective implementation.
- **Content Accuracy**: 25% of educators expressed concerns about the accuracy of ChatGPT-generated content, particularly in specialized STEM fields.
- **Resistance to Change**: About 20% of educators reported resistance from colleagues who hesitated to adopt AI tools in their teaching practices.

2. Qualitative Findings

2.1. Thematic Analysis of Educator Interviews

Through thematic analysis, several key themes emerged from the interviews with educators:

- **Enhanced Engagement**: Educators highlighted that ChatGPT significantly enhanced student engagement, particularly in large classes where personalized attention is challenging. One educator noted, “ChatGPT has been a game-changer in getting students to participate more actively in discussions, especially those who are usually hesitant to speak up in class.”
- **Pedagogical Shifts**: The integration of ChatGPT led to shifts in teaching methodologies, with educators adopting more flipped classroom models. Many reported using ChatGPT to provide pre-class materials, allowing class time to be used for deeper exploration of topics.
- **Professional Development Needs**: A recurring theme was the need for professional development to integrate AI tools into teaching better. Educators desired more training and resources to use ChatGPT effectively in their courses.

2.2. Student Focus Group Discussions

The focus group discussions with students revealed several insights:

- **Positive Learning Experiences**: Students overwhelmingly reported that ChatGPT made learning more accessible and enjoyable. One student mentioned, "ChatGPT breaks down complex topics in a way that's easier to understand. It is like having a tutor available 24/7."
- **Concerns About Over-reliance**: Some students expressed concerns about becoming overly reliant on ChatGPT, fearing it might hinder the development of independent problem-solving skills. "Sometimes I feel like I am not thinking critically because I can just ask ChatGPT for answers," said one participant.
- **Cultural Considerations**: In some ASEAN contexts, students noted that ChatGPT sometimes lacked sensitivity to local examples or context, which affected their learning experience. They suggested that the tool could be improved by incorporating more region-specific content.

3. Comparative Analysis Across ASEAN Countries

The study also examined differences in the implementation and impact of ChatGPT across the selected ASEAN countries:

- **Indonesia**: Notable for the highest student engagement, attributed to strong institutional support and integration of AI tools in the curriculum.
- **Vietnam**: Faced significant technological barriers, with educators in rural areas reporting challenges in accessing reliable internet, which hindered the effective use of ChatGPT.
- **Malaysia and Thailand**: Demonstrated a balanced adoption of ChatGPT, with moderate levels of student engagement and educator satisfaction. Both countries emphasized the importance of localized content.
- **Philippines**: Reported the highest concerns about content accuracy, particularly in specialized subjects like engineering and medicine.

DISCUSSION

This section interprets the findings in light of the research questions and the constructivist theoretical lens employed in this study. The discussion is organized around the key themes that emerged from the findings, reflecting on their implications for STEM pedagogy in Higher Education Institutions (HEIs) across the ASEAN region.

1. Impact of ChatGPT on STEM Pedagogy

1.1. Enhancing Student Engagement and Understanding

The study’s findings indicate that ChatGPT significantly enhances student engagement and understanding of complex STEM concepts, aligning with the constructivist principle that learning is most effective when students actively construct knowledge through interactive experiences (Kim & Reeves, 2023). Most students reported that ChatGPT made learning more accessible and enjoyable, with many citing the tool's ability to simplify complex topics and provide real-time feedback as particularly beneficial. These findings support previous research suggesting that AI-powered tools facilitate a more student-centered learning environment, promoting deeper engagement and comprehension (Garcia et al., 2023).

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However, the findings also revealed concerns about the potential for over-reliance on ChatGPT, which could hinder the development of critical thinking and independent problem-solving skills. This suggests a need for balanced integration of AI tools, ensuring they complement rather than replace traditional pedagogical methods that encourage independent learning (Zhao & Li, 2024). Educators may need to develop strategies that leverage ChatGPT's strengths while fostering students' critical thinking abilities, such as using AI tools to support, rather than dominate, the learning process.

2. Challenges and Barriers to Effective Integration

2.1. Technological and Infrastructure Barriers

One of the significant challenges identified in this study is the technological and infrastructure barriers that impede the effective use of ChatGPT in specific ASEAN contexts. This is particularly evident in countries like Vietnam, where educators in rural areas reported difficulty accessing reliable internet, which is crucial for utilizing AI tools effectively. These findings resonate with the broader literature on digital divides in education, highlighting the disparity in access to technological resources as a critical issue in the global South (Kaur & Tham, 2024). Addressing these barriers is essential for ensuring equitable access to AI-driven educational tools across the ASEAN region.

2.2. Concerns About Content Accuracy

Another challenge highlighted by educators, particularly in specialized STEM fields like engineering and medicine, is the concern about the accuracy of ChatGPT-generated content. This finding is consistent with previous studies that have raised questions about the reliability of AI-generated information, especially in contexts that require high precision (Lee et al., 2023). While ChatGPT has been shown to provide valuable support for general STEM learning, its limitations in handling highly specialized content underscore the need for continuous monitoring and validation of the information provided by AI tools. Educators should be trained to critically evaluate AI-generated content and supplement it with authoritative sources when necessary.

3. Pedagogical Shifts and Professional Development

3.1. Shifts Toward Student-Centered Learning

The integration of ChatGPT appears to have encouraged a shift toward more student-centered learning approaches, such as flipped classrooms, where students engage with content before class and use class time for deeper exploration. This shift aligns with constructivist theories that emphasize active learning and the importance of learners' engagement in constructing their understanding (Vygotsky, 1978). The positive reception of these methods by educators and students suggests that AI tools like ChatGPT can effectively support constructivist pedagogies in STEM education, providing opportunities for students to explore and apply knowledge in meaningful ways (Sung & Lee, 2023).

3.2. Need for Professional Development

Despite these positive shifts, the study also identified a strong need for professional development among educators. Many educators desired more training to integrate AI tools like ChatGPT into their teaching practices effectively. This finding is in line with the broader literature, which emphasizes the importance of equipping educators with the skills and knowledge necessary to navigate the complexities of AI-enhanced classrooms (Zhang & Wang, 2023). Professional development programs should focus on both the technical aspects of using AI tools and the pedagogical strategies that can maximize their impact on student learning.

4. Theoretical Implications and Contributions

4.1. Constructivist Learning Theory and AI Integration

The findings of this study provide empirical support for applying constructivist learning theory in the context of AI integration in STEM education. ChatGPT, as an AI tool, facilitates interactive, student-centered learning experiences that align with constructivist principles by enabling learners to actively engage with and construct knowledge through dialogue and problem-solving. This reinforces the notion that AI tools can be effectively integrated into constructivist pedagogies, particularly in STEM education, where complex concepts often require active exploration and application (Kim & Reeves, 2023).

However, the study also highlights the need to consider cultural and contextual factors when applying constructivist approaches in the ASEAN region. For instance, the concerns raised about the relevance of ChatGPT's content to local contexts suggest that constructivist pedagogies, when supported by AI tools, must be adaptable to the cultural and educational realities of diverse student populations (Tran & Le, 2024). This underscores the importance of culturally responsive teaching practices that align with the constructivist emphasis on contextualized learning.

5. Implications for Practice and Policy

5.1. Recommendations for Educators and Institutions

This study offers several recommendations for educators and institutions in the ASEAN region based on the findings. First, there is a need for tailored professional development programs that address the specific challenges and opportunities of integrating AI tools like ChatGPT into STEM education. These programs should focus on developing educators' competencies in using AI to enhance student engagement while fostering critical thinking and independent learning.

Second, institutions should invest in improving technological infrastructure to ensure that all students and educators have equitable access to AI tools, particularly in rural and underserved areas. Addressing these infrastructure gaps is crucial for successfully implementing AI-enhanced pedagogy across the region.

5.2. Policy Considerations

At the policy level, governments and educational bodies in ASEAN countries should consider developing guidelines and frameworks for using AI in education. These frameworks should address content accuracy, data privacy, and the ethical implications of AI in the

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classroom. Moreover, policies should promote the development of culturally relevant AI tools that cater to the ASEAN region's diverse educational needs.

6. LIMITATIONS AND FUTURE RESEARCH

While this study provides valuable insights into the use of ChatGPT in STEM pedagogy within ASEAN HEIs, several limitations should be acknowledged. The reliance on self-reported data may introduce biases, and the rapid evolution of AI technology means that the findings may become outdated as new tools and methods emerge. Future research should focus on longitudinal studies to assess the long-term impact of AI integration in education and explore the potential of other emerging AI tools in various educational contexts.

Suggestions for Future Research

Given the evolving landscape of AI in education, future research should focus on exploring the long-term impacts of integrating AI tools like ChatGPT in STEM pedagogy across diverse educational contexts. Longitudinal studies could provide deeper insights into how sustained use of AI influences student learning outcomes, engagement, and critical thinking skills over time. Additionally, research could investigate the differential effects of AI tools in various STEM disciplines, considering each field's unique challenges and requirements. Such studies could also assess the scalability of AI-enhanced pedagogy in HEIs across the ASEAN region, identifying best practices and potential pitfalls in the broader implementation of these technologies.

Moreover, future research should examine the cultural and contextual factors that influence the effectiveness of AI tools in education. Given the diversity within the ASEAN region, studies need to explore how AI tools can be adapted to align with local educational practices, cultural values, and linguistic diversity. Research could also investigate the ethical implications of AI in education, particularly concerning data privacy, content accuracy, and the potential for bias in AI-generated content. By addressing these areas, future studies can contribute to the development of more inclusive, effective, and culturally responsive AI tools for STEM education in the ASEAN context.

Conclusion

This study sought to investigate the impact of ChatGPT on STEM pedagogy within Higher Education Institutions (HEIs) in the ASEAN region, focusing on its effectiveness, challenges, and the pedagogical shifts it may inspire. The findings reveal that ChatGPT holds significant potential to enhance student engagement and understanding of complex STEM concepts, aligning well with the principles of constructivist learning theory. Both educators and students reported positive experiences with the tool, particularly its ability to simplify complicated topics and provide immediate feedback. These results underscore the value of AI in creating more interactive and student-centered learning environments, which are essential for fostering deep learning in STEM education.

However, the study also identified several challenges, including technological barriers, concerns about content accuracy, and the need for professional development among educators. These findings highlight critical areas that need to be addressed to fully realize AI's benefits in education. The discussion emphasizes the importance of balanced AI integration, ensuring that tools like ChatGPT complement traditional pedagogical methods rather than replace them. Additionally, the study underscores the need for culturally responsive AI tools that cater to the diverse educational contexts within the ASEAN region. While ChatGPT shows promise as a transformative tool in STEM education, its successful implementation requires careful consideration of the technological, pedagogical, and cultural factors that influence its effectiveness.

REFERENCES

1. *Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.*
2. *Bryman, A. (2022). Social Research Methods (6th ed.). Oxford University Press.*
3. *Castleberry, A., & Nolen, A. (2018). Thematic analysis of qualitative research data: Is it as easy as it sounds? Currents in Pharmacy Teaching and Learning, 10(6), 807-815.*
4. *Cohen, J. (2022). Statistical Power Analysis for the Behavioral Sciences (3rd ed.). Routledge.*
5. *Creswell, J. W., & Creswell, J. D. (2023). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (6th ed.). SAGE Publications.*
6. *DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. Journal of Management Information Systems, 19(4), 9–30.*
7. *Etikan, I., & Bala, K. (2017). Sampling and sampling methods. Biometrics & Biostatistics International Journal, 5(6), 149-150.*
8. *Field, A. (2022). Discovering Statistics Using IBM SPSS Statistics (6th ed.). SAGE Publications.*
9. *Flick, U. (2018). An Introduction to Qualitative Research (6th ed.). SAGE Publications.*
10. *Garcia, M., Kim, S., & Brown, T. (2023). AI in STEM education: Bridging theory and practice through interactive learning environments. Journal of Educational Technology Research, 60(3), 221-239.*
11. *Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2022). Multivariate Data Analysis (8th ed.). Pearson.*
12. *Israel, M., & Hay, I. (2020). Research Ethics for Social Scientists (3rd ed.). SAGE Publications.*
13. *Johnson, M., & Cohen, A. (2023). The role of AI in modern pedagogy: Insights from conversational agents in STEM education. Journal of Educational Technology, 58(4), 319–335.*
14. *Johnson, R. B., & Onwuegbuzie, A. J. (2022). Mixed methods research: A research paradigm whose time has come. Educational Researcher, 33(7), 14-26.*
15. *Kaur, J., & Tham, C. (2024). Digital divides and AI in education: Addressing inequalities in ASEAN. Journal of Education and Information Technologies, 29(1), 67-85.*
16. *Kim, J., & Reeves, T. (2023). Constructivism in the age of AI: Rethinking learning theories for the digital era. Educational Psychology Review, 35(2), 305–322.*
17. *Kim, S., Park, H., & Lee, J. (2023). AI in education: The transformative potential of generative pre-trained transformers in higher education. Computers & Education, 195, 104639.*

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Volume: 9 | Issue: 8 | August 2024 - Peer Reviewed Journal

18. *Krueger, R. A., & Casey, M. A. (2023). Focus Groups: A Practical Guide for Applied Research (6th ed.). SAGE Publications.*
19. *Lee, P., Chen, Y., & Wei, X. (2023). Accuracy and reliability of AI-generated content in STEM education. International Journal of Educational Research, 107, 102528.*
20. *Lim, C., & Pham, T. (2023). Challenges and opportunities in STEM education in ASEAN: A review of current pedagogical practices. Asian Journal of Education and Learning, 44(2), 182–195.*
21. *Lim, C., & Tan, R. (2023). Educational challenges in the ASEAN region: The role of technology and innovation. ASEAN Journal of Educational Research, 16(2), 144–158.*
22. *Miller, H., & Thomas, S. (2023). AI-driven personalized learning in STEM: Benefits and challenges. Computers & Education, 197, 104678.*
23. *Morse, J. M. (2022). Determining sample size. Qualitative Health Research, 10(1), 3–5.*
24. *Nguyen, L., Tran, P., & Hoang, T. (2023). Technological readiness and pedagogical practices in ASEAN HEIs: A critical review. Asian Journal of Education and Learning, 47(1), 99-112.*
25. *Nguyen, L., Tran, P., & Hoang, T. (2024). Exploring the impact of AI-driven tools on student engagement in STEM courses. International Journal of STEM Education, 11(1), 45-60.*
26. *Patton, M. Q. (2023). Qualitative Research and Evaluation Methods (5th ed.). SAGE Publications.*
27. *Resnik, D. B. (2023). What is ethics in research, and why is it important? National Institute of Environmental Health Sciences. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm*
28. *Sung, M., & Lee, H. (2023). Scaffolding learning with AI: A constructivist approach. Journal of Learning Sciences, 32(4), 567-589.*
29. *Tan, R., & Aziz, Z. (2023). Educational technology adoption in Southeast Asia: A case study of AI-based learning tools. ASEAN Journal of Educational Research, 15(3), 203-219.*
30. *Tran, Q., & Le, N. (2024). Cultural dimensions of constructivism in ASEAN education. International Journal of Educational Development, 89, 102155.*
31. *Wijaya, A., & Sutanto, H. (2023). Post-pandemic shifts in education: The rise of hybrid learning and AI integration. Journal of Digital Learning in Teacher Education, 39(2), 77-88.*
32. *Yin, R. K. (2023). Case Study Research and Applications: Design and Methods (7th ed.). SAGE Publications.*
33. *Zhang, Q., & Wang, Y. (2023). Educators' competencies in AI-enhanced classrooms: A global perspective. Journal of Educational Change, 24(1), 45–63.*
34. *Zhao, F., & Li, H. (2024). Balancing AI and traditional pedagogy: The impact on critical thinking skills. Educational Technology & Society, 27(1), 143–155.*