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ANALYSIS OF THE CAUSE-AND-EFFECT RELATIONSHIP BETWEEN AI LITERACY, AI HALLUCINATION RISK AND ACADEMIC INTEGRITY AMONG PRESERVICE TEACHERS USING THE DEMATEL METHOD

Azelina Abdul Rahman[1]
Ahmad Fauzi Mohd Ayub[2]
Jazihan Mahat[3]
Siti Hajar Abd Hamid[4]

[1]Faculty of Educational Studies, Universiti Putra Malaysia
Email: hana41300@gmail.com
[2] Faculty of Educational Studies, Universiti Putra Malaysia
[3] Faculty of Educational Studies, Universiti Putra Malaysia
[4] Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia

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Abstract: *Based on this comprehensive DEMATEL analysis examining the interrelationships among AI Literacy, AI Risks hallucination, and Academic Integrity in educational contexts, this research reveals a hierarchical causal structure where AI Literacy functions as the primary driver influencing both risk awareness and ethical behavior. The analysis progressed through multiple stages: the direct relation matrix established initial influence strengths, normalization enabled comparative assessment, the total relation matrix captured cumulative effects including indirect pathways, threshold filtering identified the most significant relationships, and the final DEMATEL output quantified each factor's role as cause or effect. The results demonstrate that AI Literacy possesses the highest causal influence (D-R = 1.85) and substantial centrality (D+R = 4.071), positioning it as the foundational factor that shapes students' understanding of AI hallucination risks (total influence = 1.269) and their commitment to Academic Integrity (total influence = 1.321). Conversely, both AI Risks hallucination (D-R = -0.838) and Academic Integrity (D-R = -1.012) emerge as net effect factors with high prominence, indicating they are primarily outcomes rather than drivers in this system. The cause-effect diagram visually reinforces this finding, with AI Literacy occupying a distinct position as a core causal factor while the other two variables cluster as dependent effects. These findings provide critical insights for educational policy and curriculum development: investing in comprehensive AI literacy education represents the most effective leverage point for systemic improvement, as it generates cascading benefits that simultaneously enhance students' critical awareness of AI limitations and strengthen their ethical academic practices, ultimately addressing the dual challenges of technological competence and academic integrity in the age of artificial intelligence.*

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Keywords: *AI Literacy, Academic Integrity, Preservice Teachers, DEMATEL Analysis and AI Hallucination Risks*

Introduction

Preservice teachers face many challenges when integrating artificial intelligence tools into their pedagogical practices, including concerns about accuracy, authenticity, and potential negative impacts on critical learning skills (Chen & Gong, 2025; Hur, 2024). This challenge is exacerbated by the phenomenon of AI hallucination, where generated content, while fluent, may contain factual inaccuracies or biases, potentially compromising academic integrity and hindering the development of students' critical thinking and problem-solving abilities (Dayagbil et al., 2025; Zhang et al., 2025). These concerns necessitate a robust understanding of AI literacy among preservice teachers, encompassing not only the operational aspects of AI tools but also the critical evaluation of their outputs and ethical implications (Jin et al., 2025). This underscores the critical need for comprehensive AI literacy education, particularly as studies indicate that AI trust and literacy significantly influence the dependency on generative AI among preservice teachers, which can negatively impact essential 21st-century skills like critical thinking and problem-solving (Zhang et al., 2025). Therefore, developing a nuanced understanding of how AI literacy influences the adoption and effective use of AI in educational settings, while mitigating risks such as AI hallucination, is crucial for maintaining academic rigor (Zhang et al., 2025). Furthermore, addressing these challenges requires exploring the causal relationships between AI literacy, the risks associated with AI hallucination, and academic integrity among preservice teachers (Hur, 2024; Zhang et al., 2025). This study aims to investigate these complex interdependencies using the DEMATEL method, thereby offering a structured approach to understand the causal relationships and their implications for educational practice.

Literature Review

Preservice teachers revealed that they only use AI when needed, but need more understanding of AI fundamentals and ethics for effective integration in education (Guan & Zhang, 2024). Therefore, teacher education programs should provide explicit training in generative AI, including practical guidelines and clear ethical frameworks, to foster effective and responsible integration into classroom practice (Ko et al., 2025). This includes fostering an understanding of AI's limitations, potential biases, and the importance of human oversight, ensuring that AI complements rather than replaces critical thinking and inclusivity in education (Dayagbil et al., 2025; Estaiteyeh & McQuirter, 2024). This integration is critical for empowering educators to harness AI's potential for personalized learning and data-driven instruction while upholding pedagogical standards (Wang et al., 2025). Such a holistic approach not only prepares preservice teachers to navigate the complexities of AI-enhanced learning environments but also empowers them to make informed decisions about technology integration, ultimately enhancing student engagement and learning outcomes (Chen & Gong, 2025; Wang et al., 2025). Furthermore, equipping educators with robust AI literacy is crucial for developing critical awareness of AI tools, enabling them to guide students effectively in evaluating AI-generated content for accuracy and bias, and fostering responsible AI use in educational settings (Daher, 2025; Estaiteyeh & McQuirter, 2024). This comprehensive preparation is vital for enabling future teachers to not only use AI tools proficiently but also to critically assess their outputs and avoid over-reliance, thereby safeguarding academic integrity and promoting effective learning (Daher, 2025). It is also important for future research to consider the perceptions and instructional practices of teachers regarding AI tools to fully understand how they integrate AI resources into their teaching, which can shed light on both the opportunities and challenges of AI-assisted learning in language education (Chen & Gong, 2025).

Academic Integrity Challenges with the Emergence of AI

Academic integrity is a key factor in the quality of education representing honesty, trustworthiness, and ethical behaviour. In today's rapidly changing education landscape, artificial intelligence (AI) poses significant challenges to the ability of the education ecosystem to maintain academic integrity. This necessitates a proactive approach from educational institutions to develop comprehensive policies and guidelines for AI usage, balancing its potential benefits with the imperative to uphold scholarly honesty (Garrote Jurado et al., 11 C.E.; Mwakapina, 2024). This requires developing comprehensive strategies that include not only the creation of clear institutional policies regarding AI use but also the integration of ethics education and the development of sophisticated detection technologies to maintain academic standards (Adillón et al., 2024). Moreover, such frameworks must address the dual nature of AI, acknowledging its capacity to enhance learning while simultaneously posing risks to academic integrity through issues like plagiarism and misinformation (Barrientos et al., 2024). Institutions must therefore foster a culture of academic honesty that embraces the ethical integration of AI, rather than simply policing its misuse (Adillón et al., 2024). This balanced approach ensures that AI tools are utilized to their full potential for personalized learning and administrative efficiencies, while simultaneously reinforcing the core principles of academic honesty and critical engagement among students (Ateeq et al., 2024). Furthermore, given the rapid advancements in AI, universities must proactively develop new policies, particularly concerning examination and grading, to ensure the continued relevance and fairness of assessments in an AI-integrated educational environment (Garrote Jurado et al., 11 C.E.).

AI Literacy among Trainee Teachers

AI literacy in education involves equipping educators with the knowledge and skills to effectively integrate AI into teaching and learning, including the capacity to discern reliable AI outputs from instances of hallucination (Huang et al., 2025). Such literacy empowers teachers to leverage AI's benefits, like automating repetitive tasks and offering personalized student feedback, while consciously mitigating associated risks, such as over-reliance and the perpetuation of biased or incorrect information (Chen & Gong, 2025; Wang et al., 2025). Crucially, this expanded definition of AI literacy, which includes ethical considerations and critical thinking, directly influences both the frequency and quality of AI integration in educational settings (Zhang et al., 2025). This comprehensive understanding is vital for preservice teachers to critically evaluate AI-generated content and effectively integrate these tools without fostering over-reliance or compromising academic standards (Chen & Gong, 2025; Huang et al., 2025). Consequently, fostering a critical perspective on AI, where preservice teachers can discern between accurate AI outputs and "hallucinations," is vital for maintaining academic integrity and promoting genuine learning outcomes (Ling Jen & Salam, 2024; Tzirides et al., 2024). This necessitates a pedagogical framework that not only introduces AI tools but also cultivates a deep understanding of their limitations and potential misapplications, particularly in the context of academic writing and research (Chen & Gong, 2025; Garrote Jurado et al., 11 C.E.). This highlights the need for structured AI literacy training in teacher education, emphasizing prompt engineering, evaluative judgment, and strategic AI integration to ensure effective and responsible AI adoption (Bui et al., 2025). This comprehensive approach ensures that future educators are not only proficient in utilizing AI tools but are also adept at discerning their outputs, thus upholding academic integrity and fostering genuine learning experiences (Chen & Gong, 2025). This critical perspective aligns

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with the need to bridge the gap between theoretical AI literacy frameworks and practical teaching contexts, empowering teachers to apply AI knowledge effectively within their classrooms (Velander et al., 2024). Moreover, such frameworks should also address potential counterarguments and challenges associated with AI integration, such as financial constraints, ethical dilemmas, and the risks of over-reliance on technology, to provide a balanced and comprehensive understanding (Daher, 2025). Recognizing the importance of AI literacy, it is imperative for teacher education programs to integrate AI education across various courses, rather than confining it to specialized technology classes (Black et al., 2024).

AI Hallucination phenomenon

In the context of AI, "hallucination" refers to a situation where an AI model produces output that contains false or misleading information presented as fact. Such occurrences undermine the reliability of AI-generated content and pose significant challenges to academic integrity, particularly when preservice teachers might be unaware of the inaccuracies or intentionally present them as factual (Chen & Gong, 2025; Nyaaba et al., 2024). Therefore, understanding the mechanisms behind AI hallucinations and developing strategies to mitigate their impact is crucial for maintaining the credibility of AI tools in educational settings. This necessitates a robust curriculum that educates future educators on methods to identify, verify, and correct AI-generated inaccuracies, alongside ethical considerations for its responsible application in pedagogy (Hur, 2024; Li, 2024). This foundational knowledge is vital for fostering AI literacy among preservice teachers, enabling them to confidently integrate AI into their instructional practices and make data-driven decisions that cater to diverse student needs (Hur, 2024; Wang et al., 2025). Moreover, AI-assisted learning tools offer substantial benefits by providing greater accessibility and individualized learning experiences, thereby overcoming traditional constraints of time, space, and interpersonal relationships (Chen & Gong, 2025; Garrote Jurado et al., 11 C.E.). However, ensuring effective and ethical integration of AI in education requires addressing potential limitations, such as the generalizability of research findings from small, context-dependent samples to broader educational settings (Kılıçkaya & Kic-Drgas, 2025).

Methodology

This study used the DEMATEL method. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method represents a sophisticated structural modeling technique originally developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 to analyze complex world problems (Fontela & Gabus, 1976). This method has evolved into a powerful multi-criteria decision-making tool that enables researchers to visualize the causal relationships among factors in complex systems through the construction of structural models and impact-relation maps (Si et al., 2018). The fundamental premise of DEMATEL lies in its ability to transform qualitative assessments into quantitative indices, thereby revealing the interdependencies and feedback mechanisms among system elements (Wu & Lee, 2007). Unlike traditional analytical methods that assume independence among criteria, DEMATEL acknowledges the intricate interrelationships and mutual influences that characterize real-world decision-making scenarios, making it particularly valuable for identifying key factors and understanding their direct and indirect effects on other elements within a system (Tzeng et al., 2007). The method has been extensively applied across diverse domains including supply chain management, environmental assessment, technology evaluation, and organizational performance analysis, demonstrating its versatility and robustness in handling complex decision problems (Govindan et al., 2013; Zhou et al., 2011).

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DEMATEL Procedural Framework

The implementation of DEMATEL follows a systematic five-step procedure that transforms expert judgments into structural matrices revealing causal relationships. The first step involves establishing a direct-relation matrix through expert evaluation, where participants assess the degree of direct influence between each pair of factors using a predetermined scale, typically ranging from 0 (no influence) to 4 (very high influence) (Seyed-Hosseini et al., 2006). The second step normalizes the direct-relation matrix by dividing each element by the maximum row sum, ensuring all values fall within a standardized range (Lin & Wu, 2008). The third step calculates the total-relation matrix by incorporating both direct and indirect effects through matrix manipulation, specifically using the formula T = X(I - X)^-1, where X represents the normalized direct-relation matrix and I is the identity matrix (Tseng, 2009). The fourth step computes the prominence and relation indices by calculating the sum of rows (D) and columns (R) of the total-relation matrix, where D + R indicates the prominence of each factor in the system, while D - R distinguishes between cause factors (positive values) and effect factors (negative values) (Liou et al., 2007). The fifth step involves constructing a causal diagram by plotting these indices on a two-dimensional graph, with the horizontal axis representing prominence and the vertical axis representing relation, thereby providing a visual representation of the structural model that facilitates decision-making and strategic planning (Hsu et al., 2013; Yang & Tzeng, 2011).

Step in DEMATEL

Step 1	**Step 1: Generate the direct relation matrix** To identify the model of the relations among the n criteria, an n × n matrix is first generated. The effect of the element in each row is exerted on the element of each column of this matrix. If multiple experts' opinions are used, all experts must complete the matrix. arithmetic mean of all of the experts ' opinions is used and then a direct relation matrix X is generated. $$X = \begin{bmatrix} 0 & \cdots & x_{n1} \\ \vdots & \ddots & \vdots \\ x_{1n} & \cdots & 0 \end{bmatrix}$$
Step 2	**Compute the normalized direct-relation matrix** To normalize, the sum of all rows and columns of the matrix is calculated directly. The largest number of the row and column sums can be represented by k. To normalize, it is necessary that each element of the direct-relation matrix is divided by k. $$k = max\left\{max \sum_{j=1}^{n} x_{ij}, \sum_{i=1}^{n} x_{ij}\right\}$$ $$N = \frac{1}{k} * X$$
Step 3	**Compute the total relation matrix** After calculating the normalized matrix, the fuzzy total-relation matrix can be computed as follows: $$T = \lim_{k \to +\infty} (N^1 + N^2 + \cdots + N^k)$$

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	In other words, an n × n identity matrix is first generated, then this identity matrix is subtracted from normalized matrix and the resulting matrix is reversed. The normalized matrix is multiplied by the resulting matrix to obtain the total relation matrix. $$\mathrm{T} = \mathrm{N} \times (I - N)^{-1}$$
Step 4	**set the threshold value** The threshold value must be obtained in order to calculate the internal relations matrix. Accordingly, partial relations are neglected and the network relationship map (NRM) is plotted. Only relations whose values in matrix T is greater than the threshold value are depicted in the NRM. To compute the threshold value for relations, it is sufficient to calculate the average values of the matrix T. After the threshold intensity is determined, all values in matrix T which are smaller than the threshold value are set to zero, that is, the causal relation mentioned above is not considered. In this study, the threshold value is equal to 1.838
Step 5	**Final output and create a causal diagram** The next step is to find out the sum of each row and each column of T (in step 3). The sum of rows (D) and columns (R) can be calculated as follows: $D = \sum_{j=1}^{n} T_{ij}$ $R = \sum_{i=1}^{n} T_{ij}$ Then, the values of D+R and D-R can be calculated by D and R, where D+R represent the degree of importance of factor i in the entire system and D-R represent net effects that factor *i* contributes to the system.

Sampling Technique for DEMATEL Application

The selection of appropriate sampling techniques constitutes a critical component in DEMATEL implementation, as the quality and representativeness of expert judgments directly influence the validity and reliability of the resulting structural model. Purposive sampling, also known as judgmental or expert sampling, represents the most commonly employed technique in DEMATEL studies, wherein researchers deliberately select participants based on their specialized knowledge, extensive experience, and deep understanding of the problem domain under investigation (Patton, 2002; Etikan et al., 2016). The determination of optimal sample size in DEMATEL applications remains a subject of scholarly debate, with recommendations typically ranging from 5 to 15 experts, as this range balances the need for diverse perspectives against the practical constraints of data collection and consensus building (Chen & Hung, 2010; Li & Tzeng, 2009). Researchers employ several criteria for expert selection, including professional experience exceeding five years in the relevant field, academic qualifications at the master's level or higher, current involvement in related decision-making processes, and demonstrated expertise through publications or practical achievements (Dalalah et al., 2011; Shieh et al., 2010). However, in this study, we used 5 experts as a main participants.

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DEMATEL Questionnaire Scale Explanation

This study employs the DEMATEL (Decision Making Trial and Evaluation Laboratory) methodology to analyze the causal relationships among the identified factors. Respondents are required to assess the direct influence of each factor on other factors using a five-point scale. The scale is defined as follows: 0 = No influence, indicating that one factor has absolutely no impact on another; 1 = Low influence, suggesting minimal impact; 2 = Moderate influence, representing a reasonable degree of impact; 3 = High influence, indicating substantial impact; and 4 = Very high influence, denoting an extremely strong causal relationship between factors. This numerical scale allows for systematic quantification of expert judgments regarding the interdependencies among variables. The collected responses are subsequently aggregated to form an initial direct-relation matrix, which undergoes mathematical normalization and matrix operations to derive the total-relation matrix. From this matrix, key indicators including prominence values (R+C) and relation values (R-C) are calculated, enabling the classification of factors into cause-and-effect groups. The prominence value indicates the overall importance of a factor within the system, while the relation value determines whether a factor primarily influences others (cause) or is predominantly influenced by others (effect). This analytical approach provides valuable insights into the structural relationships among variables and facilitates evidence-based decision-making by identifying critical factors that warrant prioritized attention in intervention strategies.

Findings

1. Identify the main factors involved in the problem.
2. The form of a direct relation matrix (Direct-Relation Matrix).
3. Matrix normalization.
4. Calculate the total relation matrix (Total Relation Matrix).

Direct relation matrix

	AI Literacy	AI Risks hallucination	Academic Integrity
AI Literacy	0	3.4	3.6
AI Risks hallucination	1	0	3.4
Academic Integrity	1	3.2	0

The normalized direct-relation matrix

	AI Literacy	AI Risks hallucination	Academic Integrity
AI Literacy	0	0.486	0.514
AI Risks hallucination	0.143	0	0.486
Academic Integrity	0.143	0.457	0

The total relation matrix

	AI Literacy	AI Risks hallucination	Academic Integrity
AI Literacy	0.37	1.269	1.321
AI Risks hallucination	0.374	0.632	0.985
Academic Integrity	0.367	0.927	0.639

The total relationships matrix by considering the threshold value

	AI Literacy	AI Risks hallucination	Academic Integrity
AI Literacy	0	1.269	1.321
AI Risks hallucination	0	0	0.985
Academic Integrity	0	0.927	0

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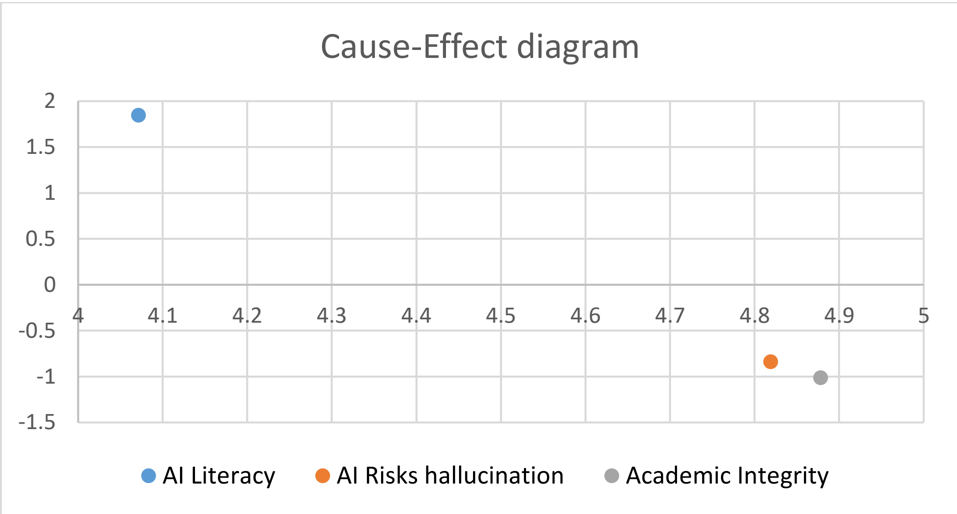
The final output

	R	D	D+R	D-R
AI Literacy	1.11	2.961	4.071	1.85
AI Risks hallucination	2.829	1.99	4.819	-0.838
Academic Integrity	2.945	1.933	4.878	-1.012

The following figure shows the model of significant relations. This model can be represented as a diagram in which the values of (D+R) are placed on the horizontal axis and the values of (D-R) on the vertical axis. The position and interaction of each factor with a point in the coordinates (D + R, D-R) are determined by coordinate system.



This cause-effect diagram visualizes the DEMATEL analysis results by plotting each factor according to its prominence (D, x-axis) and relation (D-R, y-axis), creating four conceptual quadrants that classify factors by their influence characteristics. AI Literacy (blue dot) appears in the upper-left region with a D value around 2.96 and a positive D-R of 1.85, identifying it as a "core cause" factor with high influence on others but relatively lower prominence in receiving influence, making it the primary driver of change in the system. AI Risks hallucination (orange dot) and Academic Integrity (gray dot) are positioned in the lower-right quadrant with higher D values (around 4.8-4.9) and negative D-R values (-0.838 and -1.012 respectively), classifying them as "effect" factors that are highly prominent in the network but receive more influence than they exert. The spatial separation in the diagram clearly illustrates that AI Literacy occupies a unique position as the independent causal force, while the other two factors cluster together as dependent outcomes, with Academic Integrity showing the strongest net effect status. This visual representation reinforces the strategic importance of AI Literacy as the foundational intervention point: improvements in this area will cascade through the system to enhance both students' awareness of AI risks and their commitment to academic integrity, while direct interventions on the effect factors would have limited systemic impact without addressing the underlying literacy foundation.

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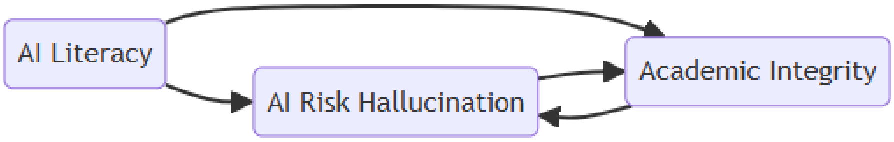
Cause-effect relationship model



This causal model shows the dynamic interaction between AI Literacy, AI Hallucination Risk, and Academic Integrity in the context of teacher trainees' use of AI. AI literacy acts as an initiating factor that influences teacher trainees' level of awareness and ability to understand, validate, and manage information generated by AI systems. Increased AI literacy directly reduces the risk of AI hallucination, which is when AI produces inaccurate or misleading information. This risk of AI hallucination in turn impacts academic integrity, the higher the risk and inability to identify AI errors, the greater the likelihood of integrity violations such as the use of false information, invalid references, or inauthentic academic work. At the same time, academic integrity also plays a role in influencing how teacher trainees assess and address the risk of hallucination; high integrity values encourage them to be more careful and efficient in validating AI results. Overall, this model depicts a two-way, mutually reinforcing relationship between all three factors, emphasizing that mastery of AI literacy and understanding of technical risks are essential foundations for ensuring ethical and responsible use of AI in teacher education.

Discussion

The DEMATEL analysis results provide compelling evidence for the foundational role of AI Literacy in shaping both students' awareness of AI risks and their academic integrity behaviors, revealing insights that have significant implications for educational policy and practice. The finding that AI Literacy functions as the primary causal factor (D-R = 1.85) rather than an outcome suggests that current educational interventions should prioritize comprehensive AI education as the first line of defense against both the misuse of AI tools and the erosion of academic standards. This causal hierarchy challenges approaches that focus solely on punitive measures or honor code reinforcement for maintaining academic integrity, instead highlighting that students equipped with deep understanding of AI capabilities and limitations are naturally more likely to use these tools responsibly and recognize their ethical obligations. The strong bidirectional relationship between AI Risks hallucination and Academic Integrity (0.985 and 0.927 respectively) indicates that these two factors operate in a mutually reinforcing cycle: students who understand AI's propensity for generating false or misleading information are more cautious in their academic work, while those committed to academic integrity are more vigilant about verifying AI-generated content. However, the threshold-filtered matrix reveals that neither of these factors significantly influences AI Literacy itself, suggesting a one-way flow of causation where knowledge drives behavior rather than behavior driving knowledge acquisition. These findings align with constructivist learning theories that emphasize understanding as prerequisite to ethical application, and they suggest that institutions investing resources in AI literacy programs will see multiplicative returns across multiple dimensions of student competence and integrity. The relatively high centrality values for all three factors (D+R > 4.0) underscore that this is an interconnected system where changes in any component affect the others, yet the clear causal structure provides actionable guidance for where interventions will be most effective.

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Conclusion

This research employed DEMATEL methodology to systematically analyze the causal relationships among AI Literacy, AI Risks hallucination, and Academic Integrity in educational contexts, yielding crucial insights for addressing the challenges posed by artificial intelligence in higher education. The comprehensive analysis, progressing from direct relations through normalized matrices to total influence calculations and threshold filtering, conclusively demonstrates that AI Literacy serves as the cornerstone factor with the strongest causal influence (D-R = 1.85) and substantial network centrality (D+R = 4.071), while AI Risks hallucination and Academic Integrity function primarily as effect factors that receive more influence than they exert. The total relationships matrix revealed that AI Literacy's influence on Academic Integrity (1.321) slightly exceeds its impact on AI Risks hallucination (1.269), suggesting that foundational AI education most directly serves to strengthen ethical academic behavior, though both pathways remain critically important. The cause-effect diagram visually reinforced the hierarchical structure of these relationships, positioning AI Literacy as an independent driver spatially separated from the clustered effect factors. These findings carry profound implications for educational institutions navigating the integration of AI technologies: rather than reactive approaches focused on detecting AI misuse or implementing restrictive policies, institutions should proactively invest in comprehensive AI literacy curricula that equip students with deep understanding of AI capabilities, limitations, and ethical considerations. Such education should explicitly address the phenomenon of AI hallucination, ensuring students recognize that AI systems can generate convincing but factually incorrect content, thereby fostering both critical evaluation skills and intrinsic motivation for academic integrity. Future research should explore longitudinal effects of AI literacy interventions on actual academic integrity violations, investigate whether the causal structure differs across disciplines or educational levels, and examine additional factors such as faculty AI competence, institutional policies, and peer influences that may moderate these relationships. As artificial intelligence continues to transform educational landscapes, this research provides an evidence-based framework for prioritizing interventions that address root causes rather than symptoms, ultimately fostering learning environments where technological advancement and academic integrity advance in tandem rather than in tension.

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