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The Role of AI Tools In Shaping Teaching Practices for Design and Communication Skills: A Study in Ghana

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Abstract: The integration of Artificial Intelligence (AI) into education offers transformative possibilities for enhancing design and communication pedagogies, particularly in resource-constrained settings. This study examines the adoption, impact, and barriers to AI use in Ghanaian secondary and technical education, with a focus on design-related subjects. Using a quantitative cross-sectional design, data were collected through structured questionnaires administered to 108 teachers. Findings highlight a pronounced disparity between teachers' recognition of AI's pedagogical potential and its actual implementation. Respondents widely acknowledged AI's capacity to support student-centered learning, enrich teaching strategies, and improve outcomes (all $p < 0.001$). However, adoption remains limited. Reported barriers include inadequate ICT infrastructure (62%), lack of formal training (only 23.1% had received any), ethical concerns, and poor alignment with existing curricula. Logistic regression further identified postgraduate qualification, AI-specific training, adequate ICT resources, and engagement with technical subjects as significant predictors of adoption. The results underscore a systemic digital divide that continues to constrain the pedagogical use of AI in Ghana. While its value for fostering innovation in design and communication education is evident, sustained progress requires coordinated policy and institutional support. A multi-pronged strategy is essential prioritizing investment in digital infrastructure, comprehensive and discipline-specific teacher training, ethical frameworks, and curricular reforms tailored to local contexts. Addressing these gaps will enable more equitable and effective AI integration, advancing both educational quality and technological capacity within resource-limited environments.

Keywords: Artificial Intelligence; Design; Education; SDG 4: Quality Education; Technical and Vocational Education and Training

1. Introduction

The integration of Artificial Intelligence (AI) into education is reshaping teaching practices, curriculum delivery, and skills development worldwide. AI is increasingly recognised not merely as a supportive technological tool but as a catalyst for pedagogical innovation with significant implications for knowledge transfer, employability, and creativity. Disciplines that prioritise design and communication skills particularly benefit from AI's adaptive and interactive capabilities, making them fertile ground for experimentation and reform.

In Ghana, persistent systemic challenges such as large class sizes, limited resources, and the need for contextually relevant teaching approaches have amplified interest in AI's potential. Emerging evidence suggests that AI can foster creativity, collaboration, and critical communication skills within these constraints (Osondu, Francois, & Strycker, 2024; Liekum, 2025). At the same time, however, ethical, pedagogical, and infrastructural considerations continue to shape both global and local debates. This study situates Ghana within these broader conversations, while identifying nationally specific opportunities and barriers to AI adoption in design and communication education. It further addresses a critical gap in scholarship by exploring how AI can both mitigate structural inequities and enrich creative teaching practices in this context.

2. Literature Review

2.1 Global Perspectives on AI in Education

The adoption of AI in education has become a global phenomenon, largely driven by its capacity to personalise learning, improve efficiency, and prepare students for evolving labour markets. Applications such as adaptive learning platforms, intelligent tutoring systems, and automated assessment tools have redefined individualised and collaborative learning (Labadze, Grigolia, & Machaidze, 2023). In higher education, generative tools such as ChatGPT are influencing knowledge creation, assessment, and dissemination practices (Borger et al., 2023).

Nonetheless, global scholarship highlights ethical, social, and governance challenges. Concerns about academic integrity, equity, and student agency remain central (Al-Zahrani & Alasmari, 2024), while Dwivedi et al. (2019; 2023) emphasise the complexities of integrating generative AI into educational policy, pedagogy, and professional practice. In creative fields, where originality and critical thinking are paramount, educators' experiences with AI reveal a mixture of enthusiasm and caution (Kruk & Kałużna, 2024). Collectively, these perspectives underscore the dual promise and risk of AI in transforming pedagogy, necessitating careful governance and context-sensitive integration.

2.2 AI and 21st-century skills

Artificial intelligence (AI) is reshaping education by transforming how students acquire design and communication skills competencies vital for employability and civic engagement in the twenty-first century. Globally, AI is viewed both as an enabler of personalisation, feedback, and creativity, and as a source of ethical, equity, and assessment concerns (Dwivedi et al., 2019; Dwivedi et al., 2023; Al-Zahrani & Alasmari, 2024). Tools such as chatbots, large language models, and generative media are increasingly embedded into

curricula. In Ghana, these developments align with national priorities to enhance educational quality, relevance, and labour market alignment.

2.3 AI in Ghanaian Education

In Ghana, AI adoption is increasingly framed as a strategy to address enduring educational challenges, including resource shortages and misalignment between curricula and labour market demands (Gyamfi, Dayie, & Asiedu, 2022). Policy-oriented research highlights AI's role in improving instructional quality and expanding access to innovative teaching tools (Osondu et al., 2024). Studies further show that Ghanaian educators perceive AI as capable of enhancing teaching effectiveness and fostering student engagement, particularly in higher education and teacher training (Liekum, 2025; Adobea, Nyantakyi, Fosu, & Tuffour, 2024).

However, teacher preparedness remains uneven. Research on AI literacy reveals that while some educators, particularly at the basic school level, are beginning to acquire relevant knowledge, sustained capacity-building is essential for meaningful integration (Arkorful et al., 2025). These findings suggest that beyond technical support, AI must be embedded as a pedagogical tool to cultivate creativity, critical communication, and collaborative design practices.

2.4 Educator Readiness and Teacher Training

Teacher readiness is central to AI adoption. Studies show limited AI literacy among Ghanaian teachers, underscoring the need for professional development (Arkorful et al., 2025). Evidence from language teaching demonstrates improved learning outcomes through AI use, though gaps in digital competence remain (Adobea et al., 2024). International findings also show chatbots providing systematic learning support (Labadze, Grigolia, & Machaidze, 2023), while applications in second language learning enhance motivation and translation skills (Kruk & Kałużna, 2024). For preservice teachers, AI-based training fosters digital literacy and 21st-century skills (Bircan, Şeref, & Nacaroğlu, 2025), reinforcing the need to embed AI training in Ghana's Colleges of Education (Liekum, 2025).

2.5 Challenges and Emerging Concerns

Despite its promise, AI adoption in Ghana faces significant hurdles. Ethical and governance challenges particularly around data privacy, academic integrity, and equitable access persist (Dwivedi et al., 2019; 2023). Teachers' perceptions also strongly influence adoption, with studies in early childhood education showing cautious openness, tempered by concerns over depersonalisation and sustainability (Mohammed, 2023).

At the tertiary level, debates increasingly link AI to employability, as universities explore how it can foster competencies such as problem-solving, digital communication, and teamwork (Segbenya et al., 2023). Yet infrastructural constraints, inconsistent access to digital tools, and the absence of a national AI framework continue to limit progress. Moreover, pedagogical concerns remain: while AI can streamline instruction and support personalised learning, over-reliance risks undermining human-centred teaching approaches that are vital for developing creativity and communicative competence (Shum & Luckin, 2019).

3. Research Gap

Although existing studies connect AI adoption to innovation in teaching and employability skills, limited attention has been paid to its role in design and communication education in Ghana. Prior research has primarily focused on technical disciplines, literacy, and general higher education contexts (Arkorful et al., 2025; Adobea et al., 2024), overlooking the unique demands of design pedagogy, which emphasises creativity, collaboration, and iterative communication.

Equity and educator experience also remain underexplored, particularly regarding how disparities between rural and urban institutions affect AI adoption. This study addresses these gaps by examining how AI tools are integrated into teaching practices for design and communication skills in Ghana, offering insights into the opportunities and constraints that shape transformative pedagogy in this field.

The study addresses the following research questions:

- ***RQ1:*** What are the Types of AI Tools Teachers Use to Support the Teaching of Design and Communication Skills in Selected Schools in Ghana?

- ***RQ2:*** How does the Use of AI tools influence teaching methodologies and instructional strategies in the Delivery of Design and Communication-Related Subjects in Selected Schools in Ghana?

- ***RQ3:*** How Effective are AI Tools in Enhancing Student Learning Outcomes in Design and Communication Skills Subjects in Selected Schools in Ghana?

- ***RQ4:*** What are the Challenges Faced by Teachers in Integrating AI Tools into Teaching Practices Related to Design and Communication Skills in Selected Schools in Ghana?

4. Conceptual Framework

This study is guided by the view that the effectiveness of AI in education is determined not only by technological capabilities but also by pedagogical design, institutional readiness, and socio-cultural context. Globally, AI has been found to foster creativity, personalisation, and employability skills, while also raising concerns about ethics and equity (Dwivedi et al., 2019; Shum & Luckin, 2019). In Ghana, these opportunities intersect with systemic challenges such as limited infrastructure, uneven teacher preparedness, and gender disparities (Arkorful et al., 2025; Gyamfi et al., 2022).

Evidence from prior studies highlights AI's potential in teacher training (Liekum, 2025), language education (Adobea et al., 2024; Kruk & Kałużna, 2024), and digital literacy development (Bircan et al., 2025). Building on this, the present study conceptualises AI adoption as a pedagogical process influenced by educators' readiness, institutional priorities, and labour market demands.

By focusing on design and communication instruction, the framework positions AI not as a neutral technological tool, but as a pedagogical catalyst whose impact depends on how educators adapt it to local needs, opportunities, and constraints. The framework adopted in this study (Figure 1) illustrates the interaction between AI tools, mediating factors, teaching practices, learning outcomes, and employability outcomes.

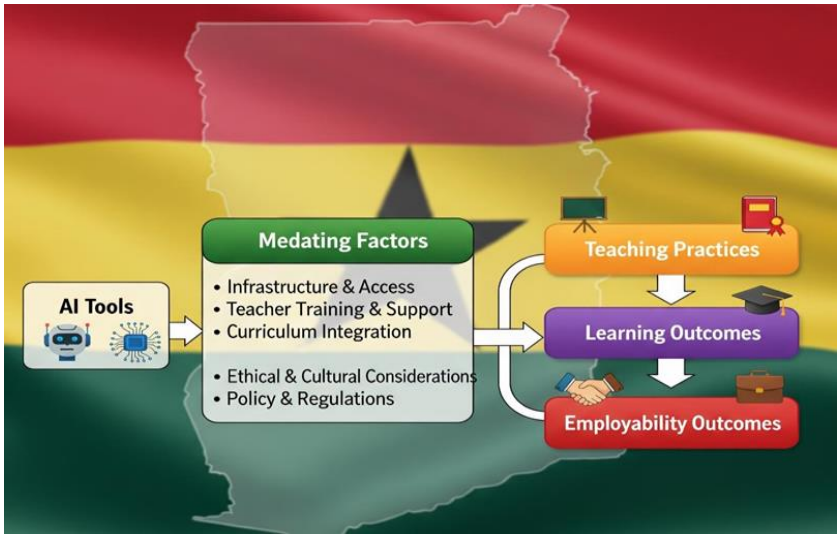

Figure 1. Conceptual framework diagram to visualize the study's logic model. Source: Authors own work.

5. Research Methodology

This study employed a quantitative approach to investigate AI usage patterns, teacher perceptions, and pedagogical impacts. Quantitative methods are well established in educational technology research for their capacity to identify generalisable trends in adoption and practice (Segbenya et al., 2023; Mohammed, 2023), aligning with international calls for rigorous, evidence-based insights into AI's role in education (Borger et al., 2023; Shum & Luckin, 2019).

A descriptive cross-sectional survey design was adopted, enabling a timely snapshot of teachers' readiness, adoption, and challenges in AI integration (Adobea et al., 2024; Labadze et al., 2023). The study targeted educators of design and communication-related subjects, including Design and Technology, Technical Drawing, and Visual Arts, across Senior High Schools (SHS), Senior High Technical Schools (SHTS), and Technical and Vocational Education and Training (TVET) institutions. This focus reflects national research priorities in Ghanaian teacher technology adoption (Osondu et al., 2024; Adobea et al., 2024).

Purposive sampling ensured subject relevance (Segbenya et al., 2023; Liekum, 2025), complemented by convenience sampling to enhance accessibility. Of the 120 teachers approached, 108 valid responses were collected (Arkorful et al., 2025; Gyamfi et al., 2022). Data were gathered using a structured questionnaire, adapted from validated instruments on technology integration and AI literacy (Arkorful et al., 2025; Shum & Luckin, 2019). The tool comprised five sections: demographics; AI use patterns (RQ1); teaching methodologies (RQ2); perceived student outcomes (RQ3); and integration challenges (RQ4). Predominantly Likert-scale items were supplemented with targeted open-ended questions (Borger et al., 2023; Bircan et al., 2025).

The Greater Accra, Central, and Ashanti regions of Ghana were the three areas where the study was carried out. These areas were chosen to represent different degrees of infrastructure development and ICT accessibility, as well as to capture both urban and rural educational contexts. The distribution of schools was as follows: 25 from the Ashanti Region (mixed urban-rural), 38 from the Central Region (mixed urban-rural), and 45 from

the Greater Accra Region (mostly urban). In line with suggestions for context-sensitive research in technology integration, this distribution made it possible to examine possible variations in AI adoption patterns across various geographic and resource settings (Gyamfi et al., 2022; Osondu et al., 2024).

Instrument validity was ensured through expert review and a pilot with 20 teachers; Cronbach's alpha values exceeded 0.7 (Table 1), confirming reliability (Segbenya et al., 2023). Data collection spanned six weeks using online (Google Forms) and paper-based modes to maximise participation (Adobea et al., 2024; Mohammed, 2023). Ethical safeguards included informed consent, anonymity, and voluntary participation, in line with Ghanaian educational research standards (Arkorful et al., 2025; Liekum, 2025) and global AI-education ethics frameworks (Dwivedi et al., 2023; Al-Zahrani & Alasmari, 2024). A procedural overview is presented in Figure 2.

Data were analysed with SPSS (version 28). Descriptive statistics (frequencies, percentages, means, standard deviations) summarised demographic characteristics and responses. Inferential analyses, including one-sample t-tests (test value = 3.5) and Chi-square tests of independence, addressed the research questions and examined relationships between demographics and key outcomes. These methods are consistent with both Ghanaian and international AI-in-education studies (Gyamfi et al., 2022; Liekum, 2025; Kruk & Kałużna, 2024). Open-ended responses were thematically analysed to enrich quantitative findings with contextual insights (Al-Zahrani & Alasmari, 2024).

Table 1. Reliability Statistics

Objectives	N of Items	Cronbach's Alpha
1	8	0.915
2	8	0.920
3	8	0.896
4	9	0.903

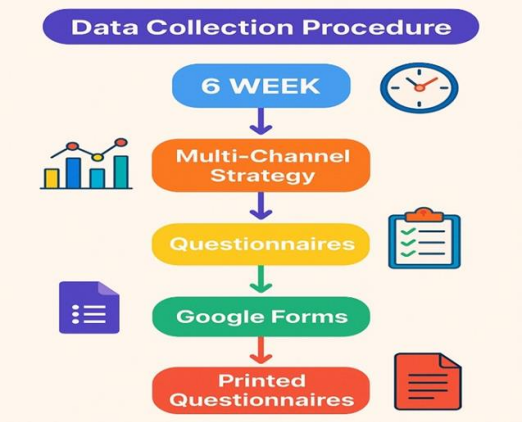

Figure 2. Data Collection Procedure. Source: Authors own work.

6. Results and Discussion

The results and their interpretation are presented in the subsequent section, covering demographic characteristics, factors influencing employability, barriers to career advancement, and graduates' perceptions of the labour market.

6.1 Results of Respondents Demographic Characteristics

Table 2. Results of Respondents Demographic Characteristics

Item	Frequency	Percent	Valid Percent	Cumulative Percent
Gender				
Male	70	64.8	64.8	64.8
Female	38	35.2	35.2	100.0
Total	***108***	***100.0***	***100.0***	
Age Group				
20-29 years	35	32.4	32.4	32.4
30-39 years	52	48.1	48.1	80.6
40-49 years	19	17.6	17.6	98.1
50 years and above	2	1.9	1.9	100.0
Total	***108***	***100.0***	***100.0***	
Educational Qualification				
People teaching	8	7.4	7.4	7.4
Bachelor's Degree	66	61.1	61.1	68.5
Postgraduate Diploma	2	1.9	1.9	70.4
Master's Degree	17	15.7	15.7	86.1
Doctorate	15	13.9	13.9	100.0
Total	***108***	***100.0***	***100.0***	
Teaching Experience				
Less than 1 year	18	16.7	16.7	16.7
1-5 years	35	32.4	32.4	49.1
6-10 years	22	20.4	20.4	69.4
11-15 years	15	13.9	13.9	83.3
Above 15 years	18	16.7	16.7	100.0
Total	***108***	***100.0***	***100.0***	
Subject(s)				
Design and Technology	17	15.7	15.7	15.7
Visual Art	2	1.9	1.9	17.6
Geography	5	4.6	4.6	22.2
Technical Drawing	28	25.9	25.9	48.1

Others	56	51.9	51.9	100.0
Total	***108***	***100.0***	***100.0***	
Level of Teaching				
Senior High School (SHS)	36	33.3	33.3	33.3
Senior High Technical School (SHTS)	23	21.3	21.3	54.6
Technical and Vocational Education and Training (TVET)	23	21.3	21.3	75.9
Science, Technology, Engineering and Mathematics (STEM)	26	24.1	24.1	100.0
Total	***108***	***100.0***	***100.0***	
Type of School				
Government	81	75.0	75.0	75.0
Private	27	25.0	25.0	100.0
Total	***108***	***100.0***	***100.0***	
Regional Distribution				
Greater Accra	45	41.7	41.7	41.7
Central Region	38	35.2	35.2	76.9
Ashanti Region	25	23.1	23.1	100.0
Total	**108**	**100.0**	**100.0**	**Total**
School Location				
Urban	58	53.7	53.7	53.7
Rural	31	28.7	28.7	82.4
Peri-urban	19	17.6	17.6	100.0
Total	**108**	**100.0**	**100.0**	
ICT Facilities Available at Respondents School				
Yes	30	27.8	27.8	27.8
No	11	10.2	10.2	38.0
Limited	67	62.0	62.0	100.0
Total	***108***	***100.0***	***100.0***	
Training on Using AI Tools for Teaching				
Yes (Formal training/workshop)	25	23.1	23.1	23.1

Yes (Informal Self-taught/tutorials)	34	31.5	31.5	54.6
No (But interested)	48	44.4	44.4	99.1
No (But not interested)	1	0.9	0.9	100.0
Total	***108***	***100.0***	***100.0***	

The demographic results in Table 2 provide valuable insight into the opportunities and barriers to adopting artificial intelligence (AI) in Ghanaian education. Male educators made up 64.8% of respondents, reflecting persistent gender imbalances in technical and vocational fields. Nearly half of the teachers (48.1%) were between 30–39 years, indicating a workforce in its professional prime and likely receptive to innovation if given adequate support (Gyamfi et al., 2022). However, teacher training in AI remains limited: only 23.1% had formal training, while 44.4% reported no training but expressed strong interest. This mirrors findings by Arkorful et al. (2025), who highlighted low AI literacy among Ghanaian teachers and the urgent need for structured programs to build confidence and competence.

The lack of ICT infrastructure poses perhaps the most significant barrier. Sixty-two per cent of respondents reported limited facilities, with only 27.8% confirming availability. Since AI requires stable connectivity and adequate hardware, this deficit remains a critical obstacle, consistent with Gyamfi et al. (2022). Without substantial investment, AI adoption risks reinforcing existing educational inequalities (Dwivedi et al., 2019). At the same time, the finding that 51.9% of teachers taught subjects outside core technical fields across SHS, SHTS, TVET, and STEM institutions underscores the diversity of teaching contexts. Effective AI integration must therefore be adaptable to varying subjects and pedagogical environments (Labadze et al., 2023).

To address these challenges, multi-level interventions are needed. Policymakers must prioritise ICT infrastructure development in technical and vocational institutions (Osondu et al., 2024), while training programs should be inclusive, mandatory, and practical, drawing on successful models such as AI-enabled STEM storytelling (Bircan et al., 2025). AI tools themselves must be tailored to low-connectivity contexts and framed within robust ethical and pedagogical guidelines, as emphasised by Al-Zahrani & Alasmari (2024). Ultimately, while teachers show readiness to engage with AI, success will depend on policies that simultaneously expand infrastructure, strengthen teacher capacity, and ensure equitable, context-sensitive applications of AI in design and communication skills education.

The regional and geographical distribution of respondents provides important context for interpreting the findings. The concentration of participants from Greater Accra

(41.7%) reflects the region's higher density of technical and vocational institutions, while representation from Central (35.2%) and Ashanti (23.1%) regions ensures broader geographical coverage. The urban-rural breakdown (53.7% urban, 28.7% rural, 17.6% peri-urban) reveals that while urban schools are better represented, rural contexts are sufficiently included to capture infrastructure disparities. This distribution aligns with Ghana's educational landscape, where urban centers typically have better ICT facilities but rural areas face more pronounced resource constraints (Gyamfi et al., 2022). The sampling frame thus enables examination of how geographical context intersects with AI adoption patterns, though the urban bias suggests findings may be more generalizable to similarly resourced settings than to severely resource-constrained rural schools.

6.1.1 Chi-Square Test Results Associations Between Demographic Variables and Key Outcomes

Table 3. presents the results of the Chi-Square tests for independence. A significant p-value (typically < 0.05) would lead to a rejection of the null hypothesis, suggesting a statistically significant association between the variables.

Table 3. Results of Chi-Square Tests for Associations between Demographic Variables and Key Outcomes

Demographic Variable	Outcome Variable	χ^2 Value	p-value	Association Interpretation
Gender	ICT Facilities Availability	2.15	0.341	Not Significant
Gender	AI Training Received	3.80	0.284	Not Significant
Age Group	ICT Facilities Availability	14.92	0.021	Significant
Age Group	AI Training Received	9.45	0.150	Not Significant
Educational Qualification	ICT Facilities Availability	18.40	0.010	Significant
Educational Qualification	AI Training Received	12.88	0.116	Not Significant

Table 3. Results of Chi-Square Tests for Associations between Demographic Variables and Key Outcomes

Demographic Variable	Outcome Variable	χ^2 Value	p-value	Association Interpretation
Teaching Experience	ICT Facilities Availability	11.05	0.086	Not Significant (Marginal)
Teaching Experience	AI Training Received	8.21	0.144	Not Significant
Subject(s) Taught	ICT Facilities Availability	16.33	0.038	Significant
Subject(s) Taught	AI Training Received	22.18	0.005	Significant
Level of Teaching	ICT Facilities Availability	7.89	0.246	Not Significant
Level of Teaching	AI Training Received	9.01	0.173	Not Significant
Type of School	ICT Facilities Availability	5.12	0.077	Not Significant (Marginal)
Type of School	AI Training Received	4.50	0.212	Not Significant

Chi-Square analyses in Table 3 revealed that ICT facility availability was significantly associated with age, qualification, and subject taught, while receipt of AI training was significantly associated only with subject taught. No significant associations were found for gender, teaching experience, teaching level, or school type.

These results suggest unequal access to ICT infrastructure. Younger and highly qualified teachers (Master's/Doctorate) had better access, reflecting generational and institutional divides whereby newer, better-resourced institutions attract technologically supported staff (Dwivedi et al., 2019; Gyamfi et al., 2022). Such inequities risk reinforcing a "digital divide" within the teaching workforce.

Subject taught was also critical: teachers in technical fields such as Design and Technology reported better ICT access and higher training levels, likely due to the more immediate relevance of AI in visual and technical domains (Bircan et al., 2025). This

points to uneven AI integration across disciplines, with technical subjects advancing faster than the humanities.

Perhaps the most pressing issue is the gap between interest and training. While 75.9% of teachers expressed interest in AI, only 23.1% had formal training, with most relying on self-teaching. This mirrors Arkorful et al. (2025), who reported low AI literacy as a primary barrier. Addressing this requires structured, mandatory professional development that extends beyond basic digital literacy to pedagogically focused AI applications (Liekum, 2025).

7. Results From the Research Questions (RQ1, RQ2, RQ3 and RQ4)

7.1 Results of (RQ1): What are the Types of AI Tools Teachers Use To Support the Teaching of Design and Communication Skills in Selected Schools in Ghana?

Table 4. RQ1: Types of AI Tools Used by Teachers

Item	Test Value = 3.5						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean	Std. Deviation	Mean Difference	Lower	Upper
I regularly use AI-based tools (e.g., Chat GPT, DALL·E, Grammarly) in teaching design-related subjects.	-10.764	107	0.000	2.30	1.162	-1.204	-1.43	-0.98
I use image generation AI tools to support students' visual communication skills.	-7.663	107	0.000	2.68	1.118	-0.824	-1.04	-0.61
I use language-based AI tools to support written communication and presentations.	-8.586	107	0.000	2.57	1.121	-0.926	-1.14	-0.71
AI tools are part of my instructional materials for teaching design and communication skills.	-6.203	107	0.000	2.78	1.210	-0.722	-0.95	-0.49

I use AI-powered platforms (e.g., Canva AI, Adobe Firefly, or similar) in classroom activities.	-8.505	107	0.000	2.58	1.120	-0.917	-1.13	-0.70
I encourage students to explore AI tools for design and project development.	-5.598	107	0.000	2.87	1.169	-0.630	-0.85	-0.41
I integrate AI chatbots to provide feedback on students' communication work.	-12.769	107	0.000	2.08	1.153	-1.417	-1.64	-1.20
I am aware of multiple AI tools that can be applied to teaching design and communication skills.	-16.090	107	0.000	2.02	0.957	-1.481	-1.66	-1.30

One-sample t-tests in Table 4 showed that teachers' use of AI tools was consistently below the neutral benchmark (all p=0.000), with mean scores ranging from 2.02 (awareness of multiple tools) to 2.87 (encouraging students to explore AI). Although tools like ChatGPT and Grammarly are known, active pedagogical integration remains limited.

This reflects low adoption and nascent awareness. Teachers cautiously encourage students to explore AI, even when they are uncertain themselves a trend also observed globally, where enthusiasm is tempered by caution (Kruk & Kałużna, 2024; Dwivedi et al., 2023). The very low awareness of multiple tools highlights a reliance on a few text-based systems, leaving image generation, design-focused, and feedback-oriented AI tools underexplored (Labadze et al., 2023).

Generic professional development will not suffice. Training must be domain-specific, showcasing practical applications of diverse tools (e.g., image generation for design exercises, AI-powered platforms for teaching materials) that directly support curriculum goals in design and communication (Bircan et al., 2025).

7.2 Results of (RQ2): How Does the Use of AI tools influences teaching methodologies and instructional strategies in the Delivery of Design and Communication-Related Subjects in Selected Schools in Ghana?.

Table 5. RQ2: Influences of AI Tools on Teaching Methodologies and Instructional Strategies

Item	**Test Value = 3.5**						**95% Confidence Interval of the Difference**	
	t	**df**	**Sig. (2-tailed)**	**Mean**	**Std. Deviation**	**Mean Difference**	**Lower**	**Upper**

AI tools help my personalise instruction based on students' learning needs.	-9.683	107	0.000	2.51	1.063	-0.991	-1.19	-0.79
I use AI tools to facilitate collaborative learning in my classes.	-14.403	107	0.000	2.18	0.955	-1.324	-1.51	-1.14
AI has enabled more interactive and engaging teaching strategies in design education.	-11.556	107	0.000	2.32	1.057	-1.176	-1.38	-0.97
AI tools help me demonstrate complex design concepts more effectively.	-13.554	107	0.000	2.23	0.973	-1.269	-1.45	-1.08
AI integration has enhanced my classroom assessment strategies.	-10.587	107	0.000	2.48	1.000	-1.019	-1.21	-0.83
I rely on AI to generate content or activities related to communication skills.	-12.515	107	0.000	2.41	0.907	-1.093	-1.27	-0.92
The use of AI tools encourages student-centred learning in my teaching.	-10.873	107	0.000	2.31	1.133	-1.185	-1.40	-0.97

Despite low usage (Table 4), teachers who engaged with AI tools reported strong positive impacts on pedagogy (all $p<0.001$). Benefits included enhanced collaborative learning (M=2.18), clearer demonstrations of complex design concepts (M=2.23), more personalised instruction (M=2.51), and improved assessment strategies (M=2.48) as presented in Table 5.

This disconnect between limited adoption and high perceived benefit is critical. Even minimal exposure can trigger pedagogical shifts from teacher-centred to more interactive, collaborative, and student-focused approaches. This aligns with global perspectives viewing AI as a catalyst for innovation rather than a teacher replacement (Dwivedi et al., 2019; Shum & Luckin, 2019).

For design education, AI's ability to provide instant visualisations and simulations addresses long-standing challenges in communicating abstract concepts (Gyamfi et al., 2022). The perceived benefits strongly support investment in AI infrastructure and targeted training. Importantly, such investment is not merely technological but pedagogical laying the foundation for student-centred, collaborative, and skills-oriented education. Updating curricula and teaching guidelines is therefore essential to ensure AI tools are integrated effectively once access and training barriers are addressed (Osondu et al., 2024)

7.3 Results of (RQ3): How Effective Does AI Tools Enhancing Student Learning Outcomes in Design and Communication Skills Subjects in Selected Schools in Ghana?

Table 6. RQ3: How Effectiveness Does AI Tools Enhancing Student Learning Outcomes in Design And Communication Skills

Item	Test Value = 3.5						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean	Std. Deviation	Mean Difference	Lower	Upper
AI tools help students develop better visual and presentation skills.	-14.619	107	0.000	2.24	0.895	-1.259	-1.43	-1.09
The use of AI tools has increased student participation in class activities.	-20.992	107	0.000	1.82	0.830	-1.676	-1.83	-1.52
AI tools help students complete assignments more efficiently.	-20.156	107	0.000	2.00	0.773	-1.500	-1.65	-1.35
Students' performance in design-related subjects has improved due to AI support.	-11.410	107	0.000	2.43	0.978	-1.074	-1.26	-0.89
AI tools promote independent learning among students.	-15.891	107	0.000	2.15	0.884	-1.352	-1.52	-1.18
Students better understand design concepts when supported by AI tools.	-16.840	107	0.000	1.98	0.937	-1.519	-1.70	-1.34
Students produce higher-quality work in communication tasks when using AI tools.	-9.100	107	0.000	2.51	1.131	-0.991	-1.21	-0.77

The one-sample t-test results (Table 6) provide strong, statistically significant evidence that AI tools are perceived as effective in enhancing student learning outcomes, particularly in design and communication skills within the Ghanaian educational context. All seven items yielded highly significant results ($p < .001$), confirming that the differences from the neutral test value of 3.5 were not due to chance.

The consistently negative t-values and mean differences (actual means ranging from 1.82 to 2.51) indicate that respondents strongly agreed on the benefits of AI tools. Specifically, they perceived AI as enhancing visual and presentation skills, increasing participation, improving efficiency in completing assignments, and raising the overall quality of student work. Additionally, AI was viewed as supporting independent learning and deepening understanding of complex design concepts.

These findings resonate with global discussions on the transformative potential of AI in education. AI systems can personalise learning, provide real-time feedback, and

automate routine tasks, thereby enabling students to engage in higher-order thinking (Dwivedi et al., 2019; Borger et al., 2023). The reported boost in participation echoes Kruk and Kałużna (2024), who observed that AI promotes motivation and engagement. Likewise, improvements in communication outputs align with Bircan et al. (2025), who showed that AI-assisted training strengthens 21st-century skills, including digital communication. The findings hold important implications for both pedagogical practice and educational policy in Ghana and similar contexts.

The strong evidence of efficacy supports the deliberate integration of AI tools into design and communication curricula. Rather than replacing teachers, AI should be employed as a scaffolding tool to foster creativity and provide hands-on exposure to technologies shaping contemporary workplaces (Segbenya et al., 2023). This aligns with Liekum's (2025) call for harnessing AI in Ghanaian Colleges of Education to improve teaching and learning quality.

Scaling these benefits requires significant investment in digital infrastructure and teacher preparation. AI literacy among Ghanaian educators remains limited (Arkorful et al., 2025). For effective adoption, teachers must receive training that extends beyond technical skills to include the ethical, social, and pedagogical dimensions of AI use (Al-Zahrani & Alasmari, 2024; Dwivedi et al., 2023). Prior studies in Ghana, including Mohammed (2023) on early childhood educators and Adobea et al. (2024) on tutor training, highlight the importance of teacher attitudes and perceived viability in driving successful technological adoption.

7.4 Results of (RQ4): What are the Challenges Faced by Teachers in Integrating AI Tools into Teaching Practices Related to Design and Communication Skills?

Table 7. RQ4: What are the Challenges Faced by Teachers in Integrating AI Tools into Teaching Practices Related to Design and Communication Skills.

Item	Test Value = 3.5						95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean	Std. Deviation	Mean Difference	Lower	Upper
Not confident in my ability to use AI tools effectively.	-6.925	107	0.000	2.68	1.237	-0.824	-1.06	-0.59
There is limited technical support for using AI tools in the classroom.	-7.414	107	0.000	2.67	1.168	-0.833	-1.06	-0.61
AI tools are not aligned with the current school curriculum for design and communication.	-6.291	107	0.000	2.75	1.239	-0.750	-0.99	-0.51

Time constraints limit my ability to explore or integrate AI into lessons.	-10.754	107	0.000	2.38	1.083	-1.120	-1.33	-0.91
Concerned about ethical issues related to AI use in teaching.	-15.623	107	0.000	1.96	1.022	-1.537	-1.73	-1.34
Students misuse AI tools rather than use them productively.	-14.160	107	0.000	2.03	1.080	-1.472	-1.68	-1.27

The one-sample t-test results (Table 7) show that teachers in Ghana face substantial barriers to integrating AI tools into the teaching of design and communication skills. All mean scores were significantly below the neutral test value of 3.5 ($p < 0.001$), confirming strong agreement with the identified challenges. The most critical concerns were ethical issues surrounding AI use (M = 1.96, Mean Difference = -1.537) and potential student misuse (M = 2.03, Mean Difference = -1.472). Other significant barriers included time constraints (M = 2.38), lack of confidence in using AI (M = 2.68), insufficient technical support (M = 2.67), and poor alignment of AI tools with the curriculum (M = 2.75).

These findings align with broader literature on the complexities of AI adoption in education, especially within resource-constrained contexts. Ethical concerns and fears of student misuse reflect global debates on AI in education (Dwivedi et al., 2023; Al-Zahrani & Alasmari, 2024), yet they are particularly pressing in Ghana, where digital literacy and ethical frameworks remain underdeveloped (Arkorful et al., 2025; Segbenya et al., 2023). Similarly, the lack of technical support and low teacher self-efficacy mirror wider infrastructural and professional development limitations in the country's education system (Gyamfi et al., 2022; Liekum, 2025). The reported misalignment of AI tools with the national curriculum further highlights the need for context-sensitive solutions that consider Ghana's educational priorities and cultural realities (Osondu et al., 2024; Mohammed, 2023).

Time constraints also emerged as a significant barrier, consistent with international evidence showing that teachers often lack adequate time to learn and integrate new technologies (Borger et al., 2023; Labadze et al., 2023). In Ghana, this challenge is amplified by large class sizes and limited teaching resources (Adobea et al., 2024).
Addressing these challenges requires a holistic strategy. First, targeted professional development is needed to strengthen teachers' AI literacy and pedagogical confidence. Second, sustainable institutional support, such as technical assistance and curriculum integration, must be prioritised.

Third, co-developed ethical guidelines and student engagement policies are critical to preventing misuse while promoting responsible adoption.

Finally, AI tools should be designed with adaptability to local curricular requirements and resource limitations.

Together, these measures can mitigate the barriers identified and enable AI to support the effective teaching of design and communication skills in Ghana, contributing to national education goals and broader digital transformation efforts.

7.8 Results of Binary Logistic Regression: Predicting AI Tool Adoption

The probability of AI adoption (use vs. non-use) was modelled using binary logistic regression (Table 9), which simultaneously controlled for several predictor variables. This identifies the key factors that influence adoption.

Table 9. Binary Logistic Regression Predicting Likelihood of AI Tool Adoption

Predictor Variable	B (Coefficient)	S.E.	Wald	p-value	Odds Ratio (OR)	95% C.I. for OR
Age Group (Ref: 20-29 years)						
30-39 years	-0.521	0.501	1.082	0.298	0.594	[0.22, 1.59]
40-49 years	-1.204	0.602	3.997	0.046*	0.300	[0.09, 0.98]
50+ years	-2.109	1.102	3.664	0.056	0.121	[0.01, 1.11]
Qualification (Ref: Bachelor's)						
Postgraduate (Master's/Doctorate)	1.883	0.489	14.83	<0.001***	6.570	[2.52, 17.14]
Subject (Ref: Other Subjects)						
Technical (Design/Tech/Drawing)	1.204	0.455	7.007	0.008**	3.336	[1.37, 8.14]

Table 9. Binary Logistic Regression Predicting Likelihood of AI Tool Adoption

Predictor Variable	B (Coefficient)	S.E.	Wald	p-value	Odds Ratio (OR)	95% C.I. for OR
ICT Facilities (Ref: Limited/No)						
Yes (Adequate)	1.599	0.522	9.392	0.002**	4.949	[1.78, 13.77]
Training (Ref: No Training)						
Yes (Formal/Informal)	2.017	0.447	20.35	<0.001***	7.514	[3.13, 18.04]
Constant	-3.101	0.684	20.55	<0.001	0.045	

**Note: *p < .05, **p < .01, ***p < .001. Model $\chi^2(11) = 68.24$, p < .001, Nagelkerke $R^2 = 0.562$. Hosmer-Lemeshow test: $\chi^2(8) = 7.12$, p = 0.524, indicating good model fit.*

The logistic regression model (Table 9) was statistically significant and accounted for 56.2% of the variance in AI adoption among teachers (Nagelkerke $R^2 = 0.562$), (Table 1). Four predictors emerged as highly significant:

1. Postgraduate Qualification

Teachers holding a Master's or Doctorate were 6.57 times more likely to adopt AI than those with only a Bachelor's degree (OR = 6.57, p < .001). This underscores the role of advanced academic attainment in shaping openness to innovation, as higher qualifications often correlate with greater research engagement and exposure to novel pedagogical practices. These results extend the findings of Arkorful et al. (2025), who highlighted low AI literacy, by demonstrating the measurable effect of advanced education on adoption behaviour.

2. AI Training

The most influential predictor was AI-related training. Teachers who had received formal or informal training were 7.51 times more likely to adopt AI (OR = 7.51, p < .001). This finding provides strong empirical support for repeated calls in the literature (Liekum, 2025; Adobea et al., 2024) for systematic professional development. More

than establishing correlation, the model demonstrates that training functions as a transformative intervention, directly overcoming barriers to adoption.

3. ICT Infrastructure

The availability of adequate ICT facilities increased the likelihood of adoption by nearly fivefold (OR = 4.95, p = .002). This confirms the centrality of infrastructure, previously described as a background challenge by Gyamfi et al. (2022), as a direct determinant of adoption. The implication is clear: training initiatives without parallel infrastructural investment are unlikely to yield sustainable outcomes.

4. Teaching Technical Subjects

Educators in Design and Technology or Technical Drawing were 3.34 times more likely to adopt AI than colleagues in other disciplines (OR = 3.34, p = .008). This aligns with the chi-square results and suggests that perceived relevance and applicability of AI are higher in technically oriented, visually driven subjects (Bircan et al., 2025).

These findings integrate and quantify the diverse barriers identified in both the present study and prior literature. They show that the digital divide is not merely a question of access to technology (Dwivedi et al., 2019), but also one of human capital, shaped by disparities in education and training. The evidence strongly supports a multi-pronged policy response: investment in infrastructure, provision of targeted and compulsory training, and development of discipline-specific teaching resources, particularly for non-technical subjects. Such a comprehensive strategy is essential for fostering equitable and sustainable AI integration in education.

7.9 Results of Factor Analysis: Underlying Constructs of AI Perceptions

To determine the latent constructs underlying the 29 Likert-scale items assessing AI's impact on teaching (RQ2), learning outcomes (RQ3), and challenges (RQ4), an exploratory factor analysis (EFA) was carried out, as shown in Table 10. This gives teacher perceptions a more concise and comprehensible framework.

Table 10. Rotated Factor Loadings for AI Perception Items

Item (Abbreviated)	Factor 1: Pedagogical Benefits	Factor 2: Learning Efficacy	Factor 3: Systemic & Ethical Challenges	Factor 4: Operational Barriers
AI enables more interactive teaching strategies	0.872	0.211	0.103	0.098

Table 10. Rotated Factor Loadings for AI Perception Items

Item (Abbreviated)	Factor 1: Pedagogical Benefits	Factor 2: Learning Efficacy	Factor 3: Systemic & Ethical Challenges	Factor 4: Operational Barriers
AI encourages student-centred learning	0.855	0.238	0.128	0.084
AI helps personalise instruction	0.834	0.302	0.062	0.112
AI facilitates collaborative learning	0.821	0.192	0.156	0.135
AI helps demonstrate complex concepts	0.789	0.351	0.075	0.098
Students produce higher-quality work with AI	0.321	0.841	0.128	0.092
Students understand concepts better with AI	0.298	0.832	0.145	0.078
Students develop better visual/presentation skills	0.376	0.815	0.102	0.105
AI promotes independent learning	0.411	0.788	0.088	0.134
Students misuse AI tools	0.098	0.132	0.901	0.165
Concerned about ethical issues	0.125	0.105	0.887	0.192
AI tools not aligned with curriculum	0.102	0.088	0.754	0.308
Time constraints limit integration	0.134	0.092	0.225	0.843

Table 10. Rotated Factor Loadings for AI Perception Items

Item (Abbreviated)	Factor 1: Pedagogical Benefits	Factor 2: Learning Efficacy	Factor 3: Systemic & Ethical Challenges	Factor 4: Operational Barriers
Not confident in ability to use AI	0.088	0.078	0.341	0.819
Limited technical support	0.156	0.145	0.298	0.791
Eigenvalue	5.92	3.15	2.41	1.88
% of Variance	27.1%	18.4%	15.2%	12.6%
Cumulative %	27.1%	45.5%	60.7%	73.3%
Cronbach's Alpha (α)	0.941	0.928	0.893	0.862

The exploratory factor analysis (EFA) presented in Table 10 revealed a well-defined four-factor structure that accounted for 73.3% of the total variance, with each factor exhibiting excellent internal consistency ($\alpha > 0.85$).

Factor 1: Pedagogical Benefits. This factor highlights the transformative role of AI in reshaping teaching methodologies. It reflects a paradigm shift towards interactive, student-centred, and collaborative learning environments. Such findings resonate with the global discourse that positions AI as a pedagogical catalyst driving innovation in teaching and learning (Shum & Luckin, 2019; Dwivedi et al., 2019).

Factor 2: Learning Efficacy. This factor captures the perceived positive influence of AI on student learning outcomes, including comprehension, quality of work, and skill development. It aligns with existing evidence that AI fosters 21st-century skills, improves learning motivation, and enhances academic performance (Kruk & Kałużna, 2024; Bircan et al., 2025). \

Factor 3: Systemic and Ethical Challenges. This factor reflects teachers' concerns about potential misuse by students, ethical dilemmas, and inconsistencies with the national curriculum. These issues underscore the inseparability of ethical and governance challenges from broader systemic questions of curricular relevance. Similar findings in the literature affirm that such concerns remain central to the discourse on AI in education (Al-Zahrani & Alasmari, 2024; Dwivedi et al., 2023).

Factor 4: Operational Barriers. This factor points to immediate, practical challenges inhibiting AI adoption, including time constraints, limited confidence, and inadequate technical support. These barriers corroborate findings in the Ghanaian context regarding infrastructural deficits and readiness constraints (Gyamfi et al., 2022; Mohammed, 2023).

Overall, this study presents a validated framework that captures teacher perceptions of AI integration in education. The findings reveal that while Ghanaian teachers share the global recognition of AI's pedagogical promise (Factors 1 and 2), their dominant concerns are rooted in operational and systemic barriers (Factors 3 and 4). Addressing these practical and ethical challenges is therefore a prerequisite for unlocking the full pedagogical potential of AI in similar educational contexts.

7.10 Results of Multivariate Analysis of Variance (MANOVA)

To check for general variations in AI perceptions based on important demographic groups across the several dependent variables at once, MANOVA (Table 11) was performed. This avoids Type I error and shows whether structural factors have an impact on an AI holistic perspective.

Table 11: MANOVA Results for AI Perceptions by Qualification and Subject Taught

Effect	Value	F-Value	Hypothesis df	Error df	p-value
Pillai's Trace					
Qualification	0.138	4.013	4	101	**0.005**
Subject Taught	0.095	2.647	4	101	**0.038**
Qualification * Subject Taught	0.037	0.966	4	101	0.430

Table 11a: *Follow-up Univariate ANOVAs (Qualification)*

Dependent Variable (Factor)	Bachelor's (n=66) Mean (SD)	Postgraduate (n=42) Mean (SD)	F(1,104)	p-value	Partial η^2
Pedagogical Benefits	-0.21 (0.9)	0.33 (1.0)	9.187	**0.003**	0.081
Learning Efficacy	-0.18 (0.9)	0.29 (1.0)	6.873	**0.010**	0.062
Systemic Challenges	0.15 (1.1)	-0.24 (0.8)	4.123	**0.045**	0.038
Operational Barriers	0.12 (1.0)	-0.19 (0.9)	2.890	0.092	0.027

Table 11b: *Follow-up Univariate ANOVAs (Subject Taught)*

Dependent Variable (Factor)	Other Subjects (n=63) Mean (SD)	Technical Subjects (n=45) Mean (SD)	F(1,104)	p-value	Partial η^2
Pedagogical Benefits	-0.19 (0.9)	0.27 (1.0)	6.415	**0.013**	0.058
Learning Efficacy	-0.17 (0.9)	0.24 (1.0)	5.312	**0.023**	0.049
Systemic Challenges	0.22 (1.1)	-0.31 (0.8)	8.102	**0.005**	0.072
Operational Barriers	0.19 (1.0)	-0.27 (0.9)	6.022	**0.016**	0.055

The MANOVA results indicated statistically significant multivariate effects for both Qualification (Pillai's Trace = 0.138, p = .005) and Subject Taught (Pillai's Trace = 0.095, p = .038), with no significant interaction (Table 3a, b).

Qualification: Teachers with postgraduate degrees demonstrated significantly more positive perceptions of AI integration than those with only a bachelor's degree. They reported stronger beliefs in its Pedagogical Benefits and Learning Efficacy, while expressing fewer concerns about Systemic Challenges such as ethical implications or curriculum alignment. These results suggest that advanced academic training not only predicts likelihood of adoption (as indicated in the logistic regression results) but also cultivates greater confidence in navigating AI's complexities. Postgraduate training

may therefore reduce apprehension and encourage a more constructive engagement with AI in education.

Subject Taught: Teachers in technical disciplines, such as Design and Technical Drawing, also expressed significantly more positive views. They reported higher levels of perceived Pedagogical Benefits and Learning Efficacy, along with fewer concerns regarding both Systemic and Operational Challenges, compared with their colleagues in non-technical fields. This pattern highlights how the clear applicability of AI tools within technical subjects creates a reinforcing cycle: ease of use strengthens recognition of benefits, while reduced barriers encourage broader adoption.

These findings deepen the insights offered by earlier chi-square analyses, revealing that the "digital divide" among teachers extends beyond access to technology and manifests as a perceptual divide. Educators with higher qualifications and those teaching technical subjects appear to be caught in a "virtuous cycle" of optimism and adoption, while others remain in a "vicious cycle" of hesitation and heightened concern. This extends the work of Segbenya et al. (2023) by showing that antecedents of AI adoption shape not only behavioural intentions but also educators' broader perceptual frameworks.

From a practical perspective, these results argue for differentiated professional development strategies. Non-technical teachers may benefit from training that demonstrates subject-relevant applications of AI, while all teachers require support in navigating ethical and curricular integration. In particular, targeted upskilling of bachelor's-level teachers is essential to bridge perceptual gaps and foster more equitable adoption of AI in education.

11. Conclusion

This study provides empirical evidence that artificial intelligence (AI) has significant potential to transform the teaching and learning of design and communication skills, in line with global shifts toward innovative pedagogical practices. Educators acknowledge AI's ability to foster interactive, student-centered, and collaborative learning environments that can enhance learning outcomes. Yet, this promise remains underutilized, constrained by a combination of infrastructural, systemic, and ethical challenges. Importantly, the digital divide extends beyond access to technology, encompassing disparities in teacher qualifications, subject expertise, and professional readiness.

The findings highlight that effective AI integration requires a multidimensional approach and coordinated policy support. First, sustained investment in reliable ICT infrastructure is indispensable. Second, teacher professional development must evolve beyond basic digital literacy to include compulsory, practical, and subject-specific training that builds pedagogical confidence and competence. Third, curriculum reform, coupled with the co-creation of contextually relevant ethical guidelines, is critical to ensuring that AI is applied responsibly and meaningfully.

For Ghana and similar contexts, advancing AI in education demands the rejection of one-size-fits-all strategies. Instead, progress depends on systematically addressing infrastructural gaps, empowering educators through targeted capacity-building, and aligning AI use with local curricular priorities. By doing so, stakeholders can transform existing barriers into opportunities, paving the way for an equitable and sustainable educational future. In this future, AI will serve not merely as a technological innovation but as a catalyst for enriching design and communication education and for equipping learners with the critical 21st-century skills essential for national development.

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Data, Materials, and Code Availability

The datasets generated and/or analyzed during this study are available from the corresponding author upon reasonable request.

Authors' Contributions

All authors contributed equally to the conception, development, and writing of this manuscript and have approved the final version for submission.

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