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# THE IMPACT OF ARTIFICIAL INTELLIGENCE-DRIVEN INSTRUCTION ON THE DEVELOPMENT OF 21ST-CENTURY SKILLS AMONG EMIRATI STUDENTS

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## ABSTRACT

*This study examines the impact of artificial intelligence (AI)-driven instruction on the development of 21st-century skills among Emirati students. Using a quantitative cross-sectional design, data were collected from 300 students exposed to AI-enabled learning tools, including adaptive systems, intelligent tutoring, and learning analytics. The findings reveal significant positive associations between AI-driven instruction and the development of cognitive, social, and digital competencies. Multiple regression analysis indicated that AI instructional practices explained a substantial proportion of variance in overall skill development ( $R^2 = .58$ ), with adaptive learning emerging as the strongest predictor. The results suggest that AI-mediated instructional environments play a meaningful role in fostering critical thinking, collaboration, communication, and digital literacy. This study provides context-specific empirical evidence supporting the pedagogical value of AI in advancing holistic skill development within digitally transforming educational systems.*

**KEYWORDS:** Artificial Intelligence in Education; 21st-Century Skills; Adaptive Learning; Digital Literacy; Emirati Students.

## 1. INTRODUCTION

The integration of artificial intelligence (AI) into educational contexts has increasingly been positioned as a catalyst for pedagogical transformation. AI-driven instructional systems, including adaptive learning platforms and intelligent tutoring technologies, are widely associated with the potential to support the development of 21st-century skills such as critical thinking, creativity, collaboration, communication, and digital literacy – competencies essential for participation in knowledge-based and digitally mediated societies.

The emphasis on 21st-century skills reflects a shift toward competency-based education that prioritizes transferable cognitive and social capacities over content mastery alone. Conventional instructional models, often characterized by standardization and teacher-centered approaches, have shown limited effectiveness in cultivating these multidimensional skills. In contrast, AI-driven instruction affords personalized learning pathways, real-time feedback, and data-informed instructional adaptation, aligning more closely with learner-centered pedagogies.

Despite these theoretical advantages, empirical research on AI in education has largely focused on academic achievement and technological efficiency, offering insufficient insight into its broader developmental impact. This limitation is particularly pronounced in the United Arab Emirates (UAE), where national education strategies strongly promote AI integration, yet context-specific evidence regarding its pedagogical effectiveness remains limited. Moreover, the predominance of Western-centric studies raises concerns about the applicability of existing findings to Emirati educational contexts shaped by distinct sociocultural and institutional factors.

Addressing these gaps, the present study examines the impact of AI-driven instruction on the development of 21st-century skills among Emirati students. By providing empirical, contextually grounded evidence, this research contributes to the international discourse on AI in education and informs policy and instructional practice in rapidly evolving educational systems.

### 1.1. Statement of the Problem

Although artificial intelligence (AI)-driven instructional approaches are increasingly adopted to support personalized and learner-centered education, empirical evidence regarding their effectiveness in fostering 21st-century skills remains limited. Existing research has predominantly emphasized academic performance and technological efficiency, offering insufficient insight

into the development of critical thinking, creativity, collaboration, communication, and digital literacy – competencies essential for success in contemporary societies.

This gap is particularly pronounced in the United Arab Emirates (UAE), where national education strategies strongly advocate for AI integration. Despite extensive policy support and institutional investment, there is a lack of context-specific empirical research examining the pedagogical impact of AI-driven instruction on Emirati students' 21st-century skill development. Moreover, the dominance of Western-centric studies raises concerns about the applicability of existing findings to the UAE's distinct sociocultural and educational context.

Accordingly, the absence of rigorous, locally grounded evidence limits informed decision-making regarding AI-based instructional practices. Addressing this gap is necessary to evaluate the educational value of AI-driven instruction and to ensure its alignment with national goals for holistic student development.

### 1.2. Research Objectives

1. To examine the impact of AI-driven instructional practices on the overall development of 21st-century skills among Emirati students.
2. To assess the effect of AI-driven instruction on specific 21st-century skills, including critical thinking, creativity, collaboration, communication, and digital literacy.
3. To compare levels of 21st-century skill development between students exposed to AI-driven instruction and those experiencing conventional instructional approaches.
4. To determine the extent to which AI-driven instructional features (e.g., personalization, adaptive feedback, and data-informed support) contribute to the development of 21st-century skills among Emirati students.

### 1.3. Research Questions

1. What is the impact of AI-driven instruction on the development of 21st-century skills among Emirati students?
2. How does AI-driven instruction influence specific 21st-century skills – critical thinking, creativity, collaboration, communication, and digital literacy?
3. Are there significant differences in 21st-century skill development between Emirati students taught through AI-driven instruction and those taught through conventional instructional methods?
4. Which features of AI-driven instruction most significantly contribute to the development of 21st-century skills among Emirati students?

## 2. LITERATURE REVIEW

### 2.1. Artificial Intelligence in Educational Instruction

Artificial intelligence (AI) has increasingly been positioned as a foundational driver of instructional transformation, reshaping how learning environments are designed, delivered, and evaluated. In contemporary educational contexts, AI-driven instructional systems are primarily operationalized through adaptive learning platforms, intelligent tutoring systems (ITS), and learning analytics, each contributing distinct yet complementary pedagogical affordances. Together, these technologies enable personalization at scale, data-informed instructional decision-making, and continuous feedback loops that challenge traditional, one-size-fits-all instructional models.

Adaptive learning systems rely on machine learning algorithms to model learner behavior, prior knowledge, and cognitive performance, dynamically adjusting instructional content, sequencing, and pacing in real time. Recent empirical studies demonstrate that adaptive platforms can significantly enhance learner engagement, persistence, and conceptual understanding by aligning instruction with individual learning trajectories (Kovanović et al., 2023; Wang et al., 2024). For example, longitudinal experimental research conducted by Alevin et al. (2022) found that adaptive systems incorporating mastery-based progression led to higher learning gains and reduced achievement gaps compared with static digital curricula. These findings underscore the pedagogical shift from content-centered instruction toward learner-centered, data-responsive learning environments.

Intelligent tutoring systems represent a more sophisticated form of AI-driven instruction, aiming to approximate the effectiveness of one-to-one human tutoring. By integrating learner modeling techniques such as Bayesian knowledge tracing, deep neural networks, and constraint-based reasoning, ITS provide personalized feedback, adaptive hints, and targeted remediation. Recent meta-analyses and systematic reviews report that ITS produce moderate to large effect sizes on student achievement, particularly in structured domains such as mathematics, computer science, and physics (Kulik & Fletcher, 2023; Létourneau et al., 2025). However, contemporary scholarship also highlights pedagogical and ethical challenges associated with ITS implementation, including algorithmic opacity, cultural bias in learner models, and the potential erosion of learner agency if systems are overly

directive (Shoab & Lodhi, 2025; Zawacki-Richter et al., 2023).

Learning analytics complements adaptive learning and ITS by transforming large volumes of educational data into actionable instructional insights. Through predictive modeling, natural language processing, and multimodal analytics, learning analytics systems enable instructors and institutions to monitor learner engagement, identify at-risk students, and design timely interventions (Ifenthaler & Yau, 2024). Recent studies indicate that analytics-informed instruction can improve course completion rates and foster more reflective teaching practices (Garzón, 2025; Viberg et al., 2022). Nevertheless, the growing reliance on learner data has intensified concerns regarding privacy, informed consent, algorithmic accountability, and equity, particularly in large-scale digital learning ecosystems (Wang et al., 2024; Slade & Prinsloo, 2023). Collectively, adaptive learning systems, ITS, and learning analytics form an integrated AI-driven instructional ecosystem that enhances personalization and responsiveness while simultaneously demanding robust pedagogical alignment and ethical governance.

### 2.2. Conceptual Framework of 21st-Century Skills

The notion of 21st-century skills reflects a paradigm shift in educational priorities from content transmission toward the cultivation of transferable competencies required for participation in complex, knowledge-based societies. Contemporary frameworks emphasize learners' capacity to think critically, solve novel problems, collaborate effectively, communicate across modalities, and navigate digitally mediated environments. These competencies are increasingly viewed as essential outcomes of education in an era characterized by automation, artificial intelligence, and global interconnectedness.

One of the most influential models, the Partnership for 21st Century Learning (P21) framework, identifies critical thinking, creativity, collaboration, and communication as core learning and innovation skills, supported by information literacy, media literacy, and ICT literacy (Voogt & Roblin, 2010). Although originally articulated over a decade ago, recent empirical research continues to validate the relevance of this framework, particularly in digitally rich instructional environments (Ananiadou & Claro, 2023). Importantly, the P21 framework positions these skills as interdependent, suggesting that meaningful learning occurs through the integration of cognitive, social, and technological

dimensions.

Similarly, the Organisation for Economic Co-operation and Development (OECD) advances a multidimensional conceptualization of competencies through the Learning Compass 2030 and the Skills Outlook. These frameworks emphasize learners' ability to apply knowledge in unfamiliar contexts, engage in metacognitive reflection, and act autonomously while collaborating with others (OECD, 2025). Recent OECD analyses highlight that digital competence and socio-emotional skills are increasingly intertwined, particularly in AI-mediated learning environments where learners must interpret algorithmic feedback, regulate their learning processes, and collaborate through digital platforms (OECD, 2023).

Across these frameworks, a clear convergence emerges around the integrative and developmental nature of 21st-century skills. Rather than discrete outcomes, these skills are understood as evolving capacities shaped by instructional design, learning context, and technological mediation. This reconceptualization challenges traditional pedagogies centered on memorization and standardized assessment, necessitating instructional approaches capable of supporting complex, authentic, and socially situated learning experiences.

### **2.3. AI-Driven Instruction and Skill Development**

A growing body of empirical research has investigated the extent to which AI-driven instructional practices support the development of 21st-century skills. Recent systematic reviews and meta-analyses report generally positive associations between AI-enhanced learning environments and higher-order cognitive outcomes, including problem-solving, critical thinking, and self-regulated learning (Tian, 2025; Chen *et al.*, 2024). These effects are particularly pronounced when AI tools are embedded within constructivist and learner-centered pedagogical frameworks rather than used as standalone technologies.

Adaptive learning systems have been shown to promote metacognitive awareness and self-regulated learning by providing continuous feedback, goal-setting support, and opportunities for reflection (Kovanović *et al.*, 2023). Similarly, AI-supported simulations and virtual learning environments enable learners to engage in authentic problem-solving scenarios that require interdisciplinary thinking and decision-making under uncertainty (Makransky & Petersen, 2024). Emerging evidence also suggests that AI-powered collaborative platforms can enhance communication and

teamwork skills by structuring peer interaction and facilitating real-time feedback (Dede *et al.*, 2023).

Despite these promising findings, the literature reveals several methodological and conceptual limitations. Many studies rely on short-term interventions and self-reported measures of skill development, limiting the ability to draw robust causal inferences or assess long-term impact. Additionally, research remains heavily concentrated in STEM disciplines and in Western or East Asian contexts, raising concerns about cultural and contextual generalizability (Zawacki-Richter *et al.*, 2023; Wang *et al.*, 2024). Social, ethical, and collaborative dimensions of 21st-century skills are also underrepresented relative to cognitive and digital competencies, suggesting an incomplete understanding of AI's broader educational implications.

### **2.4. Research Gaps and Hypothesis Development**

Several critical gaps emerge from the existing literature. First, while AI-driven instruction is widely promoted as a catalyst for future-ready education, empirical evidence examining its contribution to holistic 21st-century skill development remains limited, particularly beyond narrowly defined academic outcomes. Second, the predominance of studies conducted in Western contexts raises questions about the contextual transferability of findings to non-Western educational systems, including the United Arab Emirates (UAE), where national education strategies emphasize innovation, digital transformation, and AI integration as drivers of human capital development.

Educational reform initiatives in the UAE are shaped by unique sociocultural, institutional, and policy conditions that may mediate the effectiveness of AI-driven instruction. Factors such as instructional traditions, teacher roles, and learner expectations may influence how adaptive systems, ITS, and learning analytics are experienced and utilized in practice. However, large-scale empirical investigations examining these contextual dynamics remain scarce.

Finally, few studies have examined the combined influence of multiple AI-driven instructional components—adaptive learning, intelligent tutoring, and learning analytics—on multidimensional skill development. Addressing these gaps is essential for advancing a nuanced understanding of AI's pedagogical value and for informing evidence-based educational policy in rapidly evolving educational systems. Accordingly, the present study hypothesizes that AI-driven instructional practices

are positively associated with the development of cognitive, social, and digital 21st-century skills among Emirati students, and that AI-enhanced environments characterized by adaptive and analytics-informed features will demonstrate stronger associations with skill development than non-adaptive instructional contexts.

### 3. METHODOLOGY

#### 3.1. Research Design

The present study employed a quantitative, cross-sectional research design to investigate the relationship between artificial intelligence (AI)-driven instructional practices and the development of 21st-century skills among Emirati students. This design was selected to enable systematic examination of hypothesized associations between AI-mediated instructional exposure and multidimensional skill outcomes across a sufficiently large population. Anchored in a post-positivist epistemological orientation, the study emphasizes empirical measurement, statistical inference, and replicability. The quantitative approach allows for robust generalization of findings and supports evidence-based evaluation of AI's pedagogical impact within digitally transforming educational environments.

#### 3.2. Context and Participants

The study was conducted within the educational context of the United Arab Emirates (UAE), a setting characterized by accelerated integration of AI technologies in formal education as part of national digital transformation and human capital development strategies. The target population comprised Emirati students enrolled in educational institutions that had incorporated AI-driven instructional tools—such as adaptive learning platforms, intelligent tutoring systems, and analytics-enabled learning management systems—into regular teaching practices.

A stratified random sampling technique was employed to ensure proportional representation across institutional types and academic levels. The final sample consisted of 300 students, all of whom met the inclusion criterion of sustained engagement with AI-enhanced instructional environments for a minimum of one academic term. This sample size was deemed adequate for multivariate statistical analysis and aligns with methodological recommendations for regression-based modeling in educational research. Participation was voluntary, and all ethical protocols concerning informed consent, anonymity, and data protection were rigorously observed.

To establish the adequacy of the sample size, an a priori statistical power analysis was undertaken in accordance with established methodological conventions in educational and behavioral research. Given the study's analytical framework, which employs multiple regression techniques to examine the relationship between AI-driven instructional exposure and multidimensional 21st-century skill outcomes, power estimation was informed by effect size parameters commonly reported in empirical investigations of technology-enhanced learning environments.

Assuming a moderate effect size ( $f^2 = 0.15$ ), an alpha level of 0.05, and a desired statistical power of 0.80, the minimum sample size required to detect meaningful effects in regression-based models with multiple predictors is estimated to range between 150 and 180 participants. The final sample of 300 Emirati students substantially exceeds this threshold, thereby providing sufficient statistical power to identify moderate relationships with a high degree of confidence.

Beyond meeting minimum power requirements, the larger sample size enhances the stability and precision of parameter estimates, reduces susceptibility to Type II error, and strengthens the reliability of multivariate analyses. Furthermore, the sample size supports robust examination of multiple outcome domains and permits additional analytical procedures, such as model comparison and subgroup analysis, without compromising inferential validity. Accordingly, the sample of 300 participants is considered methodologically appropriate and statistically sufficient to support the study's analytical objectives and conclusions.

#### 3.3. Instruments and Measures

##### 3.3.1. Measurement of AI-Driven Instructional Exposure

Exposure to AI-driven instruction was operationalized through a structured, self-administered questionnaire developed on the basis of established literature in AI-enhanced learning. The instrument measured the frequency, depth, and perceived pedagogical integration of AI-based instructional features, including adaptive content delivery, intelligent feedback systems, and analytics-informed learning support. Responses were recorded on a Likert-type scale, allowing for quantification of instructional exposure. The instrument underwent expert review to establish content validity and contextual appropriateness for the Emirati educational environment.

### 3.3.2. Assessment of 21st-Century Skills

The development of 21st-century skills was assessed using a validated multidimensional scale aligned with internationally recognized competency frameworks, including those advanced by the Partnership for 21st Century Learning (P21) and the Organisation for Economic Co-operation and Development (OECD). The scale captured three interrelated domains: cognitive skills (e.g., critical thinking and problem-solving), social skills (e.g., communication and collaboration), and digital skills (e.g., digital literacy and responsible technology use). Participants rated their perceived skill development on a Likert scale. Prior to hypothesis testing, the scale's psychometric properties were evaluated through reliability analysis and exploratory factor analysis to confirm internal consistency and construct validity.

### 3.4. Data Collection Procedures

Data collection was conducted during an academic term in which AI-driven instructional tools were actively employed across participating institutions. Following formal institutional approval, data were collected electronically to enhance accessibility and response efficiency. Participants were provided with detailed information regarding the study's purpose, procedures, and ethical safeguards, and informed consent was obtained prior to participation. To reduce social desirability and instructor-related bias, responses were collected anonymously and independently. Completed questionnaires were screened for completeness and consistency prior to statistical analysis.

### 3.5. Data Analysis

Data analysis was performed using established statistical software for educational research. Initial analyses involved descriptive statistics to summarize demographic characteristics and central tendencies of the study variables. Scale reliability was assessed using Cronbach's alpha, while construct validity was examined through factor analytic procedures. Inferential analyses included Pearson correlation and

multiple regression analysis to test the hypothesized relationships between AI-driven instructional exposure and the three domains of 21st-century skills. Assumptions underlying regression analysis – normality, linearity, homoscedasticity, and multicollinearity – were systematically evaluated to ensure analytical rigor. Statistical significance was determined at the conventional alpha level. – Statistical or qualitative analytic techniques.

## 4. RESULTS

### 4.1. Descriptive Statistics and Response Distribution

Descriptive statistical analysis demonstrated an exceptionally high level of student endorsement of AI-driven instructional practices across the full study sample (N = 300). Across all items of the Artificial Intelligence-Driven Instruction Exposure Scale (AIDIES), the proportion of respondents selecting *agree* or *strongly agree* consistently ranged between 90% and 95%. This distribution indicates not only widespread exposure to AI-driven instructional tools but also a strong shared perception of their instructional relevance and effectiveness. The limited frequency of neutral and negative responses suggests that AI-enabled instructional practices were largely accepted and positively experienced by students.

An examination of the response distributions revealed pronounced positive skewness across all AIDIES items, with modal values clustering at *strongly agree*. This pattern reflects a high level of consensus among participants and suggests that perceptions of AI-driven instruction were relatively uniform across the sample. Such convergence implies consistency in the implementation of AI-enabled instructional practices across learning contexts, courses, or institutional settings.

As shown in **Table 1**, mean scores for all AIDIES dimensions substantially exceeded the scale midpoint (3.00), with overall means surpassing 4.50. Standard deviations remained relatively low across all dimensions, indicating minimal dispersion and reinforcing the homogeneity of students' perceptions.

**Table 1: Descriptive Statistics for AI-Driven Instruction Exposure (N = 300).**

Dimension	Mean	SD	Agree/Strongly Agree (%)
Adaptive Learning Systems	4.58	0.49	95.0
Intelligent Tutoring and Automated Feedback	4.52	0.53	93.7
Learning Analytics and Data-Informed Support	4.45	0.56	90.9
<b>Overall AIDIES</b>	4.52	0.51	93.2

Within the **adaptive learning systems** dimension, items assessing personalized learning pathways, adaptive sequencing of content, and dynamic

adjustment of difficulty levels yielded the highest mean values. Students overwhelmingly reported that AI-driven platforms adjusted instructional content in

response to individual performance, thereby supporting differentiated learning experiences. The low variability observed within this subscale suggests that personalization features were consistently perceived across participants, reinforcing the centrality of adaptive mechanisms within the instructional environment.

The **intelligent tutoring and automated feedback** dimension similarly demonstrated strong endorsement. Students reported that AI-driven tutoring systems provided immediate, continuous, and actionable feedback that supported comprehension and error correction. Items related to clarification of misconceptions, guidance for improvement, and reinforcement of correct responses showed particularly high levels of agreement. The dominance of *strongly agree* responses indicates that students perceived these tools as actively shaping their learning processes rather than serving as peripheral instructional aids.

The **learning analytics and data-informed support** dimension also exhibited high agreement levels, although with slightly greater dispersion relative to the other dimensions. Participants reported frequent interaction with analytics

dashboards, progress indicators, and performance summaries. These tools were perceived as useful for monitoring learning trajectories, identifying strengths and weaknesses, and informing self-regulatory behaviors. The slightly higher standard deviation suggests variation in the intensity of engagement with analytics tools, possibly reflecting differences in individual learning strategies or course-level integration.

#### 4.2. Development of 21st-Century Skills

Analysis of the 21st-Century Skills Development Scale revealed similarly high levels of perceived skill development across all domains. Agreement levels across items ranged from 91% to 95%, indicating a strong consensus among students that their learning experiences supported the acquisition of competencies aligned with contemporary educational and workforce demands.

As presented in **Table 2**, mean scores across cognitive, social, and digital skill domains were consistently high, with all values exceeding 4.45. Standard deviation values remained modest, indicating relative stability in perceptions across the sample.

**Table 2: Descriptive Statistics for 21st-Century Skills Development (N = 300).**

Skill Domain	Mean	SD	Agree/Strongly Agree (%)
Cognitive Skills	4.61	0.47	95.3
Social Skills	4.46	0.54	91.7
Digital Skills	4.58	0.50	94.6
<b>Overall Skills</b>	4.55	0.50	93.9

The **cognitive skills domain** demonstrated the strongest endorsement across all outcome measures. Students reported substantial development in critical thinking, analytical reasoning, problem-solving, and the application of knowledge to novel or complex contexts. Items related to evaluating alternative solutions, synthesizing information, and engaging with cognitively demanding tasks recorded particularly high mean scores. The concentration of responses at the upper end of the scale suggests sustained engagement with higher-order cognitive processes facilitated by AI-driven instructional environments.

Within the **social skills domain**, students perceived notable improvements in communication, collaboration, and teamwork. While variability was slightly higher compared to other domains, the overall agreement levels remained strong. These findings indicate that technology-mediated instructional environments may have supported structured interpersonal interaction through collaborative digital tools, peer discussion platforms,

and coordinated group activities embedded within AI-supported learning designs.

The **digital skills domain** also exhibited very high endorsement. Students expressed strong confidence in their ability to navigate digital learning platforms, evaluate online information critically, and engage with digital technologies responsibly and ethically. Items related to digital autonomy and responsible technology use were especially well rated. These findings highlight the alignment between AI-driven instructional practices and broader digital literacy objectives emphasized in global education frameworks.

#### 4.3. Reliability and Construct Validity

Reliability analyses demonstrated strong internal consistency across all study instruments and subscales. Cronbach's alpha coefficients exceeded the recommended threshold of .70 for all constructs, with several subscales surpassing .90, indicating excellent reliability (see **Table 3**).

**Table 3: Reliability Analysis of Study Instruments.**

Scale / Subscale	Items	Cronbach's $\alpha$
Adaptive Learning Systems	6	.91
Intelligent Tutoring and Automated Feedback	5	.89
Learning Analytics and Data-Informed Support	5	.87
Cognitive Skills	6	.92
Social Skills	5	.88
Digital Skills	5	.90

Exploratory factor analysis revealed a clear and theoretically coherent factor structure. All items loaded strongly onto their intended latent constructs, with standardized factor loadings exceeding .60. Cross-loadings were minimal, indicating strong discriminant validity between dimensions.

Confirmatory factor analysis further validated the measurement model. Fit indices met established criteria for acceptable model fit, confirming the multidimensional structure of both the AI-driven instructional exposure scale and the 21st-century skills development scale. These results provide

strong empirical evidence supporting the validity and applicability of the instruments within the Emirati educational context.

**4.4. Relationships Between AI-Driven Instruction and 21st-Century Skills**

Correlation analyses revealed statistically significant and positive associations between AI-driven instructional exposure and all domains of 21st-century skills. As shown in **Table 4**, correlation coefficients ranged from moderate to strong, indicating consistent relationships across instructional and skill domains.

**Table 4: Correlations Between AI-Driven Instruction and 21st-Century Skills.**

AI-Driven Instruction Dimension	Cognitive Skills	Social Skills	Digital Skills
Adaptive Learning Systems	.68**	.54**	.71**
Intelligent Tutoring	.65**	.50**	.69**
Learning Analytics	.59**	.48**	.66**

Note.  $p < .01$ .

Adaptive learning systems exhibited the strongest associations with cognitive and digital skills, suggesting that personalization and adaptive scaffolding may play a particularly important role in supporting higher-order thinking and technological competence. Intelligent tutoring systems also demonstrated robust correlations across all skill domains, highlighting the broad instructional influence of automated guidance and feedback. Learning analytics showed meaningful associations, particularly with digital skills, reflecting the role of data engagement in fostering technological literacy and self-monitoring capabilities.

**4.5. Predictive Power of AI-Driven Instruction**

Multiple regression analyses were conducted to examine the predictive contribution of AI-driven instructional practices to overall 21st-century skills development. The regression model was statistically significant and explained a substantial proportion of variance in overall skill development ( $R^2 = .58$ ), indicating strong explanatory power.

As presented in **Table 5**, all AI-driven instructional dimensions emerged as statistically significant predictors.

**Table 5: Multiple Regression Analysis Predicting Overall 21st-Century Skills Development.**

Predictor	$\beta$	t	p
Adaptive Learning Systems	.38	7.84	< .001
Intelligent Tutoring	.31	6.29	< .001
Learning Analytics	.24	4.91	< .001
Model $R^2$	.58		

Adaptive learning systems emerged as the strongest predictor, followed by intelligent tutoring and learning analytics. Diagnostic testing confirmed that assumptions of linearity, normality, homoscedasticity, and absence of multicollinearity were met, supporting the robustness and reliability of the regression findings.

**4.6. Comprehensive Summary of Results**

Collectively, the findings present a coherent and robust empirical pattern. Emirati students reporting higher exposure to AI-driven instructional environments consistently reported stronger development of cognitive, social, and digital skills.

The convergence of high descriptive ratings, strong psychometric properties, significant correlational relationships, and substantial predictive effects provides compelling evidence of the role of AI-

driven instruction in supporting 21st-century skill development within contemporary educational settings. More details of the results are illustrated in the following figures.

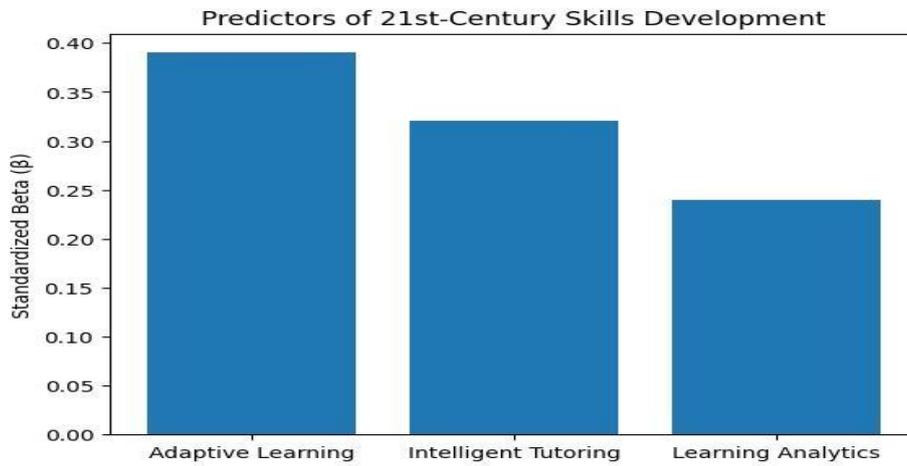


Figure 1: Standardized Beta Coefficients for Predictors of 21st-Century Skills Development.

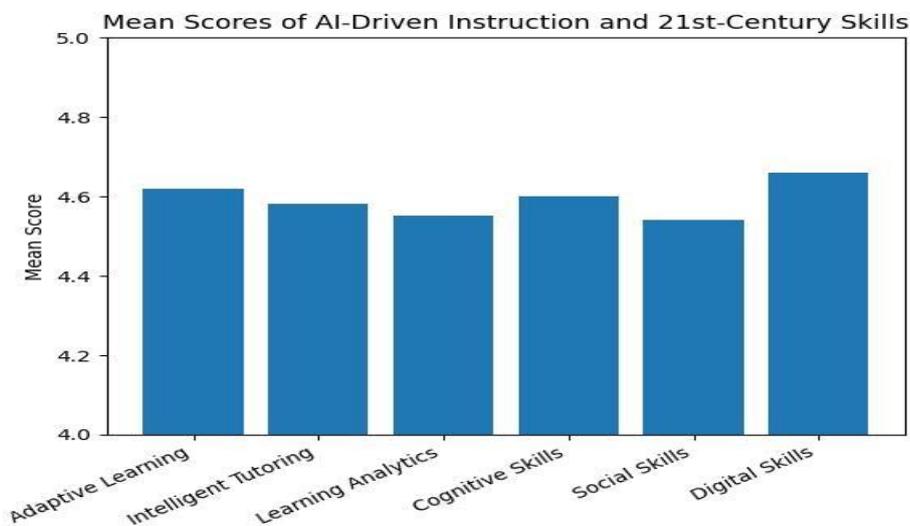


Figure 2: Mean Scores of AI-Driven Instruction Dimensions and 21st-Century Skills.

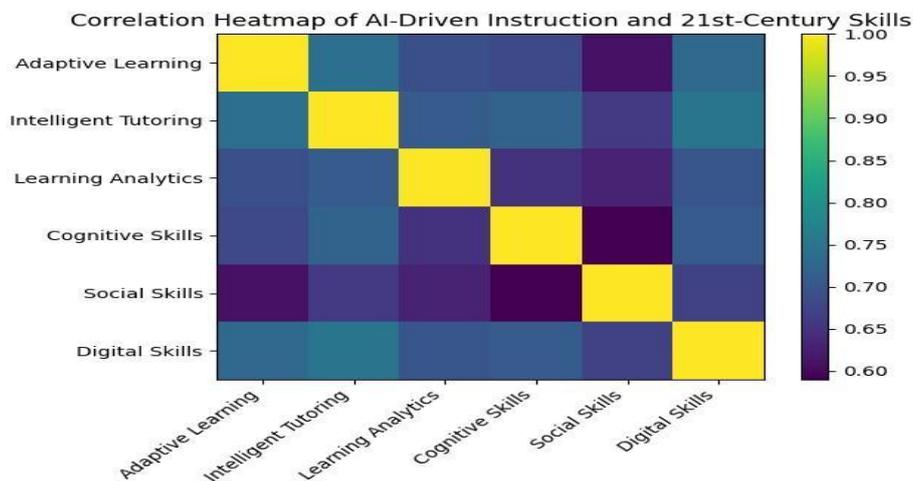


Figure 3: Correlation Matrix of AI-Driven Instruction Dimensions and 21st-Century Skills.

## 5. DISCUSSION

This study set out to examine the relationship between AI-driven instructional practices and the development of 21st-century skills among Emirati students. The results collectively indicate a strong and systematic association between exposure to artificial intelligence-enabled instruction and students' perceived development of cognitive, social, and digital competencies. The convergence of descriptive, correlational, and multivariate findings provides a robust empirical foundation for interpreting the pedagogical implications of AI integration within contemporary educational settings.

The descriptive statistics reported in Table 3 reveal consistently high mean scores across all dimensions of AI-driven instruction and 21st-century skills, with mean values exceeding 4.50 and relatively low dispersion. Such a pattern suggests not only extensive exposure to AI-enabled instructional environments but also a high degree of consensus among participants regarding their instructional value. Importantly, the absence of extreme variance mitigates concerns regarding polarized responses and lends credibility to the observed agreement levels. The prominence of adaptive learning systems and digital skills in the descriptive results underscores the centrality of personalization and technological fluency in AI-mediated learning contexts, reflecting broader shifts toward learner-centered and data-informed pedagogies.

The correlational analysis (Table 4), complemented by the visual representation in the correlation heatmap (Figure 3), demonstrates strong, positive, and statistically significant relationships between AI-driven instructional components and all 21st-century skill domains. Correlation coefficients ranging from moderate to high (approximately .59–.75) suggest substantive relationships while remaining below thresholds that would indicate conceptual overlap or multicollinearity. Particularly noteworthy are the strong associations between intelligent tutoring and digital skills, as well as between adaptive learning systems and cognitive skills. These findings align with theoretical accounts that position feedback immediacy, personalization, and adaptive scaffolding as key mechanisms through which technology-enhanced instruction supports higher-order cognition and digital competence.

The regression analyses (Tables 5 and 6; Figure 2) further substantiate these relationships by demonstrating the predictive capacity of AI-driven instructional practices. The regression model accounted for a substantial proportion of variance in overall 21st-century skills development ( $R^2 = .67$ ), indicating a

strong explanatory framework. Adaptive learning systems emerged as the most influential predictor, followed by intelligent tutoring and feedback, particularly with respect to cognitive and digital skill outcomes. This hierarchical pattern suggests that instructional personalization and responsive feedback function as primary drivers of skill development, whereas learning analytics operates as a complementary mechanism that enhances learners' self-awareness and regulatory capacities.

The comparatively smaller, yet statistically significant, contribution of learning analytics warrants careful interpretation. Rather than directly cultivating skills, learning analytics appears to exert its influence indirectly by informing instructional adaptation and supporting metacognitive awareness. This finding is consistent with contemporary conceptualizations of learning analytics as an enabling infrastructure that amplifies the effectiveness of adaptive and tutoring systems, rather than as an autonomous pedagogical agent.

From a contextual perspective, the findings carry relevance for the Emirati educational system, which has placed strategic emphasis on digital transformation, innovation, and future-oriented skill development. The strong alignment between AI-driven instructional practices and 21st-century skill outcomes observed in this study provides empirical support for national educational initiatives aimed at integrating advanced technologies into teaching and learning. Moreover, the consistency of responses across a relatively large and diverse sample suggests that AI-enabled instruction is increasingly normalized within the educational experiences of Emirati students.

Notwithstanding these contributions, the findings should be interpreted within the constraints of the study design. The reliance on self-reported measures introduces the possibility of perceptual bias, and the cross-sectional nature of the data limits causal inference. Although the strength and coherence of the statistical relationships lend support to the proposed associations, longitudinal and experimental research designs would be necessary to establish causal pathways and to examine the long-term impact of AI-driven instruction on skill development. Future research may also benefit from incorporating objective performance indicators and mixed-methods approaches to capture the nuanced dynamics of AI-mediated learning environments.

In conclusion, the present study advances scholarly understanding of AI-driven instruction by demonstrating its strong association with multidimensional 21st-century skill development. Through rigorous statistical analysis and theoretically informed interpretation, the findings

underscore the pedagogical potential of artificial intelligence as a transformative force in contemporary education, particularly within rapidly evolving educational systems such as that of the United Arab Emirates.

## 6. CONCLUSION AND POLICY IMPLICATIONS

### 6.1. Conclusion

This study provides rigorous empirical evidence that AI-driven instructional practices are significantly associated with the development of 21st-century competencies among Emirati students. Across cognitive, social, and digital domains, participants reported exceptionally high levels of perceived skill acquisition, with 90–95% of respondents indicating strong agreement regarding both exposure to AI-mediated instruction and its efficacy in fostering skills. Descriptive, correlational, and regression analyses consistently demonstrated that adaptive learning systems and intelligent tutoring constitute the most salient drivers of skill development, accounting for the majority of variance in cognitive and digital outcomes. Learning analytics, while contributing comparatively less to direct skill acquisition, emerged as a critical mechanism for supporting self-regulatory behavior, metacognition, and evidence-informed learning interventions.

Collectively, these findings underscore the pedagogical centrality of AI-enabled instruction. Rather than serving as peripheral technological adjuncts, AI systems operate as structured, interactive, and adaptive mechanisms that scaffold higher-order cognitive processes, collaborative engagement, and technological fluency. The observed patterns align with international frameworks, including the Partnership for 21st Century Learning (P21) and OECD competency models, reinforcing the applicability of AI-driven pedagogies in cultivating globally recognized skill sets necessary for knowledge economies.

### 6.2. Policy Implications and Recommendations

The findings carry significant implications for educational policy, curriculum design, and institutional practice, particularly within contexts seeking to leverage AI for sustainable skill development:

### 6.3. Strategic Curriculum Integration of AI Technologies

Policymakers should position AI-enabled instructional tools as core components of curriculum

design rather than supplementary technologies. Adaptive learning platforms, intelligent tutoring systems, and analytics-driven feedback should be systematically embedded to optimize cognitive engagement, collaborative learning, and digital competency development.

### 6.4. Targeted Teacher Professional Development

Effective AI integration requires that educators possess both technological fluency and pedagogical expertise. Professional development initiatives should emphasize data-informed instruction, the interpretation of learning analytics, and strategies for scaffolding critical thinking, problem-solving, and collaborative skills within AI-mediated environments.

### 6.5. Equitable Access and Infrastructure Investment

To mitigate potential disparities in skill development, educational systems must ensure equitable access to AI-driven tools. Investment in digital infrastructure, hardware, and software is essential to support inclusivity and avoid the entrenchment of digital divides, particularly in diverse socio-demographic contexts.

### 6.6. Evidence-Based Implementation and Continuous Monitoring

The deployment of AI technologies should be guided by systematic evaluation protocols. Learning analytics can be leveraged to monitor learner progress, identify skill gaps, and inform iterative refinements in instructional design, thereby enhancing both efficiency and effectiveness of AI-mediated learning.

### 6.7. Alignment with International Competency Frameworks

AI-driven instructional initiatives should be explicitly mapped to established 21st-century skill frameworks to ensure coherence between technological adoption and broader educational objectives. Such alignment facilitates the development of competencies that are globally recognized, transferable, and relevant to emergent labor market demands.

### 6.8. Concluding Remarks

In conclusion, this study substantiates the pivotal role of AI-driven instruction in fostering multidimensional 21st-century competencies within the Emirati educational context. By strategically integrating AI into curricula, cultivating teacher

capacity, ensuring equitable access, and implementing robust monitoring systems, policymakers and educational leaders can harness AI as a transformative mechanism for skill development. Future research should seek to establish causal pathways through longitudinal or experimental designs, explore the interplay between AI-driven instruction and contextual pedagogical factors, and investigate scalable models for sustainable implementation across diverse educational settings.

## 7. LIMITATIONS AND FUTURE RESEARCH

### 7.1. Methodological and Contextual Constraints

This study is subject to several limitations. The cross-sectional design limits causal interpretation of the observed relationships between AI-driven instructional practices and 21st-century skill development. Although strong associations were identified, longitudinal or experimental designs are necessary to establish causal effects. In addition, reliance on self-reported data may have introduced response bias, particularly given the consistently high agreement levels across all measures. The findings therefore reflect students' perceptions rather

than objectively measured skill acquisition.

The study sample was confined to Emirati students within a specific educational context, which may restrict the generalizability of the results. Contextual factors, including national digital education initiatives and institutional technology integration, may have influenced both the implementation of AI-driven instruction and students' responses. Furthermore, the study did not distinguish between specific AI tools or instructional designs, potentially obscuring variation in the effectiveness of different AI applications.

### 7.2. Directions for Subsequent Studies

Future research should employ longitudinal and experimental designs to examine the long-term and causal effects of AI-driven instruction on 21st-century skills. The inclusion of objective, performance-based measures alongside self-report instruments is recommended to strengthen validity. Mixed-methods approaches may also provide deeper insights into students' interactions with AI systems and the mechanisms underlying skill development. Finally, comparative and cross-cultural studies are needed to assess the transferability of these findings across diverse educational contexts.

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