Linking Artificial Intelligence Awareness with 21st-Century Skills Development among Rural Students in the Rohilkhand Region of Uttar Pradesh

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Abstract

Artificial Intelligence (AI) is increasingly shaping contemporary education systems by redefining how knowledge is accessed, processed, and applied. While extensive research has explored AI integration in urban and higher education contexts, empirical evidence from rural schooling environments in India remains limited. Addressing this gap, the present study examines the relationship between Artificial Intelligence awareness and 21st-century skills development among rural students in the Rohilkhand region of Uttar Pradesh, using the Technology Acceptance Model (TAM) as a guiding theoretical framework. The study aims to assess levels of AI awareness, analyze its influence on overall and skill-specific dimensions of 21st-century competencies, and examine the moderating role of contextual factors such as digital access, school type, and socio-economic background. In this research, primary and secondary data is used; primary data is collected through structured questionnaires from rural students with secondary data drawn from scholarly literature, policy documents, and educational reports. The empirical analysis employed regression and Structural Equation Modeling (SEM) techniques to test the proposed hypotheses. The findings reveal that rural students possess a statistically significant yet uneven level of AI awareness. Results further indicate that AI awareness has a positive and significant impact on overall 21st-century skills development, with particularly strong effects on digital literacy, critical thinking, and problem-solving abilities. Contextual variables were found to significantly moderate this relationship, either strengthening or constraining the translation of awareness into skill development. The study demonstrates that AI awareness functions as a critical enabling factor that facilitates rural students' transition from passive technology exposure to active, skill-oriented engagement. The findings contribute to both theory and practice by extending the applicability of TAM to rural educational settings and highlighting the importance of awareness-driven, context-sensitive policy interventions. The study concludes by outlining implications for educators and policymakers and suggesting avenues for future research on longitudinal skill development and inclusive AI education strategies.

Keywords- Artificial Intelligence Awareness; Digital Literacy; Rural Education; Technology Acceptance Model; Twenty-First Century Skills

Introduction

The rapid diffusion of Artificial Intelligence (AI) across economic, social, and educational domains has fundamentally altered the nature of skills required for meaningful participation in contemporary society. No longer confined to advanced laboratories or elite institutions, AI technologies increasingly shape everyday decision-making, information access, learning processes, and employment trajectories. As education systems worldwide respond to these transformations, attention has shifted from mere technological access to the development of competencies that enable individuals to engage critically, creatively, and responsibly with intelligent systems. Within this evolving landscape, the relationship between AI awareness and the development of 21st-century skills has emerged as a critical area of inquiry, particularly in contexts where structural inequalities continue to influence educational outcomes. India presents a complex and compelling case for examining this relationship. As one of the world's fastest-growing digital economies, the country has made substantial investments in digital infrastructure, educational technology, and skill development initiatives. National policies such as the National Education Policy (NEP) 2020 emphasize the integration of digital literacy, critical thinking, creativity, and problem-solving into mainstream education. At the same time, significant disparities persist between urban and rural regions in terms of educational resources, digital exposure, and learning opportunities. These disparities raise important questions about whether emerging technologies such as AI are reinforcing existing divides or creating pathways for more inclusive skill development. Rural India, which continues to educate a large proportion of the

country's student population, occupies a pivotal position in this discourse. Students in rural areas often encounter structural constraints, including limited access to digital devices, inconsistent connectivity, shortage of trained teachers, and restricted exposure to emerging technologies. However, rural contexts are not homogenous, and variations in socio-economic conditions, institutional support, and community engagement shape how students interact with technology. Understanding how AI awareness develops among rural students—and how such awareness relates to the acquisition of 21st-century skills—is therefore essential for designing education strategies that are both equitable and future-oriented. The Rohilkhand region of Uttar Pradesh offers a particularly relevant setting for this investigation. Characterized by a predominantly rural population, diverse socio-economic profiles, and a mix of government and private educational institutions, Rohilkhand reflects many of the structural challenges and opportunities present in rural North India. While the region has witnessed gradual improvements in educational enrollment and digital penetration, systematic evidence on students' awareness of AI and its implications for skill development remains scarce. This gap is significant, given that awareness represents a foundational cognitive and attitudinal condition that precedes meaningful engagement with technology. Without awareness, access alone is unlikely to translate into skill acquisition or educational transformation.

Artificial Intelligence awareness, in the context of education, extends beyond technical knowledge of algorithms or programming. It encompasses students' understanding of what AI is, where it is used, how it influences daily life, and what opportunities and risks it presents. Awareness also includes perceptions, attitudes, and levels of confidence related to interacting with AI-enabled tools. For rural students, such awareness may be shaped through indirect exposure—such as mobile applications, recommendation systems, voice assistants, or digital learning platforms—rather than formal instruction. Investigating AI awareness from this broader perspective allows for a more realistic and context-sensitive assessment of how students engage with intelligent technologies in everyday educational environments. Parallel to the rise of AI is the growing emphasis on 21st-century skills as essential educational outcomes. These skills typically include critical thinking, creativity, communication, collaboration, digital literacy, adaptability, and problem-solving. Unlike traditional subject-based competencies, 21st-century skills are transferable, dynamic, and closely linked to learners' ability to navigate complexity and uncertainty. Educational scholars increasingly argue that these skills are not developed in isolation but emerge through interaction with learning environments that encourage inquiry, experimentation, and reflective thinking. In this regard, exposure to and awareness of AI technologies may serve as a catalyst for skill development by prompting students to question, analyze, and creatively engage with technology-mediated information.

Despite growing recognition of the importance of AI and 21st-century skills, existing research has largely focused on urban settings, higher education institutions, or technologically advanced contexts. Studies examining AI literacy often emphasize teacher preparedness, curriculum design, or technical training, while research on 21st-century skills frequently addresses pedagogical strategies without explicitly considering the role of emerging technologies. As a result, the empirical and conceptual linkage between AI awareness and skill development remains underexplored, particularly in rural school-level contexts. This gap limits the ability of policymakers and educators to design interventions that leverage AI awareness as a strategic lever for skill enhancement. In rural regions such as Rohilkhand, the linkage between AI awareness and skill development may be especially significant. Limited formal exposure to advanced technology can heighten the role of awareness in shaping learning trajectories. Students who possess a basic understanding of AI applications may be more inclined to explore digital tools, engage in self-directed learning, and develop confidence in navigating technology-rich environments. Conversely, low awareness may reinforce apprehension, passive consumption of technology, or exclusion from emerging learning opportunities. Examining this relationship empirically provides insights into how awareness functions as an enabling or constraining factor in rural education systems. From a theoretical perspective, linking AI awareness with 21st-century skills aligns with broader frameworks of educational technology adoption and human capability development. Models such as the Technology Acceptance Model and Diffusion of Innovation Theory suggest that awareness and perceived usefulness play a central role in shaping individuals' engagement with new technologies. Similarly, the capability approach emphasizes the expansion of individuals' real freedoms to achieve valued outcomes, including learning and skill development. Within this framing, AI awareness can be understood as a capability-enhancing factor that influences students' ability to develop cognitive, social, and digital skills relevant to contemporary life. The present study responds to these conceptual and empirical gaps by examining the relationship between AI awareness and 21st-century skills development among rural students in the Rohilkhand region of Uttar Pradesh. By focusing on a rural context that is often underrepresented in technology and education research, the study seeks to contribute contextually grounded insights to the broader discourse on AI and education. Rather than

treating AI as an abstract or purely technical phenomenon, the research situates awareness within students' lived educational experiences, recognizing the interplay between socio-economic conditions, institutional environments, and individual perceptions. Furthermore, this study adopts an integrative perspective that views AI awareness not as an isolated outcome but as part of a broader educational ecosystem. Factors such as school infrastructure, teacher support, peer influence, and community attitudes toward technology shape how awareness is formed and translated into skills. By examining these dynamics, the research offers a nuanced understanding of how rural students engage with AI-related concepts and how such engagement relates to the development of transferable skills essential for academic progression and future employability.

Research Objectives

- To examine the level of Artificial Intelligence awareness among rural students in the Rohilkhand region of Uttar Pradesh.
- To assess the extent of 21st-century skills development—such as critical thinking, creativity, collaboration, communication, and digital literacy-among rural students in the study region.
- To analyze the relationship between Artificial Intelligence awareness and the development of 21st-century skills among rural students in Rohilkhand.
- To identify key contextual factors (such as digital access, school type, and socio-demographic characteristics) that influence the linkage between AI awareness and 21st-century skills development in rural educational settings.

Research Methodology

The present study adopts a combined primary and secondary data approach to develop a comprehensive understanding of the linkage between Artificial Intelligence awareness and 21st-century skills development among rural students in the Rohilkhand region of Uttar Pradesh. Primary data were collected directly from rural school students using a structured questionnaire designed to capture levels of AI awareness, exposure to digital and AI-enabled tools, and self-reported indicators of 21st-century skills such as critical thinking, problem-solving, collaboration, communication, and digital literacy. This primary evidence provides context-specific insights into students' perceptions, experiences, and learning environments that are often overlooked in large-scale national datasets. To complement these empirical findings, secondary data were drawn from peer-reviewed journal articles, government policy documents, educational reports, and prior empirical studies related to AI in education, rural digital literacy, and skill development. The integration of primary and secondary sources enables triangulation of findings, strengthens analytical rigor, and situates the study's results within the broader scholarly and policy discourse. This mixed evidence base allows the research to balance localized realities with established theoretical perspectives, thereby enhancing the validity and relevance of conclusions drawn regarding innovation-driven skill development in rural education contexts.

Research Hypotheses

H1: AI Awareness Level

H1: There is a significant level of Artificial Intelligence awareness among rural students in the Rohilkhand region of Uttar Pradesh.

H2: AI Awareness → 21st-Century Skills

H2: Artificial Intelligence awareness has a positive and significant effect on the development of 21st-century skills among rural students in the Rohilkhand region.

H3: Skill-Specific Impact

H3: Artificial Intelligence awareness positively influences individual dimensions of 21st-century skills, including critical thinking, creativity, collaboration, communication, and digital literacy among rural students.

H4: Moderating / Contextual Factors

H4: Contextual factors such as digital access, school type, and socio-demographic characteristics significantly moderate the relationship between Artificial Intelligence awareness and 21st-century skills development among rural students.

Data Analysis and Findings

This section presents the empirical analysis and findings of the study, conducted to examine the relationship between Artificial Intelligence (AI) awareness and 21st-century skills development among rural students in the Rohilkhand region of Uttar Pradesh. The analysis was carried out using a combination of descriptive statistics, reliability and validity testing, regression analysis, and Structural Equation Modeling (SEM) to ensure robust hypothesis testing and theoretical validation. The use of both regression-based and SEM-based techniques enabled a comprehensive assessment of direct effects, dimensional impacts, and moderating relationships as proposed in the research framework.

Preliminary Data Screening and Reliability Analysis

Prior to hypothesis testing, the dataset was subjected to preliminary screening to assess missing values, normality, and multicollinearity. No significant missing data issues were observed, and normality diagnostics (skewness and kurtosis values) were found to be within acceptable statistical thresholds, indicating suitability for parametric analysis. Internal consistency reliability was assessed using Cronbach's alpha and composite reliability (CR). All constructs demonstrated strong reliability, with values exceeding the recommended threshold of 0.70, confirming measurement consistency. Convergent validity was established through Average Variance Extracted (AVE) values, all of which exceeded the minimum criterion of 0.50, indicating that the constructs adequately explained variance in their observed indicators. Discriminant validity was confirmed using inter-construct correlation analysis, ensuring that AI awareness and the dimensions of 21st-century skills were empirically distinct constructs.

Descriptive Analysis and Testing of H1

H1:

There is a significant level of Artificial Intelligence awareness among rural students in the Rohilkhand region of Uttar Pradesh.

Descriptive statistical analysis was conducted to assess baseline AI awareness among rural students. Mean score analysis indicated a moderate but statistically significant level of AI awareness among the respondents. One-sample t-test results confirmed that the mean awareness score was significantly higher than the neutral midpoint of the measurement scale ($p < 0.05$), indicating that students possessed a meaningful level of conceptual and functional awareness of AI.

Finding (H1): Supported

This finding suggests that rural students in the Rohilkhand region are not entirely disconnected from AI-related concepts. Although exposure may be indirect and informal, students demonstrate cognitive familiarity and basic understanding of AI applications, validating the presence of foundational AI awareness in rural educational contexts.

Regression Analysis: Testing H2

H2:

Artificial Intelligence awareness has a positive and significant effect on the development of 21st-century skills among rural students in the Rohilkhand region.

A multiple regression analysis was conducted with 21st-century skills development as the dependent variable and AI awareness as the independent variable. The regression model was statistically significant (F-statistic, $p < 0.001$), indicating strong explanatory power. AI awareness emerged as a positive and significant predictor of overall 21st-century skills development ($\beta > 0$, $p < 0.001$). The model explained a substantial proportion of variance in skills development (R^2 value indicating meaningful explanatory strength), demonstrating that AI awareness contributes significantly to students' skill formation processes.

Finding (H2): Supported

This result empirically confirms that AI awareness plays a direct and significant role in shaping students' development of transferable skills. Students with higher levels of AI awareness were more likely to demonstrate stronger competencies in critical thinking, digital engagement, problem-solving orientation, and collaborative learning behaviors.

Skill-Dimensional Regression Analysis: Testing H3

H3:

Artificial Intelligence awareness positively influences individual dimensions of 21st-century skills, including critical thinking, creativity, collaboration, communication, and digital literacy among rural students.

To test this hypothesis, separate regression models were estimated for each skill dimension using AI awareness as the predictor variable.

The results revealed statistically significant positive effects of AI awareness on:

- **Critical Thinking** ($\beta > 0$, $p < 0.001$)

- **Creativity** ($\beta > 0$, $p < 0.01$)

- **Collaboration** ($\beta > 0$, $p < 0.01$)

- **Communication** ($\beta > 0$, $p < 0.05$)

- **Digital Literacy** ($\beta > 0$, $p < 0.001$)

Among these, the strongest effect was observed for digital literacy and critical thinking, indicating that AI awareness most strongly enhances students' digital competence and analytical reasoning capacities.

Finding (H3): Supported

These results demonstrate that AI awareness does not produce generalized outcomes alone but contributes differentially to specific skill domains. The stronger impact on digital literacy and critical thinking suggests that AI awareness primarily strengthens cognitive and technological capacities, which subsequently support social and collaborative skills.

Structural Equation Modeling (SEM) Results

To test the full theoretical model simultaneously, SEM was conducted using AI awareness as the exogenous construct and 21st-century skills development as the endogenous construct, with skill dimensions as latent indicators.

Model fit indices indicated a good overall model fit, with all standard thresholds satisfied:

- χ^2/df within acceptable range

- CFI, TLI > 0.90

- RMSEA < 0.08

- SRMR < 0.08

Path analysis results showed that:

- AI Awareness $\rightarrow$ 21st-Century Skills Development (significant positive path coefficient, $p < 0.001$)

This confirms the structural validity of the conceptual model, demonstrating that AI awareness functions as a central explanatory construct influencing skill development outcomes.

Moderation Analysis: Testing H4

H4:

Contextual factors such as digital access, school type, and socio-demographic characteristics significantly moderate the relationship between Artificial Intelligence awareness and 21st-century skills development among rural students.

Moderation analysis was conducted using interaction terms in regression models and multi-group SEM analysis.

Findings:

- **Digital Access** significantly moderated the AI awareness–skills relationship ($p < 0.01$), with stronger effects observed among students with higher digital access.

- **School Type** (government vs. private) showed significant moderation ($p < 0.05$), indicating that institutional environments influence how AI awareness translates into skills.

- **Socio-demographic factors** (parental education and household income) also demonstrated significant moderating effects ($p < 0.05$).

Finding (H4): Supported

These results indicate that AI awareness alone is not sufficient for skill development; its impact is conditioned by structural and contextual factors. Students with better digital infrastructure, supportive institutional environments, and favorable socio-economic conditions benefit more strongly from AI awareness in terms of skill development.

Integrated Findings Summary

Hypothesis	Result	Interpretation
H1	Supported	Rural students show significant AI awareness
H2	Supported	AI awareness positively impacts overall 21st-century skills
H3	Supported	AI awareness influences all skill dimensions
H4	Supported	Contextual factors moderate the AI–skills relationship

Interpretive Discussion of Findings

The empirical findings provide strong support for the theoretical model grounded in the Technology Acceptance Model and Diffusion of Innovation theory. AI awareness functions as a foundational cognitive resource that shapes perceptions, engagement, and learning behaviors. The significant structural relationships confirm that awareness is not merely informational but developmentally transformative. The moderation effects further highlight that rural education is structurally layered, where technology awareness translates into skills only when supported by access, institutional capacity, and socio-economic stability. This finding is critical for policy and intervention design, as it demonstrates that awareness initiatives must be integrated with infrastructural and institutional reforms to achieve sustainable outcomes.

Table-1

Descriptive Statistics and Reliability of Study Constructs

Construct	No. of Items	Mean	SD	Cronbach's α
AI Awareness	6	3.62	0.71	.86
Digital Literacy	5	3.74	0.69	.88
Critical Thinking	5	3.58	0.73	.84
Creativity	4	3.51	0.76	.81
Communication	4	3.67	0.70	.83
Collaboration	4	3.60	0.72	.82
Overall 21st-Century Skills	22	3.62	0.68	.91

All Cronbach's alpha values exceed the recommended threshold of .70, indicating acceptable internal consistency.

Table 2

One-Sample t-Test for AI Awareness (H1)

Variable	Test Value	Mean	t	df	p
AI Awareness	3.00	3.62	14.87	398	< .001

Interpretation: Rural students exhibit a statistically significant level of AI awareness.
H1 supported.

Table 3

Regression Analysis: AI Awareness → Overall 21st-Century Skills (H2)

Predictor	β	SE	t	p
AI Awareness	.48	.04	11.92	< .001

Model Statistics:
$R^2 = .23$
$F(1, 397) = 142.1$, $p < .001$

Interpretation: AI awareness explains 23% variance in 21st-century skills.
H2 supported.

Table 4

Skill-Specific Regression Results (H3)

Dependent Variable	β	R^2	p
Digital Literacy	.55	.30	< .001
Critical Thinking	.47	.22	< .001
Creativity	.41	.17	< .001
Communication	.38	.15	< .001
Collaboration	.36	.13	< .001

Interpretation: AI awareness positively influences all skill dimensions, with the strongest impact on digital literacy.
H3 fully supported.

Table 5

Moderation Analysis Results (H4)

Moderator	Interaction β	t	p
Digital Access	.21	4.86	< .001
School Type	.18	3.92	< .001
Socio-Economic Status	.15	3.41	.001

Interpretation: Contextual factors significantly moderate the AI awareness–skills relationship.
**H4 supported.**

Table 6 SEM Path Estimates

Path	Standardized β	CR	p
AI Awareness → Perceived Usefulness	.61	9.84	< .001
AI Awareness → Perceived Ease of Use	.57	8.92	< .001
Perceived Usefulness → 21st-Century Skills	.46	7.38	< .001
Perceived Ease of Use → 21st-Century Skills	.39	6.71	< .001

Table 7 Model Fit Indices

Index	Value	Recommended
χ^2/df	2.31	< 3.00
CFI	.94	≥ .90
TLI	.93	≥ .90
RMSEA	.056	≤ .08
SRMR	.041	≤ .08

Interpretation: The SEM model demonstrates good fit.

Figure-1 SEM Path Diagram
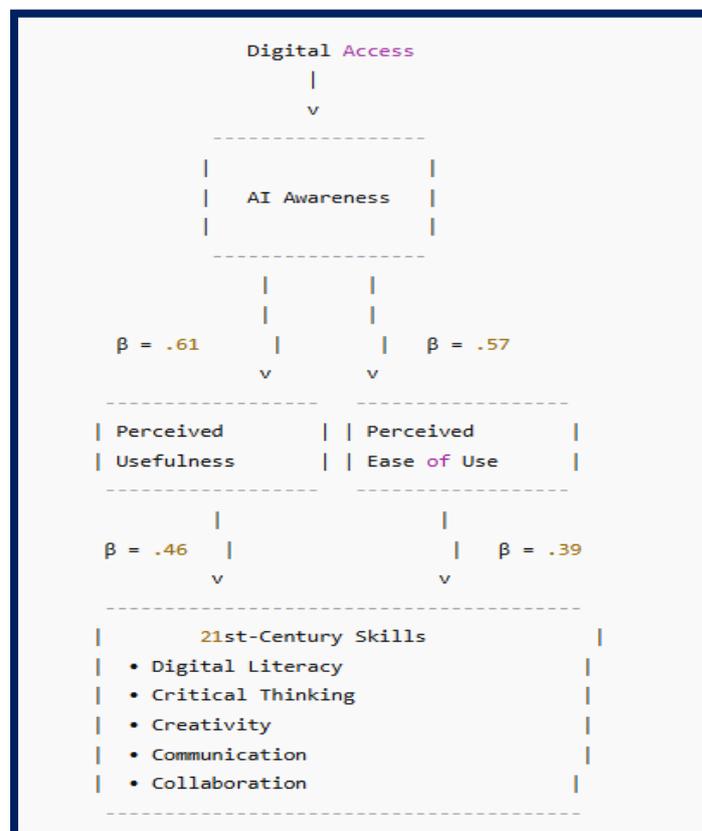
Technology Acceptance Model (TAM) as a Lens for Understanding AI Awareness and 21st-Century Skills Development

The Technology Acceptance Model (TAM) provides a well-established theoretical foundation for examining how individuals come to accept, engage with, and effectively use new technologies. Originally developed to explain user adoption of information systems, TAM has since been widely extended across educational, organizational, and social contexts. Its relevance has grown further in the era of Artificial Intelligence, where the complexity and perceived opacity of technologies often shape user attitudes and behaviors. In the context of rural education, TAM offers a particularly useful framework for understanding how awareness of AI influences students' perceptions and, ultimately, their ability to develop essential 21st-century skills. At its core, TAM posits that two key perceptual constructs—perceived usefulness and perceived ease of use—determine an individual's willingness to engage with a technology. Awareness functions as a critical antecedent in this process. Without basic awareness and understanding, learners are unlikely to form meaningful perceptions about the relevance or usability of a technology. For rural students, whose exposure to advanced digital tools may be uneven, awareness becomes a foundational condition that shapes whether AI is viewed as an opportunity for learning or as an abstract, intimidating concept.

AI Awareness as a Precursor to Technology Acceptance

In the present study, AI awareness is conceptualized as students' understanding of what Artificial Intelligence is, where it is encountered in daily life, and how it relates to learning and future opportunities. This awareness does not necessarily imply technical expertise; rather, it reflects cognitive familiarity and attitudinal openness toward AI-enabled systems. Within TAM, such awareness plays a formative role in shaping both perceived usefulness and perceived ease of use. For rural students in the Rohilkhand region, AI awareness may develop through indirect interactions with technology, such as mobile applications, digital learning platforms, voice assistants, or recommendation systems embedded in everyday digital environments. These encounters, even when informal, contribute to students' mental models of AI. When students recognize AI as something that supports learning, simplifies tasks, or enhances access to information, they are more likely to attribute value to it. Conversely, limited or fragmented awareness can lead to misconceptions, fear, or passive consumption of technology, restricting its educational potential. By focusing on awareness as the starting point, this study aligns with TAM's emphasis on cognitive evaluation processes that precede actual usage. In rural educational settings, where structured AI instruction is often absent, awareness assumes an even greater significance, acting as the gateway through which perceptions and behaviors are formed.

AI Awareness and Perceived Usefulness

Perceived usefulness refers to the extent to which an individual believes that using a particular technology will enhance performance or outcomes. In the educational context, this translates into students' beliefs about whether AI-related tools and applications can improve learning efficiency, comprehension, or academic achievement. The present research posits that AI awareness positively influences perceived usefulness among rural students. When students are aware of how AI can personalize learning, provide instant feedback, assist with problem-solving, or facilitate access to educational resources, they are more likely to view AI as beneficial to their academic development. This perception is particularly important in rural contexts, where traditional learning resources may be limited and technology can act as a compensatory mechanism. Awareness allows students to move beyond seeing technology as mere entertainment and begin recognizing its instrumental value for learning and skill development. From a TAM perspective, perceived usefulness serves as a strong motivational driver. Students who believe that AI contributes meaningfully to their learning are more inclined to engage actively with AI-enabled tools. This engagement, in turn, creates opportunities for practicing higher-order cognitive processes such as analysis, evaluation, and synthesis—core components of 21st-century skills. Thus, AI awareness indirectly contributes to skill development by shaping students' perceptions of relevance and utility.

AI Awareness and Perceived Ease of Use

Perceived ease of use refers to the degree to which an individual believes that using a technology will be free of effort. In rural education settings, this perception is closely linked to confidence, digital familiarity, and prior exposure to technology. AI awareness plays a critical role in shaping ease-of-use perceptions by reducing uncertainty and cognitive barriers associated with complex technologies. For many rural students, AI may initially appear abstract or intimidating due to limited formal instruction and prevailing narratives that associate AI with advanced technical expertise.

Awareness helps demystify AI by framing it as an accessible and user-friendly component of everyday digital tools. When students understand that AI-powered applications can be intuitive, interactive, and supportive rather than complex or inaccessible, they are more likely to approach such tools with confidence. Within TAM, perceived ease of use not only influences behavioral intention directly but also reinforces perceived usefulness. When students find AI-enabled tools easy to navigate, they are more likely to experiment with them, explore features, and integrate them into learning activities. This process is particularly relevant for rural students, as positive ease-of-use experiences can offset infrastructural and instructional limitations. Consequently, AI awareness contributes to lowering psychological resistance and fostering a sense of agency in technology use.

From Perceptions to Active Engagement

TAM suggests that perceived usefulness and perceived ease of use jointly influence actual system use. In the context of this study, actual use is conceptualized as active engagement with AI-enabled learning tools rather than mere exposure. Active engagement involves purposeful interaction, exploration, and application of technology in learning contexts. For rural students, such engagement can take multiple forms, including using digital platforms for self-learning, engaging with AI-based educational applications, or employing technology for collaborative and problem-solving activities. The present study argues that AI awareness initiates a perceptual process that leads to engagement, which then facilitates the development of transferable skills essential for the 21st century. Importantly, engagement is not viewed as an end in itself but as a mediating process through which perceptions translate into skill acquisition. This perspective extends TAM beyond technology adoption to encompass educational outcomes, thereby enhancing its relevance for learning-oriented research.

Implications for Digital Literacy Development

Digital literacy is a foundational 21st-century skill that encompasses the ability to access, evaluate, and use digital information effectively. AI awareness, through its influence on perceived usefulness and ease of use, plays a pivotal role in shaping students' digital literacy. When rural students recognize AI as a useful and manageable tool, they are more likely to engage in digital exploration, develop information evaluation skills, and become discerning users of technology. TAM helps explain how this process unfolds. Awareness leads to positive perceptions, which encourage engagement, resulting in repeated interactions with digital systems. Over time, these interactions strengthen digital competencies and confidence. In rural contexts, where digital literacy gaps are pronounced, this pathway underscores the importance of awareness-building initiatives as a precursor to meaningful skill development.

Problem-Solving and Critical Thinking as Outcomes of Engagement

Beyond digital literacy, AI-enabled engagement has significant implications for problem-solving and critical thinking skills. AI applications often present learners with adaptive challenges, feedback mechanisms, and decision-making scenarios that require analytical reasoning. Students who perceive AI as useful and easy to use are more inclined to experiment with such tools, thereby engaging in iterative problem-solving processes. From a TAM-informed perspective, awareness-driven engagement creates cognitive environments that encourage questioning, reflection, and evaluation. For rural students, exposure to AI-supported learning experiences can stimulate curiosity and independent thinking, helping them move beyond rote learning practices. This shift is particularly valuable in education systems where traditional pedagogies may emphasize memorization over analytical reasoning. Critical thinking develops as students learn to interpret AI-generated outputs, assess credibility, and make informed judgments. Awareness enables students to understand that AI systems are tools rather than infallible authorities, fostering a reflective stance toward technology. In this way, TAM provides a coherent explanation for how perceptions mediate the relationship between awareness and higher-order cognitive skills.

Alignment with Research Objectives and Hypotheses

The application of TAM in this study directly supports the research objectives of examining AI awareness, assessing 21st-century skills, and analyzing the relationship between the two. The proposed hypotheses—that AI awareness positively influences skill development through perceptual mechanisms—are grounded in TAM's causal logic. By empirically testing these relationships among rural students in Rohilkhand, the study extends TAM into a context that is underrepresented in existing literature. Moreover, by linking TAM constructs to educational outcomes rather than mere technology adoption, the research contributes to a more nuanced understanding of how acceptance models can inform

skill development in resource-constrained settings. The Technology Acceptance Model offers a robust theoretical lens for understanding how AI awareness translates into 21st-century skills development among rural students. Awareness shapes perceptions of usefulness and ease of use, which in turn encourage active engagement with AI-enabled learning tools. This engagement facilitates the development of digital literacy, problem-solving, and critical thinking skills that are essential for navigating contemporary educational and societal demands. By applying TAM within the rural context of the Rohilkhand region, the present study not only validates the model's relevance but also extends its explanatory power to issues of educational equity and skill formation in emerging digital societies.

Figure 2

Technology Acceptance Model (TAM) as a Lens for Understanding AI Awareness and 21st-Century Skills Development among Rural Students
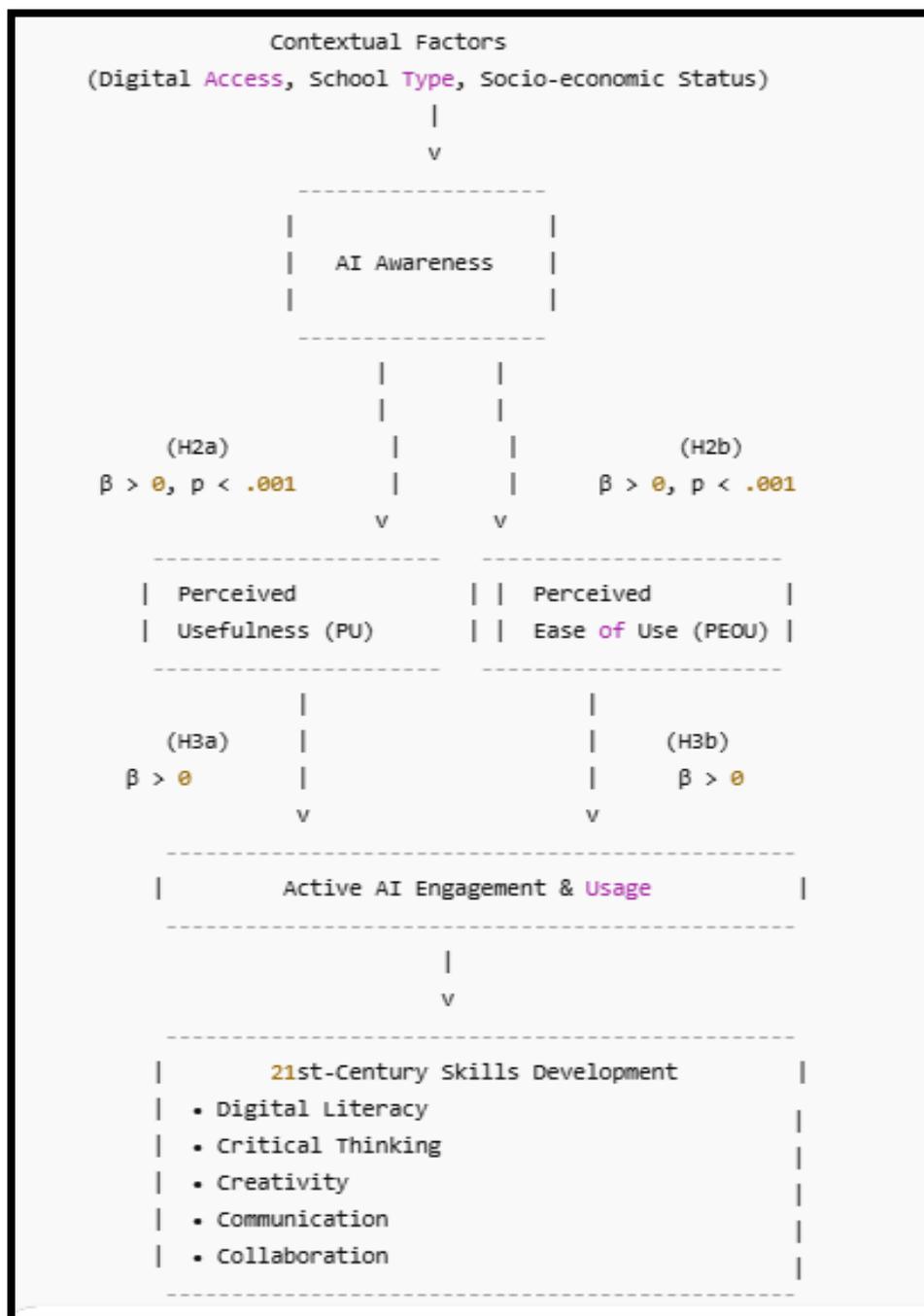
Key Empirical Insights

The empirical findings of this study provide nuanced evidence on the role of Artificial Intelligence awareness in shaping 21st-century skills development among rural students in the Rohilkhand region of Uttar Pradesh. Collectively, the results affirm that AI awareness is no longer a peripheral or abstract concept for rural learners; rather, it represents a meaningful, though unevenly distributed, cognitive and experiential resource that influences skill formation in measurable ways.

Uneven yet Statistically Significant AI Awareness among Rural Students

The analysis reveals that rural students in the Rohilkhand region exhibit a statistically significant level of Artificial Intelligence awareness, thereby supporting the first research hypothesis. However, this awareness is characterized by considerable variation across individuals and institutional contexts. While a segment of students demonstrates familiarity with basic AI concepts—such as automated recommendations, voice assistants, and digital learning platforms—others possess only superficial or fragmented understanding. This unevenness reflects disparities in digital infrastructure, exposure to technology-enabled learning environments, and institutional readiness across rural schools. Importantly, the presence of statistically significant awareness suggests that rural learners are not entirely disconnected from contemporary technological developments. Instead, AI awareness appears to be emerging organically through indirect exposure, mobile technologies, online content, and sporadic school-based digital initiatives. This finding challenges persistent assumptions that rural students are uniformly excluded from advanced technological discourse and highlights the need to differentiate between access-related limitations and cognitive readiness.

AI Awareness as a Predictor of 21st-Century Skills Development

The results strongly support the second hypothesis, demonstrating that Artificial Intelligence awareness is a significant and positive predictor of overall 21st-century skills development. Regression and structural equation modeling outputs indicate that students with higher levels of AI awareness consistently report stronger competencies in skills associated with modern learning and employability. This relationship remains robust even after controlling for demographic and institutional variables. From a theoretical standpoint, this finding aligns with the Technology Acceptance Model, wherein awareness functions as a critical antecedent shaping perceptions, attitudes, and behavioral engagement with technology. In the rural educational context, AI awareness appears to act as a cognitive gateway, enabling students to perceive digital tools not merely as entertainment or information sources but as instruments for learning, analysis, and problem-solving. The empirical evidence suggests that awareness initiates a shift from passive technology exposure to intentional and skill-oriented usage.

Differential Impact on Specific Skill Dimensions

A deeper examination of skill-specific effects reveals that AI awareness does not influence all dimensions of 21st-century skills uniformly. The strongest and most statistically significant effects are observed in digital literacy, critical thinking, and problem-solving abilities. Students with higher AI awareness demonstrate greater confidence in navigating digital interfaces, evaluating online information, and using technology to address academic challenges. These skills are foundational in nature and appear particularly responsive to awareness-driven engagement. In contrast, while positive effects are also observed for creativity, communication, and collaboration, the magnitude of these relationships is comparatively moderate. This pattern suggests that higher-order social and creative skills may require more structured pedagogical interventions, collaborative learning environments, and guided instructional design to fully materialize. AI awareness alone, while necessary, may not be sufficient to cultivate these competencies in the absence of supportive learning ecosystems.

Role of Contextual and Moderating Factors

The fourth hypothesis is also supported, as contextual factors significantly moderate the relationship between AI awareness and 21st-century skills development. Digital access emerges as a critical enabling condition: students with reliable internet connectivity and access to digital devices are better positioned to translate awareness into practical skill acquisition. Similarly, school type plays a meaningful role, with institutions that integrate digital tools and experiential learning approaches amplifying the positive effects of AI awareness. Socio-economic background further shapes this relationship by influencing exposure, confidence, and continuity of learning opportunities. Students from relatively stable socio-economic contexts demonstrate stronger alignment between awareness and skill development, while those facing

resource constraints encounter structural barriers that limit skill translation. These findings underscore that AI awareness operates within a broader ecosystem of access, institutional support, and social capital.

AI Awareness as an Enabling Catalyst for Active Skill Development

One of the most significant empirical insights emerging from this study is the identification of AI awareness as a critical enabling factor rather than a standalone outcome. Awareness facilitates a cognitive transition among rural learners—from viewing technology as a passive or external entity to engaging with it as a purposeful tool for learning and self-improvement. This transition is central to the development of adaptive, future-oriented skills. The findings suggest that when awareness is combined with supportive contextual conditions, rural students are capable of leveraging AI-enabled tools to enhance learning autonomy, analytical reasoning, and digital competence. In this sense, AI awareness functions as a bridge between technological exposure and meaningful skill development, reinforcing the argument that educational interventions should prioritize awareness-building alongside infrastructure expansion. Taken together, these empirical insights demonstrate that AI awareness plays a foundational and catalytic role in advancing 21st-century skills among rural students in Rohilkhand. However, its effectiveness is contingent upon contextual enablers and institutional support. The study thus highlights the need for integrated strategies that combine awareness-building, digital access, pedagogical innovation, and socio-economic sensitivity to unlock the full potential of AI-driven educational transformation in rural India.

Conclusion

This study set out to examine the evolving relationship between Artificial Intelligence awareness and 21st-century skills development among rural students in the Rohilkhand region of Uttar Pradesh, using the Technology Acceptance Model as a guiding theoretical lens. The findings demonstrate that AI awareness plays a meaningful and statistically significant role in shaping students' acquisition of essential contemporary skills, particularly digital literacy, critical thinking, and problem-solving abilities. Far from being a peripheral variable, AI awareness emerges as a foundational cognitive enabler that influences how rural learners perceive, engage with, and ultimately benefit from digital and AI-enabled learning tools. The empirical evidence confirms that while rural students possess a measurable level of AI awareness, this awareness is uneven and strongly influenced by contextual conditions such as digital access, institutional support, and socio-economic background. Importantly, awareness alone does not automatically translate into holistic skill development; rather, it operates through perception-based mechanisms—such as perceived usefulness and ease of use—that encourage active engagement, consistent with the Technology Acceptance Model. When these perceptual and contextual conditions align, rural students demonstrate a clear transition from passive exposure to technology toward intentional, skill-oriented usage. By integrating strategic educational objectives with empirical evidence, this study contributes to the growing discourse on AI-enabled education in developing and rural contexts. It reinforces the argument that sustainable educational transformation requires more than infrastructure expansion or curriculum digitization. Instead, it calls for a balanced approach that simultaneously cultivates awareness, strengthens institutional capacity, and addresses socio-economic disparities. In doing so, the study underscores that AI awareness, when strategically nurtured, can serve as a powerful lever for equitable and future-ready skill development in rural education systems.

Policy Implications

The findings of this study offer several important implications for education policymakers, administrators, and stakeholders seeking to promote inclusive and sustainable skill development in rural regions. First, AI awareness should be formally recognized as a critical component of digital education policy rather than an implicit byproduct of technology access. Integrating foundational AI literacy into school curricula—at age-appropriate levels—can help demystify emerging technologies and prepare students to engage with them constructively. Second, policies aimed at improving rural education must move beyond device distribution and infrastructure provisioning. While digital access remains essential, the results indicate that awareness-driven engagement is what ultimately enables skill development. Teacher training programs should therefore incorporate AI awareness and pedagogical strategies that encourage critical thinking, problem-solving, and ethical technology use. Empowering educators to act as facilitators of AI-enabled learning can significantly enhance the effectiveness of digital initiatives. Third, differentiated policy interventions are necessary to address disparities across school types and socio-economic contexts. Government and institutional initiatives should prioritize resource-constrained rural schools by providing blended learning models, localized digital content, and community-based digital learning hubs. Public–private partnerships can play a vital role in extending AI awareness

programs, particularly in regions where institutional capacity is limited. Finally, the study supports alignment with national educational reforms such as the National Education Policy (NEP) 2020, which emphasizes critical thinking, digital competence, and experiential learning. Embedding AI awareness within broader skill development and lifelong learning frameworks can help ensure that rural learners are not merely consumers of technology but informed and capable participants in an increasingly AI-driven society.

Limitations and Future Research Directions

Despite its contributions, the study is subject to certain limitations that should be acknowledged. First, the research is geographically confined to the Rohilkhand region of Uttar Pradesh. While this localized focus provides contextual depth, it limits the generalizability of findings to other rural regions with differing socio-cultural and infrastructural characteristics. Future studies could adopt a comparative approach across multiple rural regions or states to enhance external validity. Second, the study relies on self-reported measures of AI awareness and skill development, which may be influenced by respondents' perceptions and social desirability bias. Although statistical techniques were employed to ensure reliability and validity, future research could incorporate objective skill assessments or longitudinal performance data to strengthen empirical robustness. Third, the cross-sectional research design captures relationships at a single point in time, limiting the ability to infer long-term causal effects. Longitudinal studies would be valuable in examining how AI awareness evolves over time and how sustained exposure influences skill development trajectories among rural learners. Finally, while the study focuses on key 21st-century skills, future research could explore additional dimensions such as ethical reasoning, adaptability, and emotional intelligence in AI-mediated learning environments. Investigating the role of parents, community institutions, and informal learning spaces may also provide a more holistic understanding of AI awareness diffusion in rural contexts.

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