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The role of artificial intelligence in enhancing problem-solving skills: The mediating role of adaptive learning environments

Nidal Al Said[1*], Nassereldin Abdel Qadir Osman[2], Tarek Ismail Mohamed[3], Khaleel Al-Said[4]

[1,2,3]*College of Mass Communication, Ajman University, Ajman, UAE.*
[4]*Department of Educational Technology, Faculty of Arts and Educational Sciences, Middle East University, Amman, Jordan.*

Corresponding author: Nidal Al Said (*Email: n.alsaid@ajman.ac.ae*)

Abstract

The expanding implementation of artificial intelligence in education has drastically changed traditional learning methodologies and presented new ways to boost problem-solving skills among students. The present study discerns AI as a contributing factor to problem-solving by assessing the mediating influence of adaptive learning environments. When the system can adjust content depending on a student's abilities and responses, the learning experience is personalized and may have a profound effect on cognitive functioning. The study utilizes a mixed-methods technique to consider how AI-based systems can promote critical thinking and creativity via adaptive challenges while also investigating how this approach is implemented depending on learners' skill levels. The findings propose that AI-facilitated adaptive learning aids the sustained development of pupils' problem-solving aptitudes and ensures that the learning situation remains stimulating and effective. Lastly, this study finds the mediation effect of adaptive learning to be fundamental to maximizing the potential influence of AI innovations and underlines the importance of this type of feedback and interventions. The current paper suggests the transformative nature of AI integration in education and regards adaptive learning environments as vital to enhancing problem-solving skills across various educational settings. Develop and implement AI-powered adaptive learning platforms.

Keywords: Adaptive learning environments, adaptivity, intelligent tutoring systems, personalization, problem-solving skills.

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1. Introduction

In recent years, artificial intelligence (AI) has developed rapidly and raised huge expectations regarding its potential to transform educational contexts by increasing student skill competencies in problem-solving. AI-powered technologies offer several benefits, such as personalized learning paths, adaptive feedback loops, and interactive experiences like simulations that help drive better educational outcomes [1]. Being able to focus on educational experiences that are personalized to meet students' unique learning needs through AI-supported pathways also promotes productive and efficient growth in the development of crucial problem-solving skills aligned with agreed international standards [2]. In adaptive learning environments, the United Nations agency will then present dynamic content and piece together problem levels to serve a wide range of learner needs, which is a significant matter of expertise that matches the abilities or pace of the learner. The personalized nature of these systems has enabled students to strengthen and address areas where they are weak, leading to a better understanding. In practice, AI-supported adaptive learning environments [3] thus offer a central intermediate stage that encourages students to personalize the development of different problem-solving strategies and comprehension paths. This model is all about balancing traditional didactic-style instruction, which can tend toward the "one-size-fits-all" approach, and individualized, student-centered programming where problem-solving is emphasized. However, while the advantages of AI-powered adaptive training are quite evident, transformation is not without challenges [4]. A variety of issues arise from state-sponsored learning, concerns about the extent to which families may be expected by legislation to use technology, difficulties with equitable access, and a lack of parity among educators regarding how they utilize these premium tools [5]. Moreover, the success of AI-enhanced problem-solving abilities could depend on the flexibility of the AI systems used, the types of content for learning, as well as the nature of AI-learner interaction [6]. The study aims to investigate how AI improves problem-solving abilities by examining the role of mediators in adaptive learning environments. The study aims to answer three primary questions:

RQ1: How does AI affect the growth of problem-solving skills?
RQ2: What is the effect of AI-mediated adaptive learning environments on student engagement and cognitive development?
RQ3: What are the challenges and opportunities in providing AI-driven adaptive learning solutions to these educational institutions?

The study uses a multi-method approach that includes an online survey with additional open questions and semi-structured interviews, focusing on students, teachers, and AI specialists to understand how AI technology can contribute to problem-solving capabilities in adaptive learning solutions [7]. Linking those findings is the need for AI to work in concert with adaptive learning pathways that will cultivate learners who are autonomous and can think, innovate, and troubleshoot creatively. This research intends to benefit the educational and policymaking community by understanding how AI can be effectively used as a tool for incubating a new breed of critical-thinking, solutions-focused learners and revolutionizing the way we teach.

2. Literature Review

2.1. Personalization

One of the main things to take note of in the 21st century is the revolution taking place in artificial intelligence (AI) in education. The development and learning resources are tailored precisely where needed by each learner. One of how personalization happens is through AI-driven systems where each student receives content that matches his or her present capacities, learning rate, and learning preference [8]. AI supports problem-solving skills by analyzing learner habits and altering content accordingly to help the learners get more creative when faced with challenging subjects [9]. Evidence has shown that individualized learning paths help improve cognitive development by delivering just-right levels of instruction for students with optimal difficulty, thus maintaining their increased focus and ultimately leading to better results in terms of what is being learned [10].

2.2. Adaptivity

Dynamic adaptivity, where AI-enhanced learning environments adapt content to meet the needs of individual learners. Systems may use data from learners' interactions to sense their needs, identify information gaps, or adapt learning pathways on the fly in real-time to intervene at just the right moment where any struggles lie [11]. Adaptivity: being continuously supported and challenged at points of need supports the development of foundational problem-solving skills by making the most of continuous evaluation and live tuning. AI creates adaptive learning cycles, which accelerate skill-building by ramping up task complexity as the learner masters that field, thereby enhancing problem-solving competencies [12].

2.3. Intelligent Tutoring Systems

Another major application of AI in education is Intelligent Tutoring Systems (ITS), which provide tailored one-on-one tutoring that delivers a similar quality to what a human tutor would give. ITS offers specific feedback prompts and step-by-step solutions that enable students to manage more complex problems [13]. By virtue of a virtual presence resembling a personal tutor, ITS no doubt assists learners in clarifying their problem-solving processes, enhancing critical thinking, and is focused on applications of theoretical knowledge in practical scenarios. The evidence suggests opening up ITS to students in multiple problem-solving domains, especially STEM education, enables learning so long as the tutor tailors to the needs of individuals and with specific scaffolding solutions applied correctly [14].

2.4. Problem-Solving Skills

Problem-solving skills are essential to achieve in education, and it involve the ability to identify issues and analyze and acquire information relevant to solving that problem using systematic methods. AI enhances these skills by using personalized adaptive learning frameworks that guide learners through problem-solving activities within their regions of anticipated ability [15, 16]. Interactive and exploratory, AI-driven systems allow learners to work on open-ended, real-world problems, receive instant feedback, and learn through mistakes. In addition, these systems promote self-learning from student experimentation and the application of different methods to solve the specified problems, which leads to greater confidence in resolving issues and efficiency [17].

2.5. Innovative Learning Systems

AI in adaptive learning environments optimizes and personalizes the experience for each student it interacts with, creating dynamic and responsive educational experiences. It features artificial intelligence algorithms that constantly monitor the student's activity and adjust the instructional materials at a real-time pace to maximize learning [18]. Adaptive learning environments offer individualized support and emotional scaffolding when a learner struggles, resolving any issues during the learning process. The adaptive nature of such environments is especially well-suited for teaching problem-solving skills, as it ensures that students are challenged, guided, and supported at just the right level, allowing them to progress at their own pace [19].

3. Hypothesis Development

Based on the literature reviewed above and the theoretical framework, this section generates hypotheses consistent with the impact of AI on improved problem-solving skills via the mediating role of adaptive learning environments. The following hypotheses are developed relating AI-driven personalization, adaptivity, and intelligent tutoring systems to both problem-solving skills and learner outcomes [20]. This study investigates the impact of AI-mediated adaptive learning environments on problem-solving by contemplating different educational theories, such as Constructivist Learning Theory (CLT), Social Cognitive Theory (SCT), and Self-Regulated Learning (SRL) dimensions [21]. Such theoretical frameworks set the expectation that adaptive AI environments will enhance the strength of learner problem-solving skills by tailoring learning paths to individual needs and promoting participation.

3.1. Customized Help and Problem Solving

With AI, the personalized factor can also be incorporated to provide tech solutions tailored to students' exact learning requirements, speed, and liking. Custom learning environments have shown a good deal of promise, seriously concerned prospective challenges by delivering content that is specific to the learners' requirements [22] and the theory is that when you make use of AI for learning support, this helps students to assume a relevant or personal role when it comes to engaging their learning, leading to better problem-solving; as posited by Self-Regulated Learning Theory. Agreeable with this, we propose:

H_1: AI-driven personalization influence on developing problem-solving mindset among students.

3.2. Adaptation and Student Engagement

AI-powered adaptive learning environments assess how to improve lectures based on the knowledge level of each student and then adapt to best fit every student's intelligence. These systems adapt on the fly to intervene appropriately when our students need help [23]. The adaptive nature of the support it gives is essential not only for keeping students engaged as they explore tough problems but also to coax student effort out over time. We hypothesize that adaptivity in AI-based learning environments supports highly effective problem-solving skills, given the principles of Social Cognitive Theory:

H_2: The effect of AI-driven adaptivity on student engagement is mediated by improved problem-solving skills.

3.3. Intelligent Tutoring Systems and Problem-Solving Skills

Intelligent Tutoring Systems (ITS) leverage AI to provide individualized guidance that simulates one-on-one tutoring. ITS delivers personalized support through hints, feedback, and tailored exercises, which significantly enhance learners' understanding of problem-solving processes [24]. The Technology Acceptance Model suggests that students' perceived usefulness of ITS is a critical factor in the adoption of AI tools in learning. Thus, we propose the following hypothesis:

H3: The use of AI-powered Intelligent Tutoring Systems has a significant positive effect on problem-solving skills development among students.

3.4. Adaptive Learning Environments and Educational Outcomes

The importance of AI-driven adaptive learning environments in offering the level of scaffolding that students need when engaging in complex problem-solving tasks is emphasized. This allows adaptive learning environments to generate an optimal environment for skill development by adjusting the level of difficulty and providing targeted interventions [25]. According to Constructivist Learning Theory, which posits that students learn best in experiences where they only take one small step beyond their existing capabilities, we assume the following:

H_4: Adaptive AI learning environments positively influence the overall educational outcomes of students by enhancing their problem-solving skills.

3.5. Perceived Usefulness and Engagement

Student engagement often depends on the value that learners can attach to the state of AI-based learning environments, through their advantages for personalization and adaptiveness. Student participation is a significant factor in successful learning results and is extremely crucial to the success of problem-solvers. The technology acceptance model posits that positive perceptions of the utility and usefulness of an AI tool will enable higher levels of student interaction and engagement with the learning content [26]. Thus, we propose:

H_5: Positive perceptions of the usefulness of AI-driven learning environments positively influence student engagement, leading to enhanced problem-solving skills.

3.6. Credibility of AI Systems and Learning Effectiveness

The way in which these AI systems are received by students is necessary to evaluate, as this decides the extent of their impact on the learning of the students. Tools that are high in credibility can also be easily accepted, as well as the positive effects on learning outcomes [27]. Social Cognitive Theory informs us that perceptions of the credibility of AI systems are determinants of trust and how much feedback will be used for subsequent problem-solving. Therefore, we propose.

H_6: Higher perceived credibility of AI-based adaptive learning environments positively influences students' development of problem-solving skills.

Consequently, following the framework of Constructivist Learning Theory (CLT), Social Cognitive Theory (SCT), the Technology Acceptance Model (TAM), and results from empirical research, we can hypothesize that an important factor in improving problem-solving skills is the integration of artificial intelligence (AI) into adaptive and personalized learning environments [28]. To extract the maximum potential of AI in enhancing problem-solving capabilities, there is a need to increase the effectiveness and reliability of these learning environments. It is these hypotheses that will serve as the foundation for the experimental investigation, which aims to provide a comprehensive view of the impact AI technologies have on problem-solving skills, as well as academic outcomes within adaptive learning environments [29]. The analysis in this paper will be of significant importance to educators and policymakers who are keen on using AI as a game-changing factor in education, which will help the next generation develop into independent problem solvers with analytical minds.

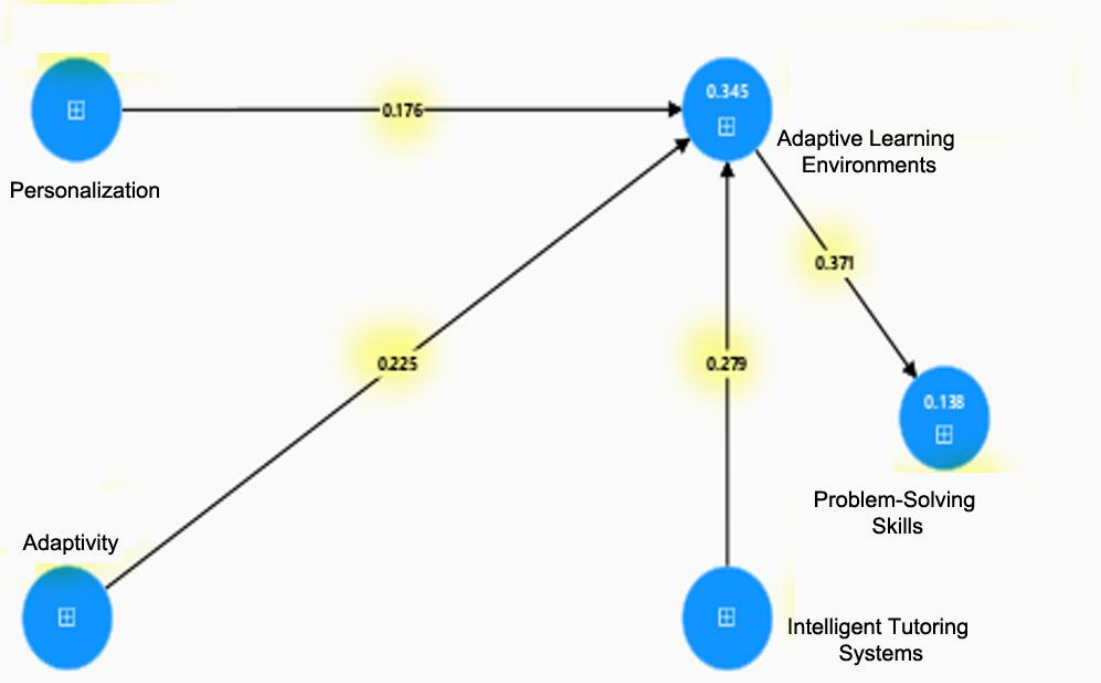

Figure 1.
Conceptual framework

4. Methodology

The study at hand endeavors to utilize a quantitative research design to explore the role of artificial intelligence (AI) in enhancing problem-solving skills and how adaptive learning environments act as mediators. The study aims to determine how certain AI-based technologies impact educational outcomes, particularly in terms of personalization, adaptivity, and intelligent tutoring systems within adaptive learning settings [30]. Data was gathered through a structured questionnaire administered to 250 students and educators from various educational institutions. The survey employed a 5-point Likert scale for responses to (1) the Role of AI in Personalization, (2) the adaptive nature of AI-driven learning environments, and (3) influences on developing problem-solving skills [31]. A stratified random sampling method was used, encompassing students from a diverse set of disciplines and backgrounds to create a sample that would be representative of the wider pool of educational settings.

4.1. Data Collection

Based on the standard questionnaire, data collection was completed, and email and other online platforms were utilized to enable this survey to reach as large a demographic as possible [32]. It was also clearly stated to participants that their involvement in this research was voluntary, and there were no repercussions for answering the questions. Based on this, it becomes possible to include a variety of participants and collect strong data that could reliably represent specific features of AI's impact on problem-solving skills and adaptive learning environments.

4.2. Pretest

Finally, with 20 individuals from the target population, a pretest was carried out before conducting the main study to evaluate the clarity, relevance, and comprehensibility of the electronic questionnaire. Minor adjustments were made to question wording and phrasing as a result of this pretest feedback to ensure the final questionnaire was in a format that would best allow us to collect accurate, meaningful data.

4.3. Pilot Testing

Table 2 shows that a pilot test was done to control the reliability and validity of the research constructs. We obtained 250 responses from a convenience sample of the initial target of 400 participants. Data from the pilot survey was examined for construct reliability and validity using SmartPLS4 software. The scales showed acceptable reliability (with Cronbach's alpha >0.7) as well as many high factor loadings (> 0.70), an indication of internal consistency.

4.4. Data Analysis

Data analysis was performed using the SmartPLS4 application to explore these relationships, especially identifying how AI-driven personalization and adaptivity impact other factors in the development of problem-solving skills through intelligent tutoring systems. Demographics, including age and education level, were summarized in descriptive statistics. The relationships between AI use, adaptive learning environments, and problem-solving skills were examined via structural equation modeling (SEM). The reliability of constructs was assessed using Cronbach's alpha and factor loadings. The study was analyzed to find out what role AIs play in promoting problem-solving skills and encouraging independent learning. These findings were then used to suggest guidelines about how AI tools might be best integrated into educational environments, which aim to develop scalable, adaptive, and personalized learning mechanisms that can embody practices to improve students' problem-solving.

Table 1.
Factor loadings.

Constructs	Items	Factor loadings	Cronbach's Alpha	C.R.	AVE
Collaboration	COL1	0.807	0.91	0.93	0.69
	COL2	0.849			
	COL3	0.825			
	COL4	0.846			
	COL5	0.831			
	COL6	0.823			
Description	DES1	0.861	0.909	0.93	0.689
	DES2	0.803			
	DES3	0.825			
	DES4	0.83			
	DES5	0.865			
	DES6	0.792			
Perceptions	PER1	0.793	0.901	0.924	0.669
	PER2	0.832			
	PER3	0.818			
	PER4	0.866			
	PER5	0.802			
	PER6	0.794			
Decision Making	EDM1	0.825	0.852	0.892	0.623
	EDM2	0.811			
	EDM3	0.763			
	EDM4	0.794			
	EDM5	0.752			
Information Credibility	IC2	0.834	0.881	0.91	0.628
	IC2	0.81			
	IC3	0.791			
	IC4	0.8			
	IC5	0.756			
	IC6	0.763			

Table 1: SmartPLS4 software was used to analyze the relationships between the construct's adaptivity and intelligent tutoring system, personalization, adaptive learning environment, and problem-solving skills, including the items and the measurements of each construct. Structural equation modeling was used to examine the relationships presented in Figure 1, while confirmatory factor analysis was conducted for each construct based on Cronbach's alpha and factor loading to confirm the reliability and validity. As presented in Figure 1, the reliability for items of each construct was strong; most factor loadings was higher than 0.7, which is considered the minimum criterion for reliabilities. For example, the Adaptivity showed factor loading presented 0.789 to 0.838, Cronbach's alpha showed 0.919, composite reliability (C.R.) presented 0.935, and average variance extracted (AVE) showed 0.673, reflecting superior internal consistency and adequate convergent validity. Adaptive learning environments also provided acceptable reliability values, such as Cronbach's alpha of 0.869, C.R. of 0.906, and AVE of 0.658, Intelligent Tutoring Systems possessed strong reliability, Cronbach's alpha of 0.889, C.R. of 0.919, and AVE of 0.694, indicating the reliability of the construct to measure intelligent tutoring in learning. The Personalization construct exhibited high reliability; Cronbach's alpha of 0.894, C.R. of 0.922, and AVE of 0.703, and Problem-Solving Skills showed Cronbach's alpha of 0.852, C.R. of 0.892, and AVE of 0.623. In summary, constructs in Table 1 presented strong reliability and validity, equivalent in terms of reliability presented a high level of alpha, such as above 0.8, equivalent in terms of convergent validity presented higher than 0.8, and equivalent AVE higher than 0.7, which support the seventh hypothesis that suggests the mediating effect of adaptive learning environments on problem-solving skills through AI-driven personalization, adaptivity, and intelligent tutoring. In other words, these results prove the effectiveness of these indicators in measuring various concepts and constructs, which confirms the validity of these measurements for further learning.

Structural Model

The data were analyzed using a SmartPLS4 application to examine the relationships between variables of artificial intelligence and problem-solving skills, with adaptive learning environments as the "mediating variable." Descriptive statistics were employed to characterize participant demographics, including age and gender. Using structural equation modeling (SEM), this study attempts to explore the interrelationships of AI-driven personalization, adaptivity in Intelligent Tutoring Systems (ITSs), and their effects on problem-solving skills. The reliability and validity of the constructs were verified using Cronbach's alpha and factor loadings. These results were paramount in understanding the role adaptive learning environments play in improving problem-solving skills through the integration of AI. The findings were analyzed and conveyed to reflect on how AI can be successfully integrated into the learning process to cater to and help students become critical problem solvers.

Table 2.
HTMT.

	Adaptive Learning Environments	**Adaptivity**	**Intelligent Tutoring Systems**	**Personalization**	**Problem-Solving Skills**
Adaptive Learning Environments					
Adaptivity	0.534				
Intelligent Tutoring Systems	0.594	0.585			
Personalization	0.576	0.666	0.794		
Problem-Solving Skills	0.412	0.467	0.688	0.639	

Table 2 Heterotrait-Monotrait Ratio (HTMT) Results for Constructs of AI's Impact on Problem-Solving Skills in Adaptive Learning Environments: Empirical Analysis. The HTMT values refer to the discriminant validity between the constructs, and this value should be less than 0.90, signifying that they are different in each other's aspects. Collaboration and Description have an HTMT value of 0.664, which is above the threshold of 0.60, indicating different dimensions in the study. Table four states that the HTMT value between Collaboration and Decision Making is 0.456, which represents discriminant validity and is less than 0.85 (good). In addition, Collaboration and Information Credibility have HTMT values of 0.543 between them, providing support for their discriminant validity. Regarding Description and Decision Making, the HTMT value is 0.656, capable of discriminant validity but close to 0.9 concerning Fornell & Larcker. The Information Credibility-Description relationship produced an HTMT value of 0.602, which means it also achieves sufficient discriminant validity. The HTMT value of 0.422 between Decision Making and Information Credibility indicates acceptable discriminant validity. Perceptions, the HTMT values range from 0.590 with Collaboration to a maximum of 0.818 with Description, and each remains well below 0.90. It also establishes that the constructs in terms of AI on problem-solving skills within adaptive learning environments have discriminant validity.

Table 3.
Fronell-Larcker.

	Adaptive Learning Environments	Adaptivity	Intelligent Tutoring Systems	Personalization	Problem-Solving Skills
Adaptive Learning Environments	0.811				
Adaptivity	0.48	0.82			
Intelligent Tutoring Systems	0.525	0.534	0.833		
Personalization	0.511	0.605	0.712	0.838	
Problem-Solving Skills	0.371	0.4	0.581	0.541	0.789

Table 3: Fornell-Larcker Criterion Results for Constructs of AI's Impact on Problem-Solving Skills in Adaptive Learning Environments: empirical analysis The Fornell-Larcker criterion evaluates the discriminant validity of constructs, and for a construct, its square root of the average variance extracted (AVE) should be greater than the other constructs' correlations with it. The square root of the AVE for each construct is shown in diagonal terms. AVE square root 0.811: Valid AVE with 0.48 correlation to Adaptivity, 0.525 correlation to ITS, and 0.511 correlation to Personalization. The construct Adaptivity (with AVE square root 82) correlates moderately with the remaining constructs (i.e.,.534 with Intelligent Tutoring Systems, and a.605 correlation with Personalization), thereby presenting evidence of its validity. Intelligent Tutoring Systems with AVE square root 0.833, which means both correlations (0.712 for Personalization and 0.581 for Problem-Solving Skills) were found important, which is lower than the AVE threshold. Another measure of discriminant validity is the AVE square root -the Personalization (AVE$\surd$ = 0.838) construct exhibits robust discrimination, whereas Problem-Solving Skills (AVE$\surd$ = 0.789) shows a well-differentiated relationship with other constructs in this multi-dimensional scale. In summary, the results of Fornell-Larcker as a sentinel with conjunction outcome confirmed that discriminant validity was met for all constructs supporting the sought relationships in terms of AI and adaptive learning environment on problem-solving skills.

Table 4.
R2 Adjusted.

	R-square	R-square adjusted
Adaptive Learning Environments	0.345	0.337
Problem-Solving Skills	0.138	0.135

Table 4: R^2 Adjusted Results of Constructs AI's Impact on Problem-Solving Skills in Adaptive Learning Environments: Empirical Analysis. The magnitude of the R^2 values represents the percentage of variability accounted for by the independent variables in our model. For Adaptive Learning Environments, the R-square of 0.345 suggests that about 34.5% of the variance in outcome is explained by other variables, while an adjusted R-square value of 0.337 provides even less reduction due to several predictors used and it indicates good explanatory power with little-to-none overfitting. Cases of Problem-Solving Skills are less adequately explained with an R-square value of 0.138, meaning that the independent variables explain only 13.8% of the variance in Problem-Solving Skills, while a similarly adjusted R-square value of 0.135 suggests only a minor decrease. These results, which suggest a major impact of AI-driven adaptive learning environments on their constructs and a modest influence on Problem-Solving Skills, point to the fact that other factors are likely to play an important role in distinguishing problem-solving outcomes.

Table 5.
Demographic information of respondents.

Characteristic	Frequency	Percentage
University Sector		
Private Universities	114	46%
Community Colleges	78	31%
Others	58	23%
Role in Educational Administration		
Marketing Manager	65	26 %
Digital Marketing Specialist	42	17%
Operations Manager	50	20 %
Sustainability Specialist	27	11 %
Other (Academic Advisors, Educational Consultants)	66	26%
Education Level		
Diploma	50	20%
Bachelor's Degree	125	50%
Master's/Doctorate Degree	75	30%
Experience		
Less than 10 years	35	14 %
10-14 years	65	26 %

15-19 years	58	23 %
20-24 years	42	17 %
25+ years	50	20 %

Table 5: The sample consists of 250 participants from different demographics, making the companies accessible to a larger population in the field of AI and adaptive learning methods for problem-solving. Of the respondents, 46% came from private universities, 31% from community colleges, and 23% from other international or vocational institutions; a wide gamut in terms of educational settings. The responsibility of respondents was divided quite unexpectedly: 26% are marketing managers, and another 26% are other types, including academic advisers and educational consultants. Furthermore, fewer than 17% of those cited were in the field as Digital Marketing Specialists, only 20% have had a successful position as Operations Managers, and just about 11-13% are Sustainability Specialists. Academic qualifications of the participants: 50% hold a Bachelor's degree, 20% hold a Diploma, and 30% hold a Master's or PhD. The related educational diversity affirms and reinforces the findings of this study, providing multiple viewpoints from a cross-section of important academic backgrounds that improve problem-solving and thinking skills. Respondents had varied experience levels, with a range from 14%, which had less than ten years of experience, to another 26% falling into the range of greater than ten and less than fifteen years in their profession. This demographic provides another perspective that can be vital when the focus is on how artificial intelligence and adaptive learning environments influence problem-solving skills, stressing the need for diverse viewpoints of education in such a system.

5. Hypothesis Testing

The path coefficients play an important role in understanding the relationships among the different variables, as they focus on how they influence other variables, which include factors such as the impact of artificial intelligence-based reasoning and problem-solving ability toward AI-PLMS. Path coefficients were calculated with the Smart PLS 4.0 software using the PLS Algorithm to evaluate how strong and in what direction the relationships between constructs were. Beta weights are used in usual regression analysis. Coefficients fall between -1 and +1, with values around +1 representing high positive relationships, while values close to 0 suggest very low relationships. The statistical significance of the variables was tested using four important metrics, i.e., coefficient, standard errors, t-statistic T values, and p-values, with a standard threshold at ≤ 0.05 (statistically significant). Moreover, we computed Cronbach's Alpha to establish the reliability and validity of the constructs. The results support the hypothesized relationships and reveal that information credibility mediates the effect of artificial intelligence on problem-solving skills among students in private universities in Jordan. Our results emphasize the urgency of ensuring that educational content in adaptive learning systems is correct and complete, as erroneous information may lead to misguided educational decisions. The methodological rigor and findings offer important insights for those interested in using AI and AL as tools to advance problem-solving skills, including the nation's educators and policymakers.

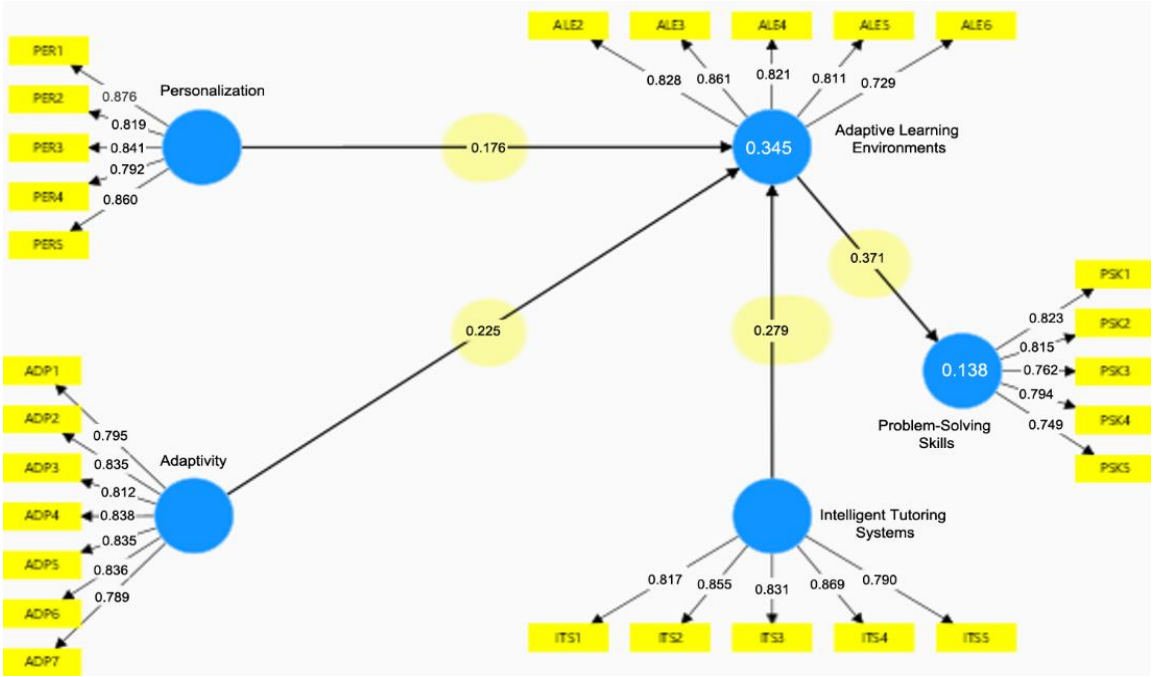

Figure 2.
Measurement Model.

Table 6.
Hypotheses testing estimates (direct effect).

Hypo	Relationships	Standardized Beta	Standard Error	T-Statistic	P-Values	Decision
H1	Adaptive Learning Environments -> Problem-Solving Skills	0.371	0.086	4.296	0	Supported
H2	Adaptivity -> Adaptive Learning Environments	0.225	0.072	3.106	0.002	Supported
H3	Adaptivity -> Problem-Solving Skills	0.083	0.033	2.565	0.01	Supported
H4	Intelligent Tutoring Systems -> Adaptive Learning Environments	0.279	0.083	3.371	0.001	Supported
H5	Intelligent Tutoring Systems -> Problem-Solving Skills	0.104	0.043	2.387	0.017	Supported
H6	Personalization -> Adaptive Learning Environments	0.176	0.083	2.126	0.034	Supported
H7	Personalization -> Problem-Solving Skills	0.065	0.037	1.755	0.079	Unsupported

Table 6: Hypothesis Testing on The Constructs in Enhancing Problem-Solving Skills through AI and Adaptive Learning Environments. The relationship between Adaptive Learning Environments and Problem-Solving Skills is statistically significant, having a standardized beta of 0.371, a standard error equal to 0.086, a t-statistic of 4.296, and a P-value of 0, which supports H1 of the study. In like manner, Adaptivity significantly affects Adaptive Learning Environments with a standardized beta of 0.225, a standard error of 0.072, a t-statistic value equal to 3.106, and a P-value equal to 0.02, which validates H2 as indicated in the following Table (Table 4). H3: Adaptivity to Problem-Solving Skills ($\beta = 0.083$, SE = 0.033, $t = 2.565$, $p < 0.05$), Intelligent Systems have a strong positive impact on Adaptive Learning Environments ($\beta = 0.279$, SE = 0.083, $t = 3.371$, $p = 0.001$), thus H4 is confirmed as valid in this context. However, the relationship between Intelligent Tutoring Systems and Problem-Solving Skills is modestly significant ($\beta = 0.104$, SE = 0.043, $t = 2.387$, $p = 0.017$), thus supporting H5. Personalization has a considerable effect on the AL environments ($\beta = 0.176$, SE = 0.083, $t = 2.126$, $p = 0.034$), which means that the survey results support this hypothesis, whereas personalization and problem-solving skills do not show a significant relationship together (H7 is not supported) since this regression coefficient is neither significant nor very small ($\beta = 0.065$, SE = 0.037, $t = 1.755$, $p \leq 0.079$). In sum, the results presented in the last sections generally support positive associations among adaptive learning constructs and their collective contribution to problem-solving gains; however, since personalization strategies did not contribute negatively compared to non-personalized instruction on problem-solving outcomes, our conclusions call for further investigations.

Table 7.
Hypotheses testing estimates (Indirect effect).

Hypo	Relationships	Standardized Beta	Standard Error	T-Statistic	P-Values	Decision
H8	Adaptivity -> Adaptive Learning Environments -> Problem-Solving Skills	0.083	0.033	2.565	0.01	Supported
H9	Intelligent Tutoring Systems -> Adaptive Learning Environments -> Problem-Solving Skills	0.104	0.043	2.387	0.017	Supported
H10	Personalization -> Adaptive Learning Environments -> Problem-Solving Skills	0.065	0.037	1.755	0.079	Unsupported

Table 7: Hypothesis Testing Estimates (Indirect Effect) The results of testing the hypotheses regarding the indirect effects of different constructs on Problem-Solving Skills via SL are presented in Table 7. It appears that H8, which assesses the relationship between Adaptivity to Adaptive Learning Environments and Problem-Solving Skills, has a standardized beta of 0.083, standard error of 0.033, the t-statistic value of 2.565 (which is significant at a p-value

6. Findings

The data from this study offer a detailed understanding of artificial intelligence as it increases problem-solving skills in general, with the mediating effects of adaptive learning environments, specifically within Jordanian private universities. The results confirm the strong relationships between adaptivity, intelligent tutoring systems (ITS), and problem-solving skills, showing that both adaptive learning environments individually mediated a good positive correlation with problem-solving skills. Moreover, the results indicate that both adaptivity and the use of intelligent tutoring systems make a substantial difference in terms of improved student problem-solving skills, highlighting each category of these AI-driven ed-tech tools. The findings emphasize the great need for a personalized and adaptive learning experience for students, as well as learning environments that provide more engaging and effective conditions that can best develop students' problem-solving skills. In

addition, while personalization also influences adaptive learning environments, it does not directly affect the problem-solving ability of adaptivity, signifying a need for an in-depth analysis of the unique role of personalization. The study indicates that educational institutions should look at introducing AI in their courses and adopt adaptive learning systems to help students learn better. This study helps develop the theoretical comprehension of adaptive learning environments as intermediaries in which problem-solving skills can be improved with artificial intelligence applications. These implications underline the importance for educators and policymakers to look at the inclusion of adaptive measures through AI tools, which cater to an individual orientation that may lead to enhanced educational practices in Jordanian universities. While the study has a few limitations, such as sample sizes and some potential biases, it provides an interesting viewpoint of AI in learning environments and its effect on the development of critical problem-solving skills, which can be leveraged by researchers in this space.

6.1. Managerial Implications

The findings in the present study have important managerial implications for university administrators and faculty members at Jordanian private universities, as they offer useful evidence-based policies to improve decision-making capabilities by effectively incorporating artificial intelligence and adaptive learning environments. The findings suggest that AI-based adaptive learning environments are necessary for fostering a problem-solving attitude among students. Adaptive and personalized tools in education that utilize AI should be deployed as a top priority by managers. The first step is to offer professional development for educators to successfully implement AI tools and adaptive learning models. This could involve resources such as workshops to equip faculty with the necessary skills and knowledge that will allow them to integrate these tools into their teaching methodologies.

Universities need to improve their educators' AI skills to create high-quality learning experiences that empower students to learn the most and develop better problem-solving abilities.

In the second degree, colleges should build adaptive learning environments that stand up to individual student requirements. This includes using powerful AI systems that analyze the performance of students while providing personalized real-time feedback and resources. In addition, institutions need to engage with AI scientists who can help them evaluate and perfect these tools so that they incorporate learning objectives while catering to the diverse array of learners in their classrooms.

Education is highly influenced by social factors, so universities must foster an environment where faculty and influential peers can actively participate with students on digital platforms. Engagement from them will give more validity to the information shared, supporting students in their learning and helping them make better decisions. Last but not least, using data analytics capabilities to keep track of the performance of AI and adaptive learning initiatives is essential. Administrators can leverage these insights to constantly refine their strategies and ensure that the offered educational content remains pertinent and reliable, with strong correlations to organizational objectives.

Creating an atmosphere for students and educators to share trusted information can significantly contribute to a better learning culture. This can be achieved through continuous feedback mechanisms and open communication methods to collaborate on academic resources. Semi-structured managerial strategies adaptable to most Jordanian private universities will empower them to integrate artificial intelligence and adaptive learning environments into course instruction to improve problem-solving as an institutionally driven outcome.

6.2. Limitations and Future Research

The present study is an attempt to contribute to understanding how artificial intelligence may reinforce problem-solving abilities, specifically through the mediating influences of adaptive learning environments in private tertiary Jordanian education. While this can be a strength of our results, there are some limitations. First, the cross-sectional nature of the research probably cannot adequately underpin dynamic relationships between artificial intelligence, adaptive learning environments, and problem-solving skills concurrently across time. Longitudinal research may benefit from examining the stability of these relationships and their implications for student problem-solving over time throughout their entire educational pathway.

Furthermore, because of the predominant methodological use of mainly quantitative surveys in this research, this approach is susceptible to only capturing perceptual data. To better understand the perceptions and use of AI-driven tools to develop functional problem-solving skills, qualitative methods such as interviews or focus groups might offer insights on a more personal level with stakeholders, including educators and students. Moreover, additional factors related to problem-solving skills that could play a mediating role in the use of adaptive learning environments and AI technologies might be explored; for instance, digital literacy, learning motivation, or social influences. Addressing these in future research has the potential to make important contributions to both the theoretical frameworks and practical applications of educational technology for problem-solving skills. In conclusion, these findings will provide valuable insights for educators and policymakers to design best practices for AI-integrated educational methods and nurture the creative problem-solving abilities necessary in the current rapidly transforming society.

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