

The Relationship between Human-AI Collaborative Teaching and Instructional Innovation among Jordanian Teachers: Mediating Roles of Technology Self-Efficacy and Adaptive Learning Mindset

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Received: 09 January 2026

Accepted: 21 March 2026

DOI: <https://doi.org/10.32479/jalef.24022>

ABSTRACT

Human-AI collaboration in teaching is increasingly becoming a revolution in the contemporary education systems. Past research also indicated that human-AI collaboration in education has a positive correlation with instructional innovation in teachers. This research examined the mediation role of technology self-efficacy and adaptive learning mindset in the connection between human-AI collaborative teaching and instructional innovation in Jordanian teachers. The research resources were human-AI teaching collaboration scale, technology self-efficacy scale, adaptive learning mindset scale, instructional innovation scale. This study was done using the cross-sectional design among kindergarten, primary, and secondary school teachers in Amman, Zarqa, and Irbid, Jordan. The PROCESS macro plug-in SPSS 26.0 was used for mediating effect analysis. These results indicated that Human-AI collaborative teaching, technology self-efficacy, and adaptive learning mindset have significant, positive correlations with each other and significant positive correlations with instructional innovation. In the meantime, findings indicated that technology self-efficacy and adaptive learning mindset mediated the relationship between human-AI collaborative teaching and instructional innovation in a parallel and consecutive fashion. These results suggest that the high degree of Human-AI collaborative teaching is significantly relevant to the development of technology self-efficacy in teachers and the promotion of adaptive learning mind that could be successful in supporting instructional innovation among teachers in Jordan in new digital learning ecosystems.

Keywords: Human-AI Collaboration, Instructional Innovations, Technology Self-Efficacy, Adaptive Learning Mindset, Jordan

JEL Classifications: I21, O3

1. INTRODUCTION

With the fast-changing environment of digital education, the application of artificial intelligence (AI) in the teaching process is changing the way teachers design, instruct, and assess learning experiences. In the education systems of countries around the world, AI-driven platforms like adaptive learning systems, intelligent tutoring systems, and generative AI applications are becoming more and more integrated into the classroom setting. According to Alqurni (2026), over 70% of education systems worldwide are now trying AI-based learning tools and the global EdTech market is already estimated to go beyond USD 600 billion

by 2030 (Zhang et al., 2025; Devanadera, 2025). In this change, teachers are not mere consumers of technology but active partners of AI systems, and this is what is increasingly being conceptualized as Human-AI collaborative teaching. This change is especially applicable in the context of emerging education systems like Jordan, where national plans to digitize education through the Ministry of Education focus on smart learning environments, digital pedagogy, and innovation-oriented pedagogical methods (Vistari et al., 2025; Xu, 2026). In this framework, Human-AI collaborative teaching can be defined as the synergistic relationship between teachers and AI-based learning technologies to co-design learning, personalize learning trajectories, and improve classroom

decision-making (Mohamed, 2026; Kyambade et al., 2025). This construct is based on the socio-technical systems theory that the human performance is maximized when technology forms a complement to human agency, as opposed to threatening it (Wang and Wang, 2026; Ali, 2025). It is significant because it might positively influence instructional innovation, which is defined as teachers capabilities to formulate and apply new, effective, and technology-enhanced pedagogical methods (Qassrawi and Al Karasneh, 2025; Song et al., 2024).

Educational competitiveness in the age of Education 5.0, in which creativity, adaptability, and AI integration are the leading indicators of teaching quality, have made instructional innovation a determining factor of educational competitiveness (Karakose et al., 2023). Nevertheless, the success of Human-AI collaboration is not only related to the availability of technologies but also to psychological and cognition processes among the teachers. Technology self-efficacy is one of them, as it entails the conviction of the teacher to be able to successfully apply and implement digital tools in instructional practices (Beirat et al., 2025; Huang and Katz, 2025). Research demonstrates that high technology self-efficacy teachers are more inclined to implement new teaching methods and continue to use AI tools even in complex and uncertain situations (Raisch and Krakowski, 2021; Alyasin and Shah, 2026). Simultaneously, adaptive learning mindset is a rather innovative concept that has been based on the growth mindset and adaptive cognition theories and indicates how teachers are willing to regularly update pedagogical strategies based on AI-generated feedback and information on learners (Li and Kim, 2024; Song et al., 2024). These two mediators combined justify the understanding that external technological cooperation is converted into internal cognitive preparedness to innovate. Jordanian teachers as the focal population are chosen theoretically and practically appropriately. The education sector in Jordan is rapidly being digitalized due to policies promoting smart education nationally and more substantial investment in EdTech infrastructure. Shao et al., (2025), asserts that Jordan has invested substantial resources in online learning, and capacity-building of teachers as part of its education reform for knowledge economy initiative. Nevertheless, infrastructural advances do not always result in teacher preparedness to adopt AI and many educators report to have weak confidence, lack of training, and resistance to adaptive technologies (Wei et al., 2025). Such an imbalance between technological investment and human capability indicates the necessity of studying psychological and cognitive mediators facilitating successful AI usage in teaching.

The focus of previous studies has been mainly on AI in education by looking at it in terms of student performance and the efficiency of the system instead of teacher-led innovation processes (Asamoah and Amarteifio, 2025; Hazaimah and Al-Ansi, 2024). Although AI tools are becoming a popular choice in the classroom, numerous studies continue to view AI as a supportive technology rather than interactive co-teaching partners in the instructional ecosystem (Allison et al., 2025; Zhang et al., 2025). Additionally, the psychological and cognitive processes underlying the integration of AI resulting in instructional innovation have not been thoroughly studied (Guberina and Prochazka, 2026; Rodrigo et al., 2022). Specifically, technology self-efficacy has

been examined in a vacuum but seldom combined with adaptive learning mindset in one explanatory paradigm (Devanadera, 2025; Asamoah and Amarteifio, 2025). Also, the majority of empirical data is based on the developed world, which introduces a contextual gap in the interpretation of AI-based teaching in the framework of developing education systems like Jordan (Alqurni, 2026; Wang and Wang, 2026). Moreover, the current models tend to focus on single-mediator models that do not reflect the complexity of the psychological mechanisms at work to affect instructional innovation in Human-AI collaborative settings (Wei et al., 2025; Qassrawi and Al Karasneh, 2025). Thus, the main goal of the research is to investigate the connection between Human-AI collaborative teaching and instructional innovation among the teachers in Jordan. Particularly, it explores the mediating effects of technology self-efficacy and adaptive learning mindset, in parallel and sequential processes.

This research is theoretically significant in its ability to combine socio-technical systems theory with social cognitive theory, mindset theory to provide an overall framework of AI-enabled pedagogy. In practice, it can offer evidence-based information to policymakers, curriculum developers, and institutions training teachers to be more AI-ready in education systems. Theoretically, it builds up on the previous studies by using a multi-mediator model in a context of the Middle East that is under-researched. This paper is both urgent and essential in terms of importance since education systems are shifting to AI-based eco systems. It is unique in that it does not just place teachers as mere users of technology but as responsive co-creators in human-AI classroom settings. Eventually, this study will add to the literature on educational futures by describing the ways in which psychological preparedness and adjustive thinking can turn AI potential into practical classroom instructional innovation.

2. THEORETICAL BACKGROUND

The theoretical framework of the study is based on the synthesis of socio-technical systems theory (STS), social cognitive theory (SCT), and Mindset Theory, which, altogether, can be seen as a powerful account of how the Human-AI collaborative teaching can be translated into the instructional innovation among the Jordanian teachers. The choice of these theories is explained by the necessity to embrace the technological environment and psychological processes which prompt teacher behavior in AI-enabled educational ecosystems. The human-AI collaborative teaching is discussed through the prism of the STS (Trist and Bamforth, 1951). STS believes that the performance of the organization comes out as a result of the interaction between the social system (teachers) and the technical system (AI tools). The notion of AI, in the framework of this research, is not viewed as a passive teaching tool, but rather as an interactive co-participant in the teaching processes (Beirat et al., 2025; Zhang et al., 2025). This opinion is supported by recent educational research, which focuses on the fact that AI-based environments transform the structure of instruction and necessitate a change in the role of a teacher (Huang and Katz, 2025; Vistari et al., 2025). This theory is a strong proponent of the independent variable as it defines the need to have Human-AI collaboration in the achievement of instructional

change, as opposed to mere technological adoption. SCT (Bandura, 1986) is added to explain the behaviour and cognitive responses of teachers. SCT goes on to stress that the dynamic interaction between personal beliefs, environmental forces and actions shapes behavior. In this context, the technology self-efficacy an important mediating variable because the teacher belief in being able to utilize AI tools has a direct impact on the willingness to implement new teaching methods (Alyasin and Shah, 2026; Xu, 2026). Empirical research attests to the fact that increased self-efficacy is correlated with increased experimentation with digital tools and better instructional performance (Raisch and Krakowski, 2021; Li and Kim, 2024). SCT applies to the context of Human-AI teaching by describing how confidence improves behavioral responses to instructional innovation conditions by exposure to AI systems (Wang and Wang, 2026). In addition to SCT, there is a psychological basis of the second mediator, adaptive learning mindset, which is Mindset Theory (Devanadera, 2025). This theory is based on the assumption that the growth-oriented mindset enables people to be more willing to take challenges, acquire feedback, and adjust to new circumstances.

The teachers in the AI-based classrooms are always provided with the algorithmic feedback and data-driven information which means that they have to adapt the teaching strategies all the time (Ali, 2025). Research indicates that adaptive mindset is one of the key factors that make teachers more welcoming to innovation and able to adapt to technological disruption (Shao et al., 2025). Therefore, mindset theory supports the rationale behind why cognitive flexibility is one of the critical processes that connect Human-AI collaboration to instructional innovation. A combination of the theories forms an elaborate explanatory model. STS describes the technological-social interaction, SCT describes the behavioral activation with the help of self-efficacy, and Mindset Theory describes the adaptive cognitive change needed to innovate. They combine to create a sequence logic where Human-AI collaborative instruction improves the interaction of teachers with digital systems which enhances the technology self-efficacy and then creates an adaptive learning attitude which results in instructional innovation. This integrated model is highly supported by empirical literature. AI in education research points out that teacher agency is an essential factor in the integration of technology (Zhang et al., 2025; Devanadera, (2025), and studies also affirm that self-efficacy is a significant predictor of the effectiveness of digital pedagogy (Kyambade et al., 2025). Also, studies prove that growth-oriented attitudes can greatly enhance the flexibility of teachers in online learning (Qassrawi and Al Karasneh, 2025). Even more recent studies also indicate that integrating cognitive and motivational factors have more explanatory power in relation to instructional innovation compared to single-theory models (Allison et al., 2025; Mohamed, 2026). In spite of this backing, the previous researches are still disjointed as many tend to implement these theories separately, but not as one coherent model of human-AI collaborative teaching. This paper fills this gap by combining STS, SCT and mindset theory into one unified theory to determine how technological engagement and psychological preparedness work together to influence instructional innovation among teachers in Jordan in emerging digital education environments.

2.1. Human-AI Collaborative Teaching and Instructional Innovation among Jordanian Teachers

Human-AI collaborative teaching is becoming a widely acknowledged innovative pedagogical strategy, which is characterized by teachers engaging in collaboration with AI systems to co-design, personalize, and optimize teaching. It is part of a larger change of traditional ways of instruction to intelligent, adaptive learning ecosystems in which human judgment and machine intelligence interact in a synergistic way (Karakose et al., 2023; Vistari et al., 2025). In this setting, instructional innovation is a serious product, which is characterized by the capacity of teachers to create and apply new, efficient, and technology-enriched teaching practices (Song et al., 2024; Beirat et al., 2025). Within the socio-technical dimension, human-AI collaboration is more effective in improving instructional innovation through better access to real-time data, adaptive feedback, and customized learning analytics, which allows teachers to redesign pedagogical strategies more effectively (Guberina and Prochazka, 2026; Asamoah and Amarteifio, 2025). Moreover, teaching learning environments powered by AI can help decrease routine mental workload and enable teachers to invest more in innovative practice design and student interaction (Shao et al., 2025; Alyasin and Shah, 2026). SCT can further explain this correlation by implying that working with AI systems helps teachers to gain a stronger sense of their ability to experiment with novel practices. It is also proven by empirical research that the digital collaboration tools and smart learning systems can considerably improve the innovative teaching and classroom flexibility (Rodrigo et al., 2022; Bali et al., 2024). Moreover, recent studies within the context of emerging digital education show that AI integration can promote pedagogical experimentation and enhance the quality of instruction when teachers are the ones who actively use technology instead of passively (Ali, 2025; Wang and Wang, 2026). Thus, Human-AI collaborative teaching is likely to have a positive impact on the innovation of instructions among Jordanian teachers as it facilitates more adaptive, data-driven, and creative instructions in the changing educational ecosystems.

H₁: Human-AI collaborative teaching is positively related to instructional innovation among Jordanian teachers.

2.2. Mediating Role of Technology Self-Efficacy

An important psychological construct is technology self-efficacy which indicates the confidence of the teacher in his/her competence in using digital and AI-based tools in the instructional contexts successfully. In the context of Human-AI collaborative instruction, the undeterred engagement with intelligent systems boosts the perceived ability of teachers to respond, adapt, and incorporate new technologies into the instruction process (Alqurni, 2026; Hazaimh and Al-Ansi, 2024). This greater confidence is an important process by which external technological exposure is reconfigured into creative teaching behavior (Karakose et al., 2023). Self-efficacy has frequently been determined as a robust foreteller of teacher readiness to embrace and explore new teaching strategies in research on educational technology (Song et al., 2024; Qassrawi and Al Karasneh, 2025). Educators become more willing to recreate lesson plans, use adaptive tools, and employ student-centered strategies to improve the quality of instruction when they feel comfortable with the use of AI-driven platforms (Li

and Kim, 2024; Vistari et al., 2025). This fits the social cognitive theory, which stipulates that the belief in personal abilities has a direct impact on the outcomes of behaviors in complex settings Devanadera (2025). Further, learning systems that learners can use with AI give instant feedback and performance metrics and decision-support systems, which also bolster teacher technological confidence and decrease doubt in instructional decision-making (Xu, 2026; Devanadera, 2025). Technology self-efficacy is especially crucial in the emerging education settings, like Jordan, where the digital transformation is only in the initial phases of development, to reduce the gap between the availability of infrastructure and its application in classrooms (Zhang et al., 2025; Qassrawi and Al Karasneh, 2025). Thus, technology self-efficacy is likely to serve as a strong level of mediation which would transform Human-AI collaborative teaching into greater levels of instructional innovation among educators.

H₂: Technology self-efficacy mediates the relationship between Human-AI collaborative teaching and instructional innovation among Jordanian teachers.

2.3. Mediating Role of Adaptive Learning Mindset

Adaptive learning mindset means the mental willingness of teachers to constantly modify, refine and enhance their teaching methods in light of new knowledge, feedback, and classroom dynamics. When it comes to Human-AI collaborative teaching, exposure to intelligent systems that deliver real-time analytics, personal suggestions, and dynamic insights about learners compel teachers to reconsider their routine teaching practices and create a more adaptable approach to teaching (Alyasin and Shah, 2026; Karakose et al., 2023). Such a mentality is especially relevant in the context of AI-enhanced learning experiences where pedagogy is not a fixed state but rather is responsive to data and is constantly changing. The use of AI-driven systems exposes teachers to performance dashboard and feedback loops, often provoking reflection and encouraging ongoing change in instruction (Mohamed, 2026; Song et al., 2024). Consequently, educators become more willing to explore new practices and improve their instructional approaches through evidence-based rather than habitual practices (Ali, 2025). Previous studies have shown that adaptive cognitive orientations are very effective at improving the ability of educators to adopt new teaching methods and be responsive to technological change (Rodrigo et al., 2022; Huang and Katz, 2025). This flexibility is even more important in the context of developing digital education systems, where teachers need to operate in the context of changing technologies, curriculum changes, and variable needs of students as soon as possible (Wei et al., 2025; Devanadera, 2025). Adaptive learning mindset, therefore, is a vital psychological linkage that can turn Human-AI collaborative teaching experiences into a valuable instructional innovation among Jordanian teachers.

H₃: Adaptive learning mindset mediates the relationship between Human-AI collaborative teaching and instructional innovation among Jordanian teachers.

2.4. Sequential Mediation

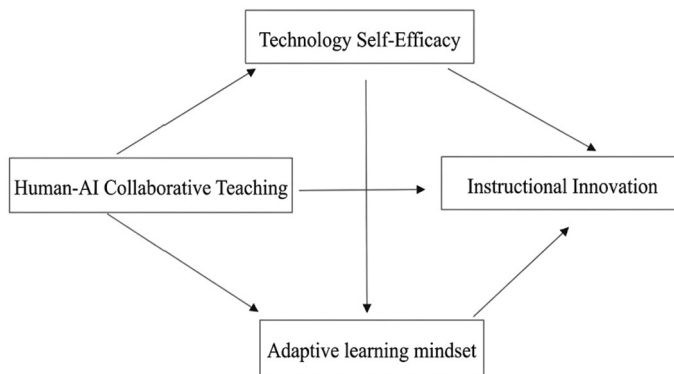
The sequential mediation pathway implies a gradual psychological change whereby human-AI partner teaching has an effect on instructional innovation. First, interactions with AI-based

instructional systems positively influence technology self-efficacy of teachers, as they become more familiar with technologies, less uncertain, and more confident about their control over complex instructional technologies (Vistari et al., 2025; Beirat et al., 2025). The enhanced ability in this stage is then a basis of further cognitive modification on teaching behaviour. When the teachers gain increased confidence in their technological skills, there are more chances that they change to a more adaptive and receptive cognitive orientation. This change creates an adaptive learning attitude, in which teachers actively read the comments of AI systems, consider the results of teaching and constantly improve their pedagogical methods (Xu, 2026; Qassrawi and Al Karasneh, 2025). Confidence and adaptability form a reinforcing cycle that promotes ongoing professional development. Research indicates that psychological development of the self-efficacy to adaptive cognition is a crucial factor to maintain innovation in the teaching practices in technology-rich educational settings (Wang and Wang, 2026). It is especially applicable to digitally transformative situations when the teachers need to not only apply the AI but also make it a significant part of the instructional design (Raisch and Krakowski, 2021; Mohamed, 2026). Empirical results also emphasize that multi-stage psychological processes are more effective as explanatory models of instructional innovation than single-mediator models (Allison et al., 2025; Devanadera, 2025). Thus, the sequential mediation model reveals the way in which Human-AI collaborative teaching eventually results in instructional innovation in a disjunctive chain of technological confidence and adaptive cognitive development among Jordanian teachers.

H₄: Technology self-efficacy and adaptive learning mindset sequentially mediate the relationship between Human-AI collaborative teaching and instructional innovation among Jordanian teachers.

The predicted model is shown in Figure 1. This study contributes to our current understanding of the mechanism linking Human-AI collaborative teaching, technology self-efficacy, adaptive learning mindset, and instructional innovation and how we should foster instructional effectiveness by taking action to enhance teachers' technological and psychological resources (Ali, 2025; Kyambade et al., 2025). This means that when developing programs to support teachers in strengthening instructional innovation from an objective standpoint, including improvements in digital infrastructure, AI-enabled classroom tools, and continuous

Figure 1: Research model



professional development, which can provide tangible support, it is imperative to focus on nurturing teachers' subjective resources as well. This is through the promotion of technology self-efficacy and adaptive learning attitude that is of paramount importance in fast changing and resource diversified learning settings like Jordan. In this way, we able to empower teachers to interact more efficiently with human-AI collaborative systems with increased confidence and flexibility, which positively transform the teaching innovation and advance a more efficient and future-oriented teaching environment.

3. MATERIALS AND METHODS

3.1. Procedures

The researchers used a sample of kindergarten, primary, and secondary school teachers in Amman, Zarqa and Irbid Governorates, Jordan and data was collected in May 2025. After a national workshop on digital education development in the region it was decided to conduct a questionnaire among all the participating teachers. The collected data were not preregistered, as they were a part of a larger research project.

The research complied with the provisions of the Declaration of Helsinki and was approved by the University of Jordan Research Ethics Committee (No. 20260084). All participants were informed and gave their consent before taking part and completed the questionnaire anonymously through a web connection managed on the Google Forms site (<https://www.google.com/forms>). A wide and geographically dispersed sample is made available using this platform. At the end of the survey, participants were thanked and given some tokens of money as appreciation of the time spent. Finally, SPSS 26.0 was used to further analyze the response data.

3.2. Participants

The Jordanian population of school teachers who were involved in the study was 3,200. The exclusion criteria were two-fold: (1) the participants were not allowed to fill out the questionnaire completely, and (2) those who showed patterning in their answers (i.e., giving the same answer to all questions). This led to 412 participants being filtered out ahead of the analysis. The final sample consisted of 890 male (30.2%) and 1,898 female respondents (69.8%). Their average age was 38 years (SD = 8.41). There were 312 kindergarten teachers (10.60%), 1,520 primary school teachers (51.70%), 705 middle school teachers (24.00%), and 251 high school teachers (13.70%). Also, 2,612 teachers (89.10) majored in teacher education and received subject-specific training and 276 teachers (10.90) majored in non-teacher education when they were in university.

3.3. Measures

3.3.1. Human-AI collaborative teaching

The Human-AI Teaching Collaboration Scale was used to measure human-AI collaborative teaching and is based on recent AI-in-education integration models (Shao et al., 2025; Mohamed, 2026), and has been shown to have a high level of reliability and validity in recent studies on digital pedagogy (Alqurni, 2026). This scale has eighteen items (e.g., I actively incorporate AI tools to co-design instructional activities with students) with a five-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). The

scores of all items are averaged and a higher score will show a strong level of Human-AI collaborative teaching. The scale was also highly reliable and in the current study Cronbach alpha was 0.95. The confirmatory factor analysis fitting index is as follows: $\chi^2/df = 2.611$, CFI = 0.981, AGFI = 0.951, TLI = 0.974, RMSEA = 0.036, which means that this tool has good validity.

3.3.2. Technology self-efficacy

The technology self-efficacy scale was the Technology Integration Self-Efficacy Scale, Beirat et al., (2025); Wang and Wang, (2026), which is highly proven in the educational technology setting (Wang et al., 2021). It comprises of five questions (e.g., I am confident in using AI-based tools to assist with teaching activities) which are rated using a five-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). The total item scores averaged (the higher the score, the higher the perceived ability to use digital and AI tools). The alpha of the scale in the present study was 0.84. The scale showed strong structural validity and the fitting index of confirmatory factor analysis is as follows:

$\chi^2/df = 4.521$, CFI = 0.991, AGFI = 0.947, TLI = 0.975, RMSEA = 0.051.

3.3.3. Adaptive learning mindset

The adaptive learning mindset scale was used to measure adaptive learning mindset, it was created in accordance with the growth mindset theory and adaptive cognition frameworks of Allison et al., (2025). The scale comprises nine items (e.g., I change my teaching approaches with the appearance of new digital feedback) with a five-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). The items are averaged to obtain scores, with the higher the score the better the adaptive learning orientation. The alpha of the scale in the present study was 0.93. The fitting index of confirmatory factor analysis is as follows: $\chi^2/df = 2.548$, CFI = 0.990, AGFI = 0.957, TLI = 0.978, RMSEA = 0.041, indicating strong validity.

3.3.4. Instructional innovation

The scale of instructional innovation was the instructional innovation scale, which was created on the basis of the diffusion of innovation and recent research on the use of AI in pedagogy (Ali, 2025; Xu, 2026). It contains ten questions (e.g., I often implement innovative AI-based instruction in my classroom) on a five-point Likert scale (1 = Strongly disagree, 5 = Strongly agree), and greater scores correspond to a greater degree of instructional innovation. The Cronbach's alpha for the scale was 0.91. The scale has good structural validity and the fitting index of confirmatory factor analysis is as follows: $\chi^2/df = 2.238$, CFI = 0.958, AGFI = 0.936, TLI = 0.942, RMSEA = 0.038.

Lastly, Table 1 presents the Cronbach alpha and model fitting index of each of the scales. The findings showed that there was good reliability and validity of all the scales in the present study.

4. RESULTS

4.1. Preliminary Analysis

The descriptive statistics and correlation between the main variables is represented in Table 2. There was a positive correlation

Table 1: Indicators for each scale’s validity and reliability

Scale	Cronbach’s α	χ^2/df	CFI	AGFI	TLI	RMSEA
Human-AI collaborative teaching	0.95	2.611	0.981	0.951	0.974	0.036
Technology self-efficacy	0.84	4.521	0.991	0.947	0.975	0.051
Adaptive learning mindset	0.93	2.548	0.990	0.957	0.978	0.041
Instructional innovation	0.91	2.238	0.958	0.936	0.942	0.038

Table 2: Means, and standard deviations, bivariate correlations among variables

Variables	M	SD	1	2	3	4
HAT	4.46	0.52	-	-	-	-
TSE	3.88	0.79	0.56**	-	-	-
ALM	3.92	0.77	0.61**	0.66**	-	-
II	2.19	0.71	-0.58**	-0.62**	-0.69**	-

HAT: Human-AI collaborative teaching, TSE: Technology self-efficacy, ALM: Adaptive learning mindset, II: Instructional innovation

between human-AI collaborative teaching and technology self-efficacy as well as adaptive learning mindset and technology self-efficacy respectively. On the other hand, instructional innovation and Human-AI collaborative teaching was negatively correlated with technology self-efficacy, and adaptive learning mindset.

4.2. Mediating Self-Efficacy of Technology

According to the Model 4 of the PROCESS macro, the investigation of the current study H2 is that technology self-efficacy is a mediator between Human-AI collaborative teaching and instructional innovation. The findings revealed that Human-AI collaborative teaching was positively predicted via technology self-efficacy ($b = 0.91, p < 0.001$) and instructional innovation was positively predicted via technology self-efficacy ($b = 0.39, p < 0.001$). The remaining direct effect was significant too ($b = 0.52, p < 0.001$). These findings have shown that technology self-efficacy moderated the relationship between Human-AI collaborative teaching and instructional innovation (indirect effect = 0.35, 95% CI = 0.30 to 0.40). On the whole, this model explained 43.10% of the variance in instructional innovation, which favored H2. The outcome of the mediation effect of technology self-efficacy is presented in detail in Table 3.

4.3. Mediating Role of Adaptive Learning Mindset

According to the H₃ hypothesis of Model 4 of the PROCESS macro, the present research will test the hypothesis and will establish whether the adaptive learning mindset is an intermediate between human-AI collaborative teaching and Instructional Innovation. The findings indicated that there was a positive prediction of human-AI collaborative teaching with adaptive learning mindset ($b = 0.98, P < 0.001$) and there was a positive prediction of instructional innovation with adaptive learning mindset ($b = 0.44, P < 0.001$). Also, the direct effect that remained after the control was significant ($b = 0.36, P < 0.001$). These findings showed that adaptive learning mindset mediated (partially) in the relationship between Human-AI collaborative teaching and instructional innovation (indirect effect = 0.43, 95% CI = 0.38-0.47). Overall, this model explained 58.92% of the variance in instructional innovation, which is in support of H₃. The result of the mediation effect of adaptive learning mindset is detailed in Table 4.

4.4. Multiple Mediation Models

The multiple mediation model was tested with the help of Model 6 of PROCESS macro. Findings portrayed that the mediations of Human-AI collaborative teaching in the pathway to Technology self-efficacy (indirect effect = 0.18, 95% CI = 0.42 to 0.33) and Human-AI collaborative teaching in the pathway to Adaptive learning mindset (indirect effect = 0.22, 95% CI = 0.25 to 0.41) were significant. This proves that the relationship between Human-AI collaborative teaching and instructional innovation was mediated by the technology self-efficacy and adaptive learning mindset. Similarly, the serial pathway of the relationship between “Human-AI collaborative teaching and the adaptive learning mindset and Instructional innovation was significant (indirect effect = 0.16, 95% CI = 0.19 to 0.27). Which shows that that high Human-AI collaborative teaching was serially correlated with higher technology self-efficacy ($b = 0.91, p < 0.001$). Therefore, and technology self-efficacy and adaptive learning mindset mediated the relationship between Human-AI collaborative teaching and instructional innovation, both simultaneously and in a sequence. In general, this multiple mediation model explained a lot of variance in instructional innovation ($R^2 = 0.41$). Table 5 shows the mediation analyses’ results.

5. DISCUSSION

The current research investigated the effects of human-AI cooperative instruction on instructional innovativeness in Jordanian educators where the technology self-efficacy and adaptive learning mindset served as parallel and sequential mediators. The general results are a good empirical data on the validity of the model and the fact that instructional innovation in AI-based educational systems is not only a technological phenomenon but also a psychologically controlled process determined by the teacher cognition and flexibility. First, the results showed positive relationship between human-AI collaborative teaching and instructional innovation to be significant. This finding allows accepting H₁ and it is consistent with socio-technical views, which state that innovation is a product of the interaction of human agency and technological systems (Vistari et al., 2025; Qassrawi and Al Karasneh, 2025). It is also not the first study that AI integration can increase instructors and pedagogical redesign ability (Karakose et al., 2023). The same results were noted by Ali, (2025) and Li and Kim, (2024) who note that AI-based environments facilitate adaptive teaching principles and innovation.

However, in contrast to previous works, which viewed AI as a supportive technology, Alqurni (2026), the current study situates AI as a collaborative partner in instruction, which further broadens the theoretical conceptualization of instructional innovation in online learning. Second, the relationship between

Table 3: The results of mediating role of TSE

Paths	M: TSE	SE	95% CI	Y: II	SE	95% CI
	B			B		
X: Human-AI collaborative teaching	0.91***	0.03	0.85, 0.97	0.52***	0.04	0.45, 0.59
M: Technology self-efficacy (TSE)	—	—	—	0.39***	0.02	0.34, 0.44
Constant	-0.41*	0.16	-0.73, -0.10	5.48***	0.12	5.25, 5.71
Model fit			Value			
R ²	0.31/0.46					
F-statistic	842.63*** (1, 1987)/815.92*** (2, 1986)					

HAT: Human-AI collaborative teaching, TSE: Technology self-efficacy, II: Instructional innovation *P<0.05; **P<0.001

Table 4: The results of mediating role of ALM

Paths	M: ALM	SE	95% CI	Y: II	SE	95% CI
	B			B		
X: Human-AI collaborative teaching	0.98***	0.04	0.90, 1.06	0.36***	0.03	0.30, 0.42
M: Adaptive learning mindset	—	—	—	0.44***	0.02	0.40, 0.48
Constant	-0.55*	0.12	-0.79, -0.31	5.62***	0.09	5.44, 5.80
Model fit			Value			
R ²	0.38/0.47					
F-statistic	1984.52*** (1, 2102)/846.44*** (2, 2101)					

HAT: Human-AI collaborative teaching, ALM: Adaptive learning mindset, II: Instructional innovation *P<0.05; **P<0.001

Table 5: Testing the pathways of the multiple mediation model

Effect	Direct effects		
	b	SE	95% CI (Lower-Upper)
Direct effects			
HAT→TSE	0.91***	0.03	0.85-0.97
HAT→ALM	0.98***	0.04	0.92-1.04
TSE→ALM	0.42***	0.02	0.39-0.46
HAT→II	0.36***	0.03	0.30-0.42
TSE→II	0.39***	0.02	0.34-0.44
ALM→II	0.44***	0.02	0.400.48
Indirect effects			
HAT→TSE→II	0.18	0.01	0.33-0.42
HAT→ALM→II	0.22	0.01	0.25-0.41
HAT→TSE→ALM→II	0.16	0.01	0.19-0.27

HAT: Human-AI collaborative teaching, TSE: Technology self-efficacy, ALM: Adaptive learning mindset, II: Instructional innovation P<0.001

Human-AI collaborative teaching and instructional innovation was greatly mediated by technology self-efficacy. This confirms H₂ and strengthens Social Cognitive Theory that focuses on the importance of self-belief on the development of behavioral results (Alyasin and Shah, 2026; Devanadera., 2025). The more actively involved teachers in AI-teaching mentioned increased confidence in digital tools usage, which consequently improved their innovativeness in the instruction. This finding is consistent with Zhang et al. (2025) and Mohamed (2026), who found that technology self-efficacy is a strong predictor of digital teaching competence. On the same note, Beirat et al. (2025) and Xu (2026) emphasized the fact that self-efficacy provides a psychological linkage between technology exposure and innovative teaching practices. Nevertheless, unlike the past where self-efficacy was frequently analyzed as a predictive variable itself, the given study has contributed to the literature because it has proved its mediating role in the context of AI-based teaching, specifically in the under researched setting of Jordan. Third, the relationship between the Human-AI collaborative teaching and instructional innovation also constituted an important mediating role of adaptive learning

mindset, in favor of H₃. This is supported by the mindset theory that proposes that employees with a growth-oriented cognitive framework are more adaptive and innovative in the event of change (Bangulzai et al., 2025; Qassrawi and Al Karasneh, 2025).

Our finding is consistent with Allison et al. (2025) and Li and Kim (2024), who reported that adaptive cognition increases the willingness of teachers to act innovatively and become responsive to feedback. With AI-enhanced classrooms, reflective teaching and adaptive decision-making conditions are cultivated through constant exposure to algorithmic feedback and learning analytics (Kyambade et al., 2025; Rodrigo et al., 2022). Nonetheless, unlike certain studies where resistance to AI adoption because of cognitive rigidity Wei et al. (2025) was reported, the current results show that adaptive mindset can contribute strongly to counter technological resistance and promote the transformation of instruction. Fourth, the paper established that the self-efficacy of technology and adaptive learning mindset follow a sequential mediation process, which proves H₄. This finding can give a more profound understanding of how an instructional innovation works through the process of psychological transformation. In particular, Human-AI collaborative teaching serves to boost teacher confidence in the utilization of AI tools, which, in its turn, promotes their adaptive cognitive orientation towards ongoing learning and refining of their instructions. This step-by-step process is in line with the SCT-based dynamic learning models, Mohamed (2026); Zhang et al., (2025) and in-line with the results of Xu (2026) and Asamoah and Amarteifio (2025) who indicated that self-efficacy tends to come before cognitive adaptability in technology-rich settings.

Notably, the research enhances the previous studies by empirically confirming a two-way psychological process, which was mostly ignored in previous single-mediator models (Bangulzai et al., 2025; Guberina and Prochazka, 2026). On the whole, the results indicate that instructional innovation cannot be referred to as a direct consequence of the AI integration but a multi-layered

process that presupposes the development of cognitive confidence and adaptive mindset. This promotes socio-technical arguments that technological systems are not enough without the need to have the psychological preparedness (Hazaimah and Al-Ansi, 2024). Moreover, the findings also lead to the emergent discussions of educational futures literature, which highlights the necessity of human-focused AI integration into teaching practices (Vistari et al., 2025; Wang and Wang, 2026). The research incorporates three theoretical perspectives, namely, STS, SCT, and mindset theory, to provide a more detailed explanation of the process of AI-based educational change in the context of actual classrooms. In summary, though past studies have independently looked at technology adoption, self-efficacy and mindset, the current study offers a comprehensive and integrated framework that shows how the three interrelate to influence instructional innovation. The fact that the results were consistent with the previous literature also makes the model very robust, whereas the slight differences in the conceptualization indicate the significance of the context-specific dynamics in the development of the educational system like in Jordan.

5.1. Theoretical Contributions

The theoretical contributions presented in this research are very robust as they combine the STS, SCT and the Mindset Theory into one comprehensive explanatory model of instructional innovation in the Human-AI teaching collaboration settings. To begin with, the study stretches the theory which, according to the STS view, empirically confirms that AI is not just a technical instrument but a co-active instructional collaborator that leads to pedagogical change (Rodrigo et al., 2022; Song et al. 2024). This reinforces the point that innovation in education is the result of a system of interaction between the technological systems and human agency, not technology itself (Bali et al., 2024). Second, SCT is expanded with the introduction of positioning technology self-efficacy as a dynamic mediator instead of a static belief, demonstrating that the ongoing experience of interacting with AI systems enhances the confidence of teachers and transforms it into an innovative teaching behavior (Qassrawi and Al Karasneh, 2025; Raisch and Krakowski, 2021). This is added to the recent discussions that self-efficacy should be viewed in developing digital environments, instead of in the real classroom (Ali, 2025; Devanadera., 2025). Third, Mindset Theory is developed with the incorporation of adaptive learning mindset as a digital age supplement of the growth mindset, with a focus on the responsiveness to the AI-generated feedback and real-time data (Shao et al., 2025; Mohamed, 2026). The research also adds to the existing body of research by validating a cascading psychological model between self-efficacy and adaptive mindset, an organization hardly investigated in previous research of educational AI (Kyambade et al., 2025; Beirat et al., 2025). Together, this combined model give us a more in-depth theoretical clarification of how Human-AI collaboration change the learning innovation in new learning ecosystems.

5.2. Practical Implications

The results of this research provide valuable practical implications to policy makers, school administrators and teacher training programs. First, it is crucial that Human-AI collaborative teaching plays a prominent role which means that educational systems must

facilitate the adoption of AI-based teaching classrooms where educators are not only encouraged to design their instruction collaboratively with intelligent systems but also use them as a secondary tool (Xu, 2026; Shao et al., 2025). The allocation of resources towards AI-based infrastructure and adaptive learning platforms, thus, plays a crucial role in boosting instructional innovation. Second, the mediating effects of technology self-efficacy emphasize the necessity of the continual program of professional development aimed at the development of teachers confidence in the use of AI tools. Perceived competence of teachers can be positively influenced by training workshops, learning based on simulations, and hands-on learning experiences in digital pedagogy (Guberina and Prochazka, 2026; Qassrawi and Al Karasneh, 2025). In the absence of this trust, the use of AI superficial and not translate to innovation. Third, it is also important to promote an adaptive learning attitude. Educational leaders must promote reflective practices related to teaching, the use of feedback, and professional cultures that promote experimental AI-based teaching (Kyambade et al., 2025; Li and Kim, 2024). The schools must also create conducive environments where there is no fear of technological change and continuous learning should be encouraged. Lastly, the sequential mediation result indicates that the psychological factors should not be isolated when engaging policy interventions. Rather, joint capacity-building approaches that can boost self-efficacy and adaptive thinking concomitantly would be more effective in generating long-lasting instructional innovation within AI-based education systems.

6. CONCLUSION

This paper explored the association between the Human-AI collaborative teaching and instructional innovation among teachers in Jordan with the mediating variables being technology self-efficacy and adaptive learning mindset. The results affirm that Human-AI collaboration has a significant positive impact on instructional innovation both directly and indirectly in psychological channels. In particular, technology self-efficacy and adaptive learning mindset are essential parallel and consecutive to changing the AI engagement into new teaching practices. The research adds to the theory by merging STS, SCT, and Mindset Theory into a single framework, which provide a more comprehensive view of how AI-based transformation can be applied to education. In practice, it underscores the need to build the technological confidence and adaptive cognitive skills of teachers to make the best use of AI in education. In general, the research reveals that the introduction of instructional innovation in the age of AI not only relies on the existence of technologies but is more complex due to the psychological preparedness and adaptability of the teachers in the new learning environment.

This study has a few limitations although it has made contributions. First, it has a cross-sectional nature which does not allow concluding about causal relations between human-AI collaborative teaching and instructional innovation. The longitudinal or experimental designs must be used in future studies in order to study the changes in these relationships as time goes by. Second, self-reported data could also bring about common method bias and social desirability effects, indicating that the multi-source

data collection should be employed in future research. Third, the research is carried out with only Jordanian teachers, which could restrict the extrapolation to other cultural and educational environments. The model should be replicated in various countries in future studies to ensure cross-cultural applicability. Fourth, even though the study has two mediators, additional applicable variables like AI anxiety, digital leadership or organizational support have not been analyzed. These variables should be combined in the future researches in order to come up with more detailed models. Last but not least, qualitative research methods might be considered in the future to learn more about how teachers feel about human-AI collaboration in the real classroom environment, gaining a deeper insight into behavioral and emotional aspects of AI-based teaching change.

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