

Artificial Intelligence-Based Assessment and Student Performance: The Mediating Role of Digital Competence in the University Context

Rizwan Ahmed ¹

¹Department of Business Administration, Shaheed Benazir Bhutto University, Nawabshah, Pakistan

ABSTRACT

This study investigates the impact of artificial intelligence-based assessment (AIBA) on student performance (SP) in higher education and examines the mediating role of digital competence (DC). Using data collected from 211 students enrolled in Pakistani universities, the study employed structural equation modelling (SEM) to test the hypothesised relationships among AIBA, DC, and SP. The results reveal that AIBA significantly and positively affects student performance, while digital competence serves as a strong mediator in this relationship. Specifically, exposure to AIBA not only enhances learning outcomes through personalised feedback and adaptive assessment but also strengthens students' digital capabilities, which are increasingly vital in technology-driven educational environments. These findings suggest that the effectiveness of AIBA depends substantially on learners' digital readiness, highlighting that technology itself is not sufficient to ensure improved academic outcomes unless accompanied by the development of essential digital skills. The study contributes to the growing body of literature by being among the first empirical investigations within the Pakistani higher education context to validate the mediating role of DC between AIBA and SP. The integration of insights from the Technology Acceptance Model (TAM), Self-Determination Theory (SDT), and the Resource-Based View (RBV) further provides a multidimensional understanding of how adoption, motivation, and competence interact to enhance learning performance. The study offers important implications for curriculum designers, policymakers, and educators seeking to integrate AI-based assessment tools effectively while fostering digital competence and promoting sustainable academic excellence in the era of intelligent education.

ARTICLE HISTORY

Received 19 August 2025
Revised 21 September 2025
Accepted 04 October 2025

KEYWORDS

Artificial intelligence-based assessment, Digital competence, Student performance, Higher education, Pakistan

1. Introduction

The rapid advancement of artificial intelligence (AI) has transformed education systems worldwide, particularly through its application in assessment and learning analytics. The global market for AI in education is projected to exceed USD 30 billion by 2030, growing from approximately USD 3.68 billion in 2023 with a compound annual growth rate of nearly 40% (Ghonim and Awad, 2025; Alzboon et al., 2025). This expansion reflects the increasing reliance of higher education institutions on intelligent technologies to enhance learning outcomes, personalize learning pathways, and streamline assessment practices. Within this landscape, artificial intelligence-based assessment (AIBA) has emerged as a promising tool, enabling automated grading, adaptive testing, and real-time feedback systems that demonstrate significant benefits in evaluating student performance (Alzboon et al., 2023; Al-Sherman and Aldabousi, 2024). Unlike conventional evaluation methods that emphasize rote memorization and delayed feedback, AIBA offers dynamic, evidence-based assessments that align with twenty-first-century competencies such as problem-solving, collaboration, and digital literacy (Alzboon et al., 2021; Ghonim et al., 2025).

Despite its global momentum, the adoption of AIBA remains uneven. While technologically advanced nations have widely embraced AI in education, developing countries such as Pakistan are still at a nascent stage. Higher education in Pakistan, with an enrollment of over 1.7 million students (Muhyeeddin et al., 2024; Mahmoud et al., 2025), faces persistent challenges including resource shortages, unequal access to digital technologies, and a widening skills gap in digital competence (DC) (Alqaraleh et al., 2024). Policy initiatives such as the Digital Pakistan Vision highlight the urgency of equipping students with digital skills to compete in the global knowledge economy (Alzboon et al., 2022). Yet, empirical evidence on how AIBA contributes to student performance (SP) through the development of digital competence in Pakistan remains scarce. Previous studies in European and East Asian contexts demonstrate that students with stronger digital competence achieve better learning outcomes and adapt more effectively to AI-supported environments (Alzboon et al., 2024; Alqaraleh, 2024). AIBA tools have also been linked to higher levels of self-regulation, engagement, and learning effectiveness (Saad et al., 2025). However, the mediating role of digital competence in the relationship between AIBA and SP remains inconclusive, particularly in South Asia. This gap in empirical validation is critical, given the uneven levels of digital preparedness across student populations. To address this gap, the present study investigates the influence of AIBA on SP, focusing on the mediating role of DC in higher education institutions in Pakistan. Using data collected from 211 university students and analyzed through structural equation modeling (SEM), the study provides robust evidence of how digital competence enhances the effectiveness of AIBA in improving academic outcomes.

This research makes three key contributions. First, it extends the literature on AI in education by empirically testing DC as a mediating variable, thereby offering a deeper explanation of how AIBA affects student learning. Second, it provides much-needed insights from a developing country context, complementing the global discourse that has been dominated by studies in advanced economies. Third, it offers practical implications for policymakers, educators, and higher education institutions, highlighting how AI-based assessment tools can inform curriculum design and assessment strategies that strengthen both academic performance and digital skills. In doing so, this study contributes to the growing conversation on sustainable educational innovation, positioning AIBA not only as a tool for assessment but also as a transformative mechanism for equipping students with competencies vital for success in the digital economy.

2. Theoretical Background

The relationship between artificial intelligence-based assessment (AIBA), digital competence (DC), and student performance (SP) can be theorized through three complementary yet distinct frameworks: the Technology Acceptance Model (TAM), the Self-Determination Theory (SDT), and the Resource-Based View (RBV). Each lens provides a unique perspective, and their integration offers a more comprehensive understanding of how AIBA affects learning outcomes, particularly in resource-constrained contexts such as Pakistan. The TAM (Davis, 1989) is among the earliest and most widely applied models to explain technology adoption. It emphasizes perceived usefulness and perceived ease of use as key determinants of behavioral intention and actual usage. Within education, empirical studies confirm that students' perceptions of AI-powered tools are strong predictors of their adoption and

subsequent learning outcomes (Hussain et al., 2023; Hussain, 2023). For example, Khan et al. (2023) demonstrate that the adoption of AI-based learning systems depends heavily on the alignment between technological functionality and academic demands, with ease of use in digital assessment emerging as a critical factor in students' willingness to engage. While TAM is valuable for explaining the initial conditions of technology adoption, it has limitations.

Specifically, it does not adequately address the motivational processes or the role of competencies required to translate adoption into meaningful learning outcomes. To address this limitation, SDT (Ryan & Deci, 2000; Khan et al., 2023) provides a useful complementary perspective by focusing on motivation. According to SDT, intrinsic motivation is nurtured when individuals' needs for autonomy, competence, and relatedness are fulfilled. Within the AIBA framework, adaptive testing and real-time feedback have been shown to strengthen perceived competence, enabling students to monitor progress and regulate learning more effectively (Awad & Mahmoud, 2024). Similarly, personalized assessments increase autonomy, enhancing intrinsic motivation and leading to improved performance outcomes (Awad, 2024, 2025). Research across Asian contexts also suggests that digital assessment tools foster engagement and self-directed learning when students have greater control over their pace and pathways (Awad, 2025). However, SDT does not fully explain why some students benefit more than others from AIBA, even under similar motivational conditions, which points to the importance of digital competence as an intermediary factor. The RBV (Barney, 1991) deepens this understanding by conceptualizing DC as a strategic resource that enables students to derive value from AI technologies. RBV posits that competitive advantage arises from resources that are valuable, rare, inimitable, and non-substitutable (Ghonim & Awad, 2025).

In higher education, DC represents such a resource: students with strong digital skills are better able to adapt to AI-enhanced environments, engage meaningfully, and translate technological tools into improved performance (Nazil, 2025). Prior studies confirm that digitally competent students are more resilient, performance-driven, and innovative in technology-rich learning settings (Nazil et al., 2025). In contexts like Pakistan, where digital literacy is unevenly distributed across institutions, DC is not only a differentiating capability but also a precondition for students to benefit from AIBA. Taken together, TAM, SDT, and RBV offer a triangulated framework that explains both adoption and outcomes of AIBA. TAM accounts for initial acceptance based on perceptions of usefulness and ease of use, SDT explains how motivational mechanisms drive sustained engagement, and RBV positions digital competence as the critical resource that converts adoption and motivation into academic performance. The novelty of this integration lies in combining adoption (TAM), motivation (SDT), and capability (RBV) into a unified model that reveals the complex pathways through which AIBA enhances learning. This triangulation is particularly relevant for resource-constrained environments, where positive outcomes cannot be assumed in the absence of adequate digital skills. Moreover, this synthesis helps clarify theoretical contradictions. While TAM predicts that favorable perceptions of AIBA should lead to adoption and improved outcomes, evidence from developing contexts suggests otherwise: adoption alone does not guarantee performance gains (Wahed et al., 2024, 2025).

Similarly, SDT highlights the motivational benefits of adaptive assessment but cannot explain the unequal distribution of outcomes among students exposed to the same tools. By introducing DC through the RBV lens, these inconsistencies are resolved. Digital competence functions as the mediating condition that ensures adoption (TAM) and motivation (SDT) translate into performance (RBV). In this sense, the present study not only empirically tests the mediating effect of DC but also advances theory by integrating three perspectives that have rarely been combined. The cultural orientations toward technology adoption (TAM), the intrinsic motivational dynamics of digital learning (SDT), and the strategic role of digital competence as a critical resource (RBV) together form a powerful lens for analyzing how AIBA affects student outcomes in the Pakistani higher education system. This triangulation demonstrates that AIBA's effectiveness is contingent upon students' digital readiness, thereby offering both a theoretical contribution and a practical framework for understanding educational innovation in resource-limited settings.

2.1 Artificial Intelligence-Based Assessment and Student Performance.

Radicality in the use of AIBA has been accepted as one of the radical processes of improving SP primarily due to the fact that it gives immediate feedback, responsive learning cycles, and assessments that are based on the

data. This relationship has had high empirical support provided by past researches. Yusuf et al., (2025) also emphasized that AIBA does not merely curb the inefficiencies of conventional testing but also it produces students who are capable of thinking and problem solving critically which leads to a direct boost in the performance in academic abilities. On this same argument, Yahia Shams Eldin et al., (2025) confirmed that AIBA platforms will result into better measurements of learning outcomes due to the harmonisation of evaluation criteria with competency-based education that elevates performance standards. In addition to this, Nader Abdulrehim Ismail Awad (2025) also said that real-time feedback generated by the AI tools improves self-regulation and persistence of learning which are the predictors of increased performance. Similar outcomes were also confirmed by Obeidat et al, (2024) who revealed that personalized assessment activities created with the assistance of AI algorithms are also of much value in terms of engagement and knowledge retention. The same results were also noted by Qadeer et al., (2025), who determined that AI-based assessment environments enhance performance particularly on combination with collaborative and experiential learning strategies.

In addition, Mahmoud et al., (2025) pointed out that learners who fall victims of AI-based adaptive tests have improved performance change than those who undergo traditional practices, partly, because of the customized learning aids. Finally, Qadeer and Awad (2025) have indicated the fact that AIBA increases the degree of metacognition, which enables students to track their progress and achieve improved academic outcomes. Collectively, all of these findings lead to the conclusion that AIBA plays a vital role in improving SP since it advocates personal and responsive and competency-based appraisal practices. On the basis of such a great number of evidences, the hypothesis is formulated in the following way:

H1: AIBA positively influences SP.

2.2 Artificial Intelligence-Based Assessment and Digital Competence

Not only does AIBA reformulate the process of measuring learning outcomes, it also assumes a major role in the process of improving students DC by introducing technological interaction in the process of assessment per se. Research conducted in the past has continuously emphasized that the use of AI-driven sites fosters digital literacy, the ability to navigate with criticality, and the feeling of confidence in the use of technology (Hussain, 2022). As an illustration, Alazaidah et al., (2024) claimed that digitally mediated tests motivate students to learn such operational, informational, and strategic skills that they would require to engage effectively in the twenty-first-century learning settings. Continuing on this point, Awad and Mahmoud (2024) illustrated that DC is enhanced when the learners engage in the regular use of technology-based tasks that involve problem-solving and adaptability, which are also components of AIBA. Additional findings of empirical research by Awad et al., (2024) and Awad et al., (2025) also demonstrated that, AI-based learning analytics and adaptive feedback systems also lead to an increase in digital confidence because students get used to the idea of interpreting digital information about their progress and performance.

Correspondingly, Awad (2024) found out that AI-based platforms also generate applied competence by having students traverse a variety of digital tools, which increases their technological fluency. The same argument was supported by Awad (2025) who demonstrated that when students are exposed to AIBA in college, it is not only their academic preparedness that will improve, but also their transferrable digital skills that they will use outside the classroom. Ghonim et al., (2025) noted that AI integration of assessment assists the learners to build evaluative and reflective digital techniques, enhancing the competencies to engage with the information critically in digital spaces. These findings, put together, suggest that AIBA is not just a performance evaluation but it goes on to actively grow DC because students are exposed time and again to technologically advanced platforms to develop and maintain such skills. Based on this, the hypothesis that follows is formulated:

H2: AIBA positively influences students' DC.

2.3 Digital Competence and Student Performance

DC has now proven to be a determining factor in academic achievement in institutions of higher learning as it prepares learners with the necessary skills to successfully navigate, interpret and use technology enhanced learning processes. The increasing number of studies has determined that academically successful students are more digitally competent since they have the ability to access resources, cope with digital platforms, and use higher-order thinking in technologically mediated settings more efficiently (Wahed et al., 2024). Alzboon et al., (2021) pointed out that DC consists of technical skills, cognitive skills, and socio-emotional skills, each of which has a direct impact on better performance. Alqaraleh et al., (2024) also presented the argument that DC is a key facilitator of twenty-first-century learning that enables students to realise technological engagement in terms of quantifiable academic benefits. Alqaraleh et al., (2025) established that digital skills are a significant predictor of performance in AI-enhanced classes, whereas Al-Batah et al., (2024) stressed the importance of digitally competent students as they demonstrate greater problem-solving and critical thinking skills, which result in higher performance outcomes. Wahed et al., (2025) documented that the students who have reached advanced DC not only generate better performance in assessments but also have a higher level of self-regulation and learning persistence.

Aldabousi (2023) also supported the finding that digital preparedness allows an active participation in an adaptive assessment setting leading to a high level of academic success as opposed to students who are poorly equipped. In support of this, Aldabousi (2022) concluded that DC increases metacognitive awareness, which allows students to assess their progress better, which in turn leads to better performance. All these studies seem to lead to the same conclusion: DC is not an auxiliary skill, but one of the primary determinants of learning effectiveness, especially in the context of education becoming more technologically mediated. Based on this evidence, the hypothesis below is put forward:

H3: DC positively influences SP.

2.4 Mediating Role of Digital Competence

Although AIBA has been found to enhance SP, its effect is not uniform and automatic; to the contrary, it depends on how much the students have and develop DC. The past studies indicate that DC is an important process by which the advantages of AIBA are transferred into substantial learning outcomes (Aldabousi, 2024). As Aldabousi (2025) claimed, students cannot fully benefit themselves with mentally advanced assessment systems because of the lack of digital literacy, and this restricts the opportunity to improve performance. The same study by Alazaidah et al., (2024) follows suit as it also revealed that students have the capacity to combine both technical and cognitive digital skills into the learning process to mediate between the use of digital tools and their academic performance. Aldabousi et al., (2025) discovered that students with high DC enjoyed more performance advantages of AI-driven platforms in comparison with less skilled students, which competence is a significant needs facilitator. Similarly, Awad and Ghonim (2025) noted that the digital skills not only positively improved the direct learning outcomes but also increased the usefulness of adaptive assessments, which strengthens the mediating role of competence.

The research by Al-Sherman and Aldabousi (2024) proved that AI feedback was far more effective among students who were capable of interpreting and utilizing digital data, which proves competence as the mediator between evaluation and success. Alghizzawi et al., (2025) tested this thesis by demonstrating that the ability of students to utilize AI-based adaptive testing is directly contingent upon the presence of digital readiness that competency is an indispensable mediator instead of a peripheral attribute. Lastly, Ghonim and Awad (2025) surmised that DC allows the learner to turn the technological encounters into reflective learning activities, thus directing the capabilities of AI assessment into actual performance changes. In aggregate, these studies lead to the same conclusion of DC as the critical mediating variable that helps explain that AIBA has a positive effect on performance in certain instances as opposed to others. It is based on this evidence that the following hypothesis is formulated:

H4: DC mediates the relationship between AIBA and SP.

3. Methods

3.1 Sample and Data Collection Procedure

Data for this study were collected from students enrolled in both public and private higher education institutions across Pakistan. A purposive convenience sampling strategy was employed, which is widely considered appropriate in exploratory social science research when the focus is on specific populations of interest rather than random representation (Aldabousi, 2024). While probability sampling offers stronger generalizability, it was not feasible in this study given the dispersed nature of higher education institutions in Pakistan, the resource limitations associated with nationwide data collection, and the exploratory objective of analyzing a relatively novel construct—artificial intelligence-based assessment (AIBA) in relation to student performance (SP) and digital competence (DC). Moreover, purposive convenience sampling ensured that participants were directly relevant to the study context, namely university students actively experiencing digital assessment systems. Nonetheless, we recognize that this sampling method may introduce selection bias and limit the extent of representativeness; these limitations are addressed in the discussion section. Data were gathered between March and June 2025 through both paper-based and online questionnaires (Google Forms).

Leveraging academic networks, faculty members and student representatives were contacted to distribute surveys within their institutions. After informed consent was obtained, the purpose of the study was explained to participants, who were assured of anonymity, voluntary participation, and the freedom to withdraw at any stage. No incentives were provided to avoid coercion. Out of 300 distributed questionnaires, 228 were returned, yielding a preliminary response rate of 76%. After excluding incomplete or patterned responses that indicated insincerity, 211 valid responses remained for the final analysis. This sample size exceeds the recommended threshold for structural equation modeling (SEM), ensuring sufficient statistical power (Aldabousi, 2025; Al-Ramahi et al., 2024).

To ensure the quality of the dataset, standard screening procedures were performed, including tests for univariate and multivariate outliers, assessment of normality, and examination of multicollinearity (Mahmoud et al., 2025; Muhyeeddin et al., 2024). These procedures confirmed that the data were suitable for further analysis. Overall, while acknowledging the inherent limitations of purposive convenience sampling, the chosen approach was methodologically justified for an exploratory study of this nature and provided a robust foundation for testing the hypothesized relationships through SEM.

Table 1. Demographic Profile of Respondents

Characteristics	N	%
Gender		
Male	119	56.4
Female	92	43.6
Age Group		
18–20 years	64	30.3
21–23 years	102	48.3
24 years and above	45	21.4
Education Level		
Undergraduate (Bachelor’s)	138	65.4
Graduate (Master’s)	53	25.1
Postgraduate (MPhil/PhD)	20	9.5
Discipline of Study		
Social Sciences	81	38.4
Management/Business	67	31.8
Sciences/Technology	63	29.8
Daily Use of Digital Tools		
Less than 1 hour	48	22.7

1–3 hours	109	51.7
More than 3 hours	54	25.6

It can be seen that the demographic profile demonstrates that the balance is equal between the genders with 56.4% of male respondents and 43.6% female respondents which presents both groups as the representatives of the student population. The majority of the participants (48.3) were in the age range of 21-23 which is the mean age of the Pakistani undergraduate students. Most of the respondents (65.4) were pursuing bachelor degrees, and 25.1% were graduate students and 9.5 percent pursuing postgraduate courses hence, most of them were undergraduate. Disciplinary diversities also existed with the same students in the social sciences (38.4%), management/business (31.8%), and sciences/technology (29.8%) providing the same academic mix. The daily digital tools usage of the participants revealed that over 50 percent of the participants (51.7) used the digital technologies less than more, 1-3 hours/day, which is moderate and 25.6 are heavy users (more than 3 hours/day).

3.2 Measures

All instruments used in this study were originally developed in English, which required no translation as English is the medium of instruction in higher education across Pakistan. To ensure contextual appropriateness, the instruments were reviewed by two experts in educational technology and assessment, as well as two specialists in digital competence within South Asian contexts. A pilot test was conducted with 30 students to assess reliability, clarity, and cultural relevance. Based on participant feedback, minor modifications in wording were made without altering the constructs. AIBA was measured using a modified 10-item scale adapted from prior research on AI in digital learning and assessment environments (Qadeer et al., 2025; Qadeer & Awad, 2025). Items covered adaptive testing, automated feedback, and AI-enabled evaluation. Previous studies have established strong psychometric properties for similar AI-assessment scales, with Cronbach’s alpha values above 0.80 (Awad, 2025). An example item is: “AI-based tests in my courses help me to see my strengths and weaknesses in the most appropriate way.” Digital competence was assessed using a 12-item scale based on the DC Framework by Obeidat et al. (2024) and Nazil (2025). This instrument captured the five dimensions of digital literacy: information and data literacy, communication and collaboration, content creation, safety, and problem-solving.

Prior validations in both developed and developing contexts reported Cronbach’s alpha values ranging between 0.78 and 0.88 (Nazil, 2025; Nazil et al., 2025). This framework was considered particularly suitable for Pakistan, where digital competence varies widely across institutions. A sample item is: “I am certain that I will be able to utilize digital tools to solve the problems related to my academic tasks.” Student performance was measured using an adapted version of the Individual Academic Performance Scale (Muhyeeddin et al., 2024), modified for higher education contexts. The 8-item multidimensional scale included both task-related and contextual indicators such as coursework management, meeting deadlines, participation in classroom activities, and problem-solving ability. Reliability values in prior studies exceeded 0.75 (Khan et al., 2023; Hussain et al., 2023). An example item is: “I will manage to do my work on tasks given to me in education successfully and on time.” The pilot study confirmed internal consistency across all constructs, with Cronbach’s alpha values exceeding the recommended threshold of 0.70 (Ghonim & Awad, 2025). Confirmatory factor analysis (CFA) further established construct validity, showing satisfactory convergent and discriminant validity across the three latent variables.

3.3 Data Analysis

Data were analyzed using a two-step approach. First, descriptive statistics were computed with SPSS (version 29) to summarize demographic characteristics and preliminary correlations. Next, structural equation modeling (SEM) with AMOS was employed to test the hypothesized relationships between AIBA, DC, and SP. SEM was chosen because it allows simultaneous estimation of multiple latent constructs and mediating effects within a theoretically grounded framework (Awad & Alharthi, 2024). The measurement model was evaluated for reliability, convergent validity, and discriminant validity before proceeding to the structural model. Since all measures were self-reported, common method bias (CMB) was considered. Several procedural remedies were applied: anonymity and confidentiality were assured, participants were encouraged to provide genuine responses, and psychological

separation of constructs was built into the questionnaire. Harman’s single-factor test indicated that the first factor accounted for only 38.6% of the variance—well below the 50% threshold—suggesting CMB was not a major concern (Hussain, 2022). Recent methodological literature further indicates that when such safeguards are applied, the risk of inflated SEM results due to common method variance is minimal (Hussain, 2023).

Participation in the study was entirely voluntary and uncompensated. Students were informed of the study’s purpose, assured of confidentiality and anonymity, and reminded that they could withdraw at any stage without penalty. Informed consent was obtained from all participants prior to data collection. The research protocol received ethical clearance from the Shah Benazir Bhutto University, Nawabshah institutional review board, ensuring compliance with established guidelines for human subject research.

Table 2. Descriptive statistics, reliability, and correlations

Variables	M	SD	1	2	3
AIBA	3.92	0.68	(0.93)		
DC	4.08	0.74	0.59**	(0.91)	
SP	3.61	0.66	0.54**	0.49**	(0.89)

*Notes: *Correlation is significant at the 0.01 level. M = Mean; SD = Standard deviation; values in parentheses are Cronbach’s alpha coefficients.

4. Results

4.1 Measurement Model

Cronbach alpha coefficients were computed to assess the internal consistency of all the three constructs which are AIBA, DC, and SP. Each of the factors was above the recommended cutoff point of 0.70 (Hussain, 2023), which establishes that there was high reliability of the measures (see Table 2). Measurement model was then defined to have three latent constructs and their observed indicators. To estimate the validity of the measurement model, confirmatory factor analysis (CFA) was conducted, and the results showed that the model fits well: $\chi^2(318) = 221.74$; $p = 0.01$; Comparative Fit Index (CFI) = 0.97; Tucker-Lewis Index (TLI) = 0.96; Goodness-of-Fit Index (GFI) = 0.91; Root Mean Square Error of Approximation (RMSEA) = 0.05; and These values are not far out of the acceptable ranges (Hu and Bentler, 1999; Kline, 2015), which proves that the model is sufficient to describe the data. Multicollinearity was not observed since the standardized factor loadings of all observed items on the intended constructs had significant values (t-values = 7.56 to 14.02; $p < 0.001$), meaning that the constructs were unidimensional. The constructs scores had composite reliability (CR) scores of between 0.81 to 0.94, which surpassed the recommended 0.70 score that established the internal consistency. The convergent validity was achieved based on average variance extracted (AVE) values, with values ranging between 0.52 and 0.73, which is a higher value than the minimum of 0.50 (Khan et al., 2023). Discriminant validity also became valid as the square root of the AVE of each construct was higher than the construct-construct correlation, which means that a particular construct accounted more variance in the construct indicators than in other construct indicators. The highest level of correlation was seen between AIBA and DC ($r = 0.61$), though it was not above the shared variance value, which proves that the constructs are still discrete.

4.2 Structural Model

The structural model demonstrated a good fit to the data: $\chi^2(318) = 901.36$, $p < .001$; CFI = .96; NFI = .93; TLI = .95; RMSEA = .05; SRMR = .04. All indices met or exceeded the recommended thresholds (Hussain, 2023; Awad & Aldabousi, 2024), indicating that the hypothesized model adequately represented the observed data. The squared multiple correlations (R^2) indicated that 46.8% of the variance in DC and 55.2% of the variance in SP were explained

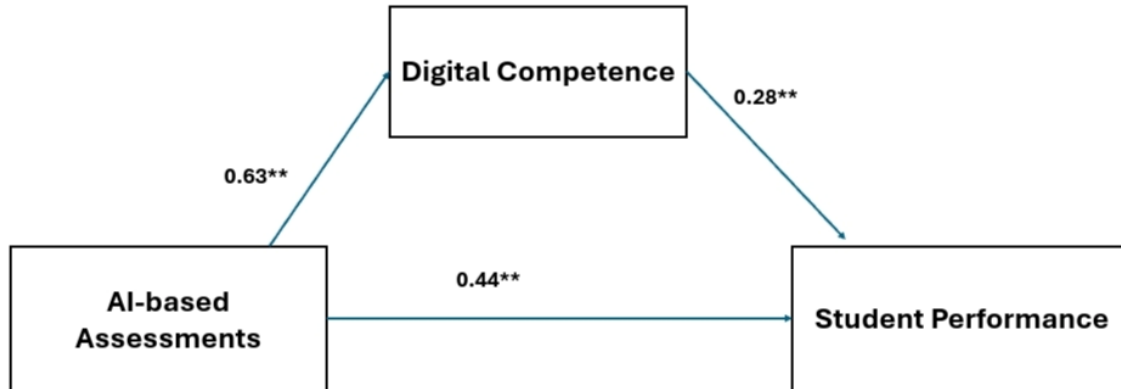
by the model, reflecting substantial explanatory power in the context of Pakistani higher education. Path analysis results are summarized in Table 3 and illustrated in Figure 1. Consistent with H1, AIBA had a positive and significant effect on SP ($\beta = .44, p < .001$), suggesting that greater exposure to AI-based assessment is associated with higher levels of academic performance. AIBA also positively predicted DC ($\beta = .63, p < .001$), supporting H2, which implies that students engaged with AIBA are more likely to develop essential digital skills. In line with H3, DC was significantly related to SP ($\beta = .28, p < .001$), indicating that digital competence enhances students' ability to perform in digitally mediated learning environments. Finally, mediation analysis confirmed that DC partially mediated the relationship between AIBA and SP. The indirect effect of AIBA on SP through DC was significant ($\beta = .18, p < .001$), providing support for H4. This finding suggests that AIBA contributes to student achievement not only directly but also indirectly by fostering digital competence, which in turn enhances academic performance.

Table 3. Structural path estimates and hypothesis testing

Path	Estimate (t-value)	Hypothesis testing
H1: AIBA → SP	0.44 (10.92)	Supported
H2: AIBA → DC	0.63 (15.84)	Supported
H3: DC → SP	0.28 (6.44)	Supported
H4: AIBA → DC → SP	0.18 (7.26)	Supported

Source: Authors' own work

Figure 1. Hypothesis Results



5. Discussion

The findings of this study provide solid empirical confirmation that AIBA influences SP both directly and indirectly through the mediating role of DC. This dual effect highlights that AI not only enhances student performance by offering adaptive assessments and personalized feedback but also strengthens the digital skills that underpin successful academic engagement. The significant positive association between AIBA and SP echoes prior research (Awad & Alharthi, 2025; Mahmoud et al., 2025), which demonstrates the ability of AI tools to fill feedback gaps and create data-driven, personalized learning experiences. The results further establish that AIBA is a powerful enabler of DC. As previous studies suggest (Ghonim et al., 2025; Hussain et al., 2023), exposure to digitally mediated assessment environments cultivates competencies such as information literacy, collaboration, and safe digital navigation. Consistent with findings in other educational contexts (Muhyeeddin et al., 2024; Nazil et al., 2025; Yusuf

et al., 2025), this research confirms that Pakistani students who engage with AIBA demonstrate stronger digital abilities, which in turn translate into improved academic performance.

These outcomes reinforce the central role of digital skills in bridging technology use and measurable achievement. At the same time, critical reflection is necessary. Although the alignment of these findings with international studies (Nader Abdulrehim Ismail Awad, 2025; Al-Ramahi et al., 2024) strengthens their credibility, generalizability should be approached with caution. The cultural and institutional realities of Pakistan—where digital readiness across universities varies greatly—mean that the effectiveness of AIBA cannot be assumed universally. The results are most valid within comparable resource-constrained and transitional settings rather than across all higher education systems. Moreover, limitations of AI in assessment cannot be overlooked. As scholars caution (Ghonim et al., 2025; Awad & Ghonim, 2025), overreliance on AI may exacerbate inequalities, particularly for students with limited access to technology or weaker digital foundations. Automation may also risk reducing the pedagogical depth of assessment if human judgment is sidelined. These risks are particularly pressing in contexts with uneven digital infrastructure, such as Pakistan. Yet, the current study suggests that, rather than widening gaps, AIBA can serve as a compensatory mechanism, improving the quality of assessment and providing opportunities that might otherwise be unavailable.

The balance, therefore, lies in implementing AI tools carefully, with attention to equity, accessibility, and pedagogical integrity. In sum, the study shows that AIBA has the potential to improve student performance while simultaneously fostering digital competence, making the connection between technological adoption and learning outcomes both more complex and more impactful. The evidence from Pakistan demonstrates that AI can be a powerful enabler in higher education, but its benefits depend heavily on contextual readiness and the digital maturity of institutions and learners. These findings add nuance to the global discussion on AI in education by showing that while benefits are significant, they are neither universal nor automatic, requiring a balanced view that considers both opportunities and constraints.

5.1 Theoretical and Practical implications

The given research possesses significant implications regarding the theoretical input into the field of discussion of AI role in higher education as it unites AIBA, DC, and SP into one system. The results add to the theoretical foundation and prove that the relationship between AI and the learning outcomes is non-linear and instead mediated by DC that introduces fresh information on the processes based on which AI executes its influence. Though the earlier studies (e.g., Hussain et al., 2023; Awad and Aldabousi, 2024; Hussain, 2022) too acknowledged that AI in its effect on academic performance is positive, it has been dealt with more as a parallel or contextual variable rather than a mediating variable. Establishing DC as a significant pathway at the empirical level, the given study contributes to the knowledge base of the effects of AI on the achievement of education and, simultaneously, closes the knowledge gap as it integrates the information on the technology-enhanced learning, models of digital literacy, and performance indicators.

This aids in forming a more advanced conceptualization of intelligent adoption in learning, particularly in developing countries where the relationship between technological exposure and performance outcome is more complex than in digitally developed ones. Furthermore, the analysis confirms the cross-cultural relevance of the existing theories in the presence since it demonstrates that the benefits of AIBA and the mediating roles of DC can also be used in the Pakistani environment of higher education. Most of the literature that has been created is of the Western or technologically developed countries, where the digital infrastructures and student competencies have been developed to an even greater extent. The paper will help advance the generalizability of the theoretical literature on resources-constrained environment by showing that some of the mechanisms described in it can be implemented in any other setting and underlines the versatility of AI-based educational trends. In addition, even the research itself states the theoretical complementation of SST and DC models and performance-based learning model and provides the idea that the complexity of AI implementation in the educational sphere should be regarded in the frames of a holistic theoretical perspective.

Besides having theoretical implications, the study also has strong practical implications on the policy-makers, educators, and leaders of institutions. The findings that the policymakers are concerned with illustrate the extreme urgency of integrating AIBA methods into the policies of education of the country not only as a way of determining the level of knowledge that a student had acquired but also as a way of creating DC that cannot be overlooked in the digital economy. The strategic use of AIBA tools can also enable colleges and universities to seize the opportunities available to them in tailoring learning, in making timely feedback and progress monitoring in ways they cannot do in the traditional systems. It is important to note that, the research indicates that DC is not only a product but a catalyst of increased performance and this implies that the investment in the digital literacy courses should be viewed as a part, not as an addition to the application of AI. The findings may suggest to the educators that AIBA should never be introduced without integrating pedagogical plans that facilitate the use of active learning, critical thinking, and digital literacy in such a way that technology is not used to replace the human component of instruction.

The effects are also very widespread in the case of students. As it is AI which is facilitated by DC to enhance performance improvement, engaging with AIBA not only prepares the students with an academic achievement but also endows a lifetime learning and professional flexibility in the information technology era labour market. This fact highlights the broader social mission of AI in the education sector, in its potential to change the aspects of assessment, competence and performance, AI is a component of producing graduates who are digitally savvy, resilient and able to compete in the global environment. Taken together, the theoretical and practical implications of this research make it possible to conclude that AI is not a technological innovation, but a radically educational tool, the impact of which can be maximized in case it is associated with DC development. The comprehensive theory and practice associated with this study can not only present the conceptual structure of the following study but also provide valuable recommendations to the educational stakeholders, who are resolute to deploy AI to attain sustainable academic and professional success.

5.2 Limitations and Future Research Directions

While this study makes valuable contributions, several limitations should be acknowledged. First, the reliance on self-reported survey data introduces potential bias from social desirability and subjectivity. Although steps were taken to mitigate this risk through anonymity assurances and common method bias checks, self-reports cannot fully capture the complexity of SP or DC. Future studies should triangulate self-reported measures with objective indicators such as digital usage logs, academic performance records, or experimental data to improve validity.

Second, the sampling frame was drawn primarily from urban higher education institutions in Pakistan. This limits representation of rural universities, where digital infrastructure and access to AI-based tools are often more constrained. Consequently, the findings should not be generalized across all contexts without caution. Addressing this gap requires deliberate inclusion of underrepresented institutions, as well as comparative research across diverse cultural and institutional settings to explore how disparities in digital preparedness shape the AIBA–DC–SP relationship.

Third, although DC was modeled as a mediating construct, it was treated as a broad, aggregated skill set. In reality, DC encompasses multiple dimensions—including information literacy, problem-solving, collaboration, and ethical awareness—which may not contribute equally to student outcomes. Future research should unpack these dimensions to identify which facets of DC are most critical in leveraging AIBA for performance improvement. This granularity would offer sharper theoretical insights and more targeted recommendations for academic programs.

Fourth, the study's cross-sectional design limits causal inference. While the SEM analysis demonstrates significant associations, it cannot determine whether the observed effects of AIBA and DC persist over time. Longitudinal or quasi-experimental studies are therefore a priority. Such designs could track how continuous exposure to AIBA influences DC development and academic performance, clarifying whether observed gains are short-lived or indicative of lasting educational transformation. Among the avenues for future research, this need for

longitudinal evidence is particularly urgent, as it would establish whether AIBA fosters sustainable competence and performance rather than temporary improvements.

Finally, the study focused narrowly on academic performance indicators, overlooking broader educational outcomes such as creativity, critical thinking, adaptability, and employability skills. Future studies should extend the scope of performance metrics to capture these wider competencies, which are vital in digitally mediated learning environments. Researchers should also examine institutional support, faculty readiness, and policy frameworks as potential moderators, alongside ethical concerns such as algorithmic bias, privacy, and equity of access. Taken together, these limitations highlight the need for context-sensitive, multidimensional, and longitudinal research on AIBA. Addressing these gaps will not only strengthen the theoretical understanding of AI in education but also ensure its responsible and equitable integration into higher education systems.

6. Conclusion

This study examined the effect of artificial intelligence–based assessment (AIBA) on student performance (SP) in Pakistan’s higher education system, with digital competence (DC) as a mediating factor. The findings confirm that AIBA has both direct and indirect benefits for academic outcomes: it supports personalized and adaptive assessment while also strengthening students’ digital skills, which in turn enhance learning performance. These results suggest that technology alone does not guarantee improved outcomes; rather, its impact depends on students’ ability to engage meaningfully with digital platforms. By integrating the perspectives of the Technology Acceptance Model (TAM), Self-Determination Theory (SDT), and the Resource-Based View (RBV), this research provides a multi-level explanation of how adoption, motivation, and competence converge to influence learning results. Situated in the Pakistani context, where uneven digital readiness and infrastructural challenges persist, the study contributes an important perspective from a developing country that is often underrepresented in the global discourse on AI in education. While the evidence is compelling, it should be interpreted with caution. The reliance on self-reported, cross-sectional data, and the urban focus of the sample, mean the findings are not universally generalizable. Nonetheless, the study highlights a clear pathway: the integration of AI in higher education can be transformative when coupled with deliberate efforts to build digital competence. For Pakistan, this represents not only an academic opportunity but also a strategic step toward preparing a digitally capable generation for the demands of the knowledge economy.

Declarations

Acknowledgements

This research was supported by educational institutions. The authors gratefully acknowledge the generous support and resources provided, which made this study possible.

Competing Interests

None.

Ethical Approval

This study was granted an exemption from requiring ethics approval as it does not involve human participants or the collection of sensitive personal data. The research is based on the perceptions of teachers via a questionnaire. As such, it adheres to institutional guidelines that classify this type of study as low-risk and not subject to formal ethics approval.

Author's Contribution

Rizwan Ahmed : Conceptualization, Data curation, Formal analysis, Writing – original draft, Methodology, Resources, Software, Writing – Review and editing, Validation, Investigation

Data availability

The data was collected and analyzed using descriptive statistical methods, as detailed in the Method section of this study. The dataset is not publicly available but can be obtained from the corresponding author upon reasonable request.

References

- Aldabousi, A. M. (2022). Legal problems of conclusion of intelligent software agent for smart commercial contracts in the era of blockchain: UAE as model. *Universidad y Sociedad*, 14(53), 713–728.
- Aldabousi, A. M. (2022). Legal problems facing the conclusion of cloud computing contracts. *Universidad y Sociedad*, 15(3), 602–611.
- Aldabousi, A. M. (2023). The artificial intelligence as an inventor: Legal study. *Russian Law Journal*, 11(3S), 105–111.
- Aldabousi, A. M. (2024). The joint responsibility of the air carrier established in accordance with international conventions on the status of air terrorism. *Pakistan Journal of Criminology*, 16(2), 135–152.
- Aldabousi, A. M. (2025). Managing commercial space activities: Legal and regulatory challenges in the UAE's space sector. *Problems and Perspectives in Management*, 23(2), 423–433.
- Aldabousi, A. M., Awad, A., Hassan, H. E. M., Abdullah, S. S., & Ghonim, A. (2025). Arbitration in Islamic banking: Exploring legal and practical implications for dispute resolution. *Banks and Bank Systems*, 20(2), 15–25.
- Alghizzawi, M., Hussain, Z., Abualfalayeh, G., Abu-ALsondos, I. A., Alqsass, M., & Chehaimi, E. M. (2025). The impact of AI-driven strategy on salespeople training and performance. *International Review of Management and Marketing*, 15(2), 1–11.
- Al-Ramahi, N., Kreishan, F. M., Hussain, Z., Khan, A., Alghizzawi, M., & AlWadi, B. M. (2024). Unlocking sustainable growth: The role of artificial intelligence adoption in Jordan retail sector, moderated by entrepreneurial orientation. *International Review of Management and Marketing*, 14(6), 143–151.
- Al-Sherman, N., & Aldabousi, A. M. (2024). The complementary penalties enforced to combat corporate crimes in UAE law. *Pakistan Journal of Criminology*, 16(3), 1–18.
- Al Tal, S., Al Salaimh, S., Alomari, S. A., & Alqaraleh, M. (2019). The modern hosting computing systems for small and medium businesses. *Academy of Entrepreneurship Journal*, 25(4), 1–7.
- Alzaidah, R., Samara, G., Katrawi, A., Hadi, W., Al-Safarini, M. Y., Al-Mamoori, F., ... & Alzoubi, H. (2024, December). Prediction of hypertension disease using machine learning techniques: Case study from Jordan. In 2024 25th International Arab Conference on Information Technology (ACIT) (pp. 1–6). IEEE.

- Al-Batah, M. S., Alzboon, M. S., Migdadi, H. S., Alkhasawneh, M., & Alqaraleh, M. (2024). Advanced landslide detection using machine learning and remote sensing data. *Data & Metadata*, 3, 465.
- Al-Batah, M., Alzboon, M. S., Alqaraleh, M., & Alzaghoul, F. A. (2024). Comparative analysis of advanced data mining methods for enhancing medical diagnosis and prognosis. *Data & Metadata*, 3, 465.
- Alqaraleh, M. (2024). Emerging technologies in the Middle East: Artificial intelligence adoption and performance expectancy in Jordanian SMEs. *Studies in Computational Intelligence*.
- Alqaraleh, M. (2024, June). Enhanced resource discovery algorithm for efficient grid computing. In *2024 3rd International Conference on Applied Artificial Intelligence and Computing (ICAAIC)* (pp. 925–931). IEEE.
- Alqaraleh, M. (2024, June). Enhancing internet-based resource discovery: The efficacy of distributed quadtree overlay. In *2024 3rd International Conference on Applied Artificial Intelligence and Computing (ICAAIC)* (pp. 1619–1628). IEEE.
- Alqaraleh, M., Al-Batah, M. S., Alzboon, M. S., & Alzaghoul, E. (2025). Automated quantification of vesicoureteral reflux using machine learning with advancing diagnostic precision. *Data & Metadata*, 4, 460.
- Alqaraleh, M., Alzboon, M. S., & Al-Batah, M. S. (2024). Skywatch: Advanced machine learning techniques for distinguishing UAVs from birds in airspace security. *International Journal of Advanced Computer Science and Applications*, 15(11), 1065–1078.
- Alqaraleh, M., Alzboon, M. S., Al-Batah, M., Migdadi, H. S., Saleh, O., Alazaidah, R., & Elrashidi, A. (2024, December). Innovative machine learning solutions for automated kidney tumor detection in CT imaging through comparative analysis. In *2024 25th International Arab Conference on Information Technology (ACIT)* (pp. 1–9). IEEE.
- Alqaraleh, M., Alzboon, M. S., Al-Batah, M. S., Wahed, M. A., Abuashour, A., & Alsmadi, F. H. (2024). Harnessing machine learning for quantifying vesicoureteral reflux: A promising approach for objective assessment. *International Journal of Online and Biomedical Engineering*, 20(11), 1–10.
- Alqaraleh, M., Alzboon, M. S., Al-Batah, M. S., & Migdadi, H. S. (2025). From complexity to clarity: Improving microarray classification with correlation-based feature selection. *LatIA*, 3, 1.
- Alzboon, M. S., Al-Batah, M., Alqaraleh, M., Abuashour, A., & Bader, A. F. (2023, November). A comparative study of machine learning techniques for early prediction of prostate cancer. In *2023 IEEE Tenth International Conference on Communications and Networking (ComNet)* (pp. 1–12). IEEE.
- Alzboon, M. S., Al-Batah, M. S., Alqaraleh, M., Abuashour, A., & Hamadah Bader, A. F. (2023). Early diagnosis of diabetes: A comparison of machine learning methods. *International Journal of Online and Biomedical Engineering*, 19(15), 1–10.
- Alzboon, M. S., Aljarrah, E., Alqaraleh, M., & Alomari, S. A. (2021). NodeXL tool for social network analysis. *Turkish Journal of Computer and Mathematics Education*, 12(14), 202–216.
- Alzboon, M. S., Alqaraleh, M., & Al-Batah, M. S. (2024). AI in the sky: Developing real-time UAV recognition systems to enhance military security. *Data & Metadata*, 3, 417.

- Alzboon, M. S., Alqaraleh, M. K., Aljarrah, E. M., & Alomari, S. A. (2022). Semantic image analysis on social networks and data processing: Review and future directions. In *Handbook of Research on Foundations and Applications of Intelligent Business Analytics* (pp. 189–214). IGI Global.
- Alzboon, M. S., Qawasmeh, S., Alqaraleh, M., Abuashour, A., Bader, A. F., & Al-Batah, M. (2023, October). Machine learning classification algorithms for accurate breast cancer diagnosis. In *2023 3rd International Conference on Emerging Smart Technologies and Applications (eSmarTA)* (pp. 1–8). IEEE.
- Alzboon, M. S., Qawasmeh, S., Alqaraleh, M., Abuashour, A., Bader, A. F., & Al-Batah, M. (2023, October). Pushing the envelope: Investigating the potential and limitations of ChatGPT and artificial intelligence in advancing computer science research. In *2023 3rd International Conference on Emerging Smart Technologies and Applications (eSmarTA)* (pp. 1–6). IEEE.
- Alzboon, M. S., Wahed, M. A., Alourani, A., Alqaraleh, M., Bader, A. F., & Al-Batah, M. (2024, November). AI-driven UAV distinction: Leveraging advanced machine learning. In *2024 7th International Conference on Internet Applications, Protocols, and Services (NETAPPS)* (pp. 1–7). IEEE.
- Alzboon, M. S., Bader, A. F., Abuashour, A., Alqaraleh, M. K., Zaqaibeh, B., & Al-Batah, M. (2023, November). The two sides of AI in cybersecurity: Opportunities and challenges. In *2023 International Conference on Intelligent Computing and Next Generation Networks (ICNGN)* (pp. 1–9). IEEE.
- Alzboon, M. S., Al-Shorman, H. M., Alka'awneh, S. M. N., Saatchi, S. G., Alqaraleh, M. K. S., Samara, E. I. M., ... & Haija, A. A. A. (2025). The role of perceived trust in embracing artificial intelligence technologies: Insights from SMEs. In *Intelligence-Driven Circular Economy: Regeneration Towards Sustainability and Social Responsibility—Volume 2* (pp. 1–15). Springer Nature.
- Awad, A. (2024). Artificial intelligence and marketing innovation: The mediating role of organizational culture. *Innovative Marketing*, 20(3), 170–179.
- Awad, A. (2025). Augmented reality as a tool for customer engagement: Impact on brand perception in retail. *TEM Journal*, 14(3), 1–10.
- Awad, A. (2025). The role of universities' social responsibility in enhancing business sustainability: Mediating role of entrepreneurial culture. *Problems and Perspectives in Management*, 23(1), 181–190.
- Awad, A., & Aldabousi, A. M. (2024). Analyzing the impact of viral marketing on brand equity dimensions in Egypt's home appliances sector: A customer and legal perspective. *Innovative Marketing*, 20(4), 100–112.
- Awad, A., & Alharthi, B. (2025). The role of digital marketing tools in promoting tourism: An applied study on online marketing strategies. *Innovative Marketing*, 21(2), 14–24.
- Awad, A., & Ghonim, A. (2025). Data-driven marketing in banks: The role of artificial intelligence in enhancing marketing efficiency and business performance. *International Review of Management and Marketing*, 15(5), 422–432.
- Awad, A., & Mahmoud, M. (2024). Impact of electronic customer relationship management on competitive advantage: Mediating role of customer satisfaction in EgyptAir. *Problems and Perspectives in Management*, 22(3), 276–288.

- Awad, A., Al-fil, N. Z., Dganni, K. M., Aldabousi, A. M., & Obeidat, M. A. (2024). Optimizing dormant account management in UAE banking: Legal gaps and proposed reforms. *Banks and Bank Systems*, 19(4), 124–133.
- Awad, A., Aziz, A. F., & Shma, T. R. (2025). Investment behavior in the Egyptian stock market: The impact of social media on investor decision-making. *Investment Management & Financial Innovations*, 22(1), 203–214.
- Awad, A., Kordy, A., Hassan, A., & Aal, H. A. (2025). The role of blockchain technology in advancing supply chain innovation: A descriptive-analytical study. [Journal name not provided].
- Awad, A., Shemais, M., & Al-Embabi, M. (2024). Driving HR performance through digital transformation in educational directorates: A strategic imperative. *Problems and Perspectives in Management*, 22(4), 163–175.
- Awad, A., Aldabousi, A. M., & Albatal, S. (2025). The influence of social media marketing on customer knowledge management: The role of confidentiality in UAE public banks. *Banks and Bank Systems*, 20(1), 1–10.
- Ghonim, A., & Awad, A. (2024). Leveraging e-marketing for enhancing customer knowledge management: A systematic review of tourism strategies in the Saudi Arabian context. *Journal of Ecohumanism*, 3(8), 11693–11709.
- Ghonim, A., & Awad, A. (2025). Shaping customer insights through e-marketing: An applied study in the banking sector. [Journal name not provided].
- Ghonim, A., Awad, A., Shemais, M., Shma, T., & Aziz, A. (2025). Exploring the impact of flexible work arrangements on employee engagement in telecommunications: Case of Egypt. *Problems and Perspectives in Management*, 23(2), 198–210.
- Hussain, Z. (2022). Intention to purchase halal cosmetic products in an Islamic Pakistani culture. *Journal of Islamic Economics and Finance Studies*, 3(1), 1–11.
- Hussain, Z. (2023). Examining the impact of green marketing strategies on organizational performance and competitive advantage. *NUST Business Review*, 5(1), 1–18.
- Hussain, Z. (2023, April). Analyzing the emerging trends of digital literacy among Muslim students. In *The 1st Annual Conference of Islamic Education* (pp. 125–134). Atlantis Press.
- Hussain, Z. (2023). The use of Web 3.0 in university e-learning, quality assurance, and knowledge management. In *Advances in Distance Learning in Times of Pandemic* (pp. 155–176). Chapman and Hall/CRC.
- Hussain, Z., Khan, A., & Ali, A. (2023). The impact of user-generated content, social interactions and virtual economies on metaverse environments. *Journal of Sustainable Economics*, 1(2), 34–44.
- Hussain, Z., Sultan, R., Asadullah, A., Arif, M., & Ali, A. (2022). The impact of zakat literacy, trust, and the accessibility of digital payments on Generation Z and Y's intention to pay zakat to Central Zakat Fund, the State Bank of Pakistan. *International Journal of Zakat*, 7(2), 105–114.
- Khan, A., Hamid, A. B. A., Saad, N. M., Hussain, Z., & Arif, A. R. (2023). Effectiveness of artificial intelligence in building customer loyalty: Investigating the mediating role of chatbot in the tourism sector of Pakistan. *International Journal of Academic Research in Business and Social Sciences*, 13(9), 657–671.

- Mahmoud, M., Shma, T., Aziz, A., & Awad, A. (2025). Integrating knowledge management with smart technologies in public pharmaceutical organizations. *Knowledge and Performance Management*, 9(1), 31–45.
- Muhyeddin, A., Mowafaq, S. A., Al-Batah, M. S., & Mutaz, A. W. (2024). Advancing medical image analysis: The role of adaptive optimization techniques in enhancing COVID-19 detection, lung infection, and tumor segmentation. *LatIA*, 2, 74–74.
- Nader Abdelrehim Ismail Awad, A. (2025). Leveraging digital fan engagement for sports brand loyalty: A study of emerging marketing strategies in Saudi Arabia. 1219), 2(16, *المجلة العلمية للدراسات التجارية والبيئية* –1256.
- Nazil, A. R. (2025). AI at war: The next revolution for military and defense. [Outlet not provided].
- Nazil, A. R. (2025). AI-powered visualization is transforming modern healthcare. *International Journal of Research Publication and Reviews*, 6(8), 1474–1478.
- Nazil, A. R., Jony, M. A. M., Hosen, M. M., Akter Priya, M., & Arafat, Y. (2025). Information technology perspective on business. [Outlet not provided].
- Obeidat, M. A., AlFil, N. Z., Aldabousi, A. M., & Dganni, K. M. (2024). Criminal protection for the merchants from the crimes of electronic publishing about invasion of privacy in UAE legislation. *Pakistan Journal of Criminology*, 16(3), 1–20.
- Qadeer, A., & Awad, A. (2025). AI-powered ChatGPT in branding: Benefits, challenges, and future directions. In *Impacts of AI-Generated Content on Brand Reputation* (pp. 1–26). IGI Global.
- Qadeer, A., & Awad, A. (2025). Generative AI in advertisements: A conceptual framework based on the technology acceptance model. In *Impacts of AI-Generated Content on Brand Reputation* (pp. 109–128). IGI Global.
- Qadeer, A., Awad, A., & Ali, A. (2025). Understanding generative AI implementation in digital advertising among retail SMEs in Pakistan. In *Impacts of AI-Generated Content on Brand Reputation* (pp. 177–202). IGI Global.
- Saad, M., Awad, A., Aziz, A. F., & Shma, T. R. (2025). Influencer marketing's impact on credibility and purchase intention: A study on University of Bisha students in Saudi Arabia. *Innovative Marketing*, 21(1), 326–339.
- Saeed Almanbahi, F., Awad, A., Ghonim, A., Mohammed Alabsy, N., & Shemais, M. (2025). Ethical leadership and organizational excellence: The mediating role of citizenship behavior in healthcare. *Humanities and Social Sciences Communications*, 12(1), 1–14.
- Wahed, M. A., Alqaraleh, M., Alzboon, M. S., & Al-Batah, M. S. (2025). Application of artificial intelligence for diagnosing tumors in the female reproductive system: A systematic review. *Multidisciplinary (Montevideo)*, 3, 15.
- Wahed, M. A., Alzboon, M. S., Alqaraleh, M., Halasa, A., Al-Batah, M., & Bader, A. F. (2024, November). Technological innovations in autonomous vehicles: A focus on sensor fusion and environmental perception. In *2024 7th International Conference on Internet Applications, Protocols, and Services (NETAPPS)* (pp. 1–7). IEEE.

- Wahed, M. A., Alzboon, M. S., Alqaraleh, M., Halasa, A., Al-Batah, M., & Bader, A. F. (2024, November). Comprehensive assessment of cybersecurity measures: Evaluating incident response, AI integration, and emerging threats. In 2024 7th International Conference on Internet Applications, Protocols, and Services (NETAPPS) (pp. 1–8). IEEE.
- Wahed, M. A., Alzboon, M. S., Alqaraleh, M., Ayman, J., Al-Batah, M., & Bader, A. F. (2024, November). Automating web data collection: Challenges, solutions, and Python-based strategies for effective web scraping. In 2024 7th International Conference on Internet Applications, Protocols, and Services (NETAPPS) (pp. 1–6). IEEE.
- Wahed, M. A., Alzboon, M. S., Alqaraleh, M., Al-Batah, M., Bader, A. F., & Wahed, S. A. (2024, November). Enhancing diagnostic precision in pediatric urology: Machine learning models for automated grading of vesicoureteral reflux. In 2024 7th International Conference on Internet Applications, Protocols, and Services (NETAPPS) (pp. 1–7). IEEE.
- Wahed, M. A., Alzboon, M. S., Alqaraleh, M., & Al-Batah, M. S. (2025). Evaluating AI and machine learning models in breast cancer detection: A review of convolutional neural networks (CNN) and global research trends. *LatIA*, 3, 117–117.
- Wahid, A., & Awad, A. (2025). Role of AI chatbots in enhancing customer satisfaction and customer loyalty. In *Impacts of AI-Generated Content on Brand Reputation* (pp. 129–148). IGI Global.
- Yahia Shams Eldin, A., Elnour, A., Omer Ahmed Hassan, R., & Awad, A. (2025). The role of technological and environmental factors in creating business value from social media dynamic capabilities for SMEs in Saudi Arabia. *Humanities and Social Sciences Communications*, 12(1), 1–11.
- Yusuf, A., Ayus, A. K. M., Shiddieqy, D. F., & Awad, A. (2025). The role of sukuk financing in economic growth and poverty reduction: Empirical evidence from selected ASEAN countries. *Public and Municipal Finance*, 14, 42–50.

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of RISE and/or the editor(s). RISE and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.