



**MEDIATING EFFECT OF ARTIFICIAL
INTELLIGENCE TOOLS ON THE LINK BETWEEN
PERFORMANCE-BASED ASSESSMENT TASKS DIFFICULTY
AND TRAINEES' INNOVATION SKILL DEVELOPMENT IN
SELECTED TECHNICAL INSTITUTIONS, KENYA**

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Abstract:

The fundamental purpose of this study was to assess the mediating effect of Artificial Intelligence (AI) technology tools on the link between Performance-Based Assessment (PBA) tasks' difficulty and innovation skill development among Information and Communication Technology (ICT) diploma trainees in selected technical institutions in Kenya. Guided by Vygotsky's Social Constructivism theory, the research employed a convergent parallel mixed-methods design. A sample of 346 trainees was drawn from a target population of 2,247 Module III ICT diploma trainees. Quantitative data were collected using an ICT Diploma Trainees' Questionnaire (IDTQ), while qualitative data were obtained through Focus Group Discussions (FGDs). The questionnaire's reliability was established using Cronbach's alpha for internal consistency, and its face and content validity were confirmed through expert judgment. Trustworthiness of qualitative findings was enhanced through member checking, while triangulation ensured confirmability. Quantitative data were analysed using descriptive statistics and linear regression-based mediation analysis, whereas qualitative data were analysed through thematic analysis. Integration of findings was achieved using a side-by-side comparison approach. The study found that the use of AI technology tools partially mediated the relationship between PBA task difficulty and innovation skill development ($\beta = 0.041$,

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BootLLCI = 0.009, BootULCI = 0.082). Qualitative findings indicated that difficult PBA tasks encouraged repetition, exploration and experimentation. However, the transition of this to innovation skill development was dependent on the availability of adequate support, including but not limited to relevant AI technology tools. The study concluded that the effectiveness of innovation skill development is not merely a function of the usage of supporting AI tools but also the task difficulty itself. The study recommends that technical institutions offering ICT diploma courses should establish structured AI-enabled support applications so that trainees can effectively engage with cognitively demanding PBA tasks.

Keywords: artificial intelligence, innovation skills, tasks difficulty, performance-based assessment, ICT diploma

1. Introduction

The demand for technical and vocational skills, especially ICT innovation skills, has in the 21st century become more pronounced than ever before. This trend is largely attributed to the rapid infusion of ICT-enabled technologies across various sectors of society, which has strengthened the link between a nation's technological innovation capacity, its global competitiveness, and its economy's sustainability. Consequently, the skill need of ICT professionals has shifted from possession of basic digital literacy to the ability to design and implement innovative ICT solutions that advance a country's economic growth. This transformation highlights the growing recognition of innovation skills as a critical component of skills an ICT graduate should possess (Grech & Camilleri, 2020).

Literature on innovation skill development suggests that innovation is most effectively cultivated in learning environments that expose learners to cognitively demanding tasks that stimulate creative thinking, opportunity recognition, and informed risk-taking (Beghetto & Kaufman, 2013; Ovbiagbonhia, Kollöffel & Brok, 2019). Within educational settings, Performance-based Assessments (PBA) have increasingly been identified as assessment approaches capable of fostering such outcomes. This is due to their inherent nature of requiring test takers to apply knowledge in authentic, problem-oriented contexts, often culminating in polished products for both classroom and external audiences (Gallardo, 2020; Darling-Hammond & Adamson, 2010; Mc Tighe, 2014).

However, Syahril, Nabawi and Safitri (2021) highlight that it is not just the mere use of PBAs that matters but the design of PBA tasks with appropriate levels of difficulty. This is because the degree of PBA task difficulty determines the rigor and level at which test takers utilize higher-order thinking skills to analyze problems, think critically and create novel or improved products (Herrera, Cabral & Murry, 2013; Espinosa, 2015). This viewpoint brings to the fore the significant role PBA task difficulty plays in providing learning experiences that promote discovery rather than mere assignment of grades. As

such, the construct “difficulty of PBA tasks” is viewed in terms of how cognitively demanding a PBA task is, considering the level of knowledge, skills, and effort required for a trainee to complete it (Albay & Eisma, 2021). This study therefore operationalized it as the degree of cognitive challenge entrenched in a task used during PBAs within formative and summative assessment of trainees’ achievement of practical competencies within the ICT diploma course. As such, assessing the levels of this difficulty involves determining whether the tasks require trainees to move beyond routine recall, engage in higher-order thinking, and complete tasks with substantial breadth and depth.

In the wake of the push for the use of PBA tasks with difficulty levels that promote trainees’ innovation skill development, AI technology tools have infiltrated the PBA execution settings. This infiltration has spurred debates regarding the effects these tools bring in the relationship between PBA tasks difficulty and trainees’ innovation skill development. Scholars who express optimism with this permeation view it as an opportunity for trainees to foster their creativity and higher-order thinking skills, if a balance between the use of AI tools and traditional classroom practices is achieved (Klopfers, *et al.*, 2024; Vasconcelos & dos Santos, 2023; Wang’ang’a, 2024). Conversely, scholars who are pessimistic about it, see it as an avenue that could potentially derail the process of nurturing higher-order skills since AI technology tools may cause trainees to dodge cognitive processes. They also express concerns of a possible spike in over reliance of generative AI, which could deter cognitive engagement of learners (Hamilton, 2023; Wang, Díaz, Brown & Chen, 2023). Despite these debates, AI technology tools have rapidly advanced and are now transforming various industries, including education. Extant literature shows that they have the potential to revolutionize the way teaching, learning and assessments are implemented, ultimately impacting educational outcomes for students (Owan *et al.*, 2023; Naqvi, 2020). However, their effects on the relationship between PBAs tasks difficulty and innovation skill development among ICT diploma trainees remain underexplored. Bridging this gap is important for informing ICT diploma curriculum implementation and policy directions aimed at reinventing PBA task difficulty as a catalyst for innovation skill development in an AI technology-infiltrated environment.

1.1 Problem Statement

The use of PBA tasks with appropriate difficulty levels in both formative and summative assessments within practical-oriented programs such as ICT diploma provide avenues to accurately assess trainees’ practical competencies while fostering higher-order thinking skills, including innovation. They also enable sustained cognitive engagement and motivation among trainees throughout the assessment process. This is because they require trainees to actively apply their knowledge and skills in solving meaningful, real-world problems rather than passively recalling information. Against this backdrop, the Technical Vocational Education and Training Curriculum Development, Assessment and Certification Council (TVET CDACC) provides for their inclusion as critical elements in

the ICT diploma curriculum implementation in Kenya's TVET institutions (RoK, 2018). Amidst these provisions, AI technology tools have permeated PBA execution environments, giving rise to a new landscape for PBA tasks utilization. For instance, a survey by Manyukwe (2023) and Yonda Consulting (2023) revealed that Generative AI was the most popular AI tool in Kenya's higher education systems, with a usage rate of 63% in the year 2023. These findings were supported by Wachira, Wachira, Mwangi, Absaloms and Jeon (2023), who found that over 30% of the student body in tertiary institutions in Kenya actively used ChatGPT, an AI tool, in the assessment space. However, the mediating effect of these AI technology tools in the relationship between PBAs tasks difficulty and innovation skill development among ICT diploma trainees remains under-examined. At the same time, although there are studies that attempt to address this gap, their methodological approaches, contextual focus, and variables examined limit their ability to bring clarity to the foregoing knowledge gap. Left unaddressed, this gap presents a danger of continued dependence on PBA practices that may not optimally anchor the development of innovation skills envisioned in Kenya's TVET policy framework. It is against this backdrop that the present study sought to assess the mediating effect of AI technology tools on the relationship between PBA tasks difficulty and innovation skills development among ICT diploma trainees in selected technical institutions in Kenya.

1.2 Purpose of the Study

The purpose of this study was to examine the extent to which AI technology tools mediate the relationship between PBA tasks difficulty and innovation skills development among Information and Communication Technology diploma trainees in selected public technical institutions in Kenya.

1.3 Research Question

- What are the experiences of ICT diploma trainees regarding PBA tasks difficulty, use of AI technology tools and innovation skills development within Kenya's public technical institutions?

1.4 Research Hypothesis

The study tested the following hypothesis while controlling for ICT diploma trainee's gender and prior experience with PBAs:

H₀₁: There is no statistically significant mediating effect of AI technology tools on the relationship between PBA tasks difficulty and innovation skills development among ICT diploma trainees in public technical institutions in Kenya.

1.5 Theoretical Framework

This study was guided by Social Constructivism; a theory grounded on Vygotsky's (1978) sociocultural view of human mind development. This theory underscores the criticality

of task difficulty levels, cultural tools mediation and scaffolding in human mind development. Vygotsky emphasized that meaningful human mind development occurs within the Zone of Proximal Development (ZPD)—the distance between what a learner can achieve autonomously and what they can achieve with support provided by a More Knowledgeable Other (MKO) (Vygotsky, 1978; McLeod, 2023; Syomwene, 2016). Vygotsky argued that, left alone, learners' mind development may occur, but not to full potential; it is through scaffolding by the MKO that this gap is bridged. An MKO refers to someone with greater expertise than the learner in a given task or concept (McLeod, 2023; Syomwene, 2016). Scaffolding refers to the structured support provided by an MKO to help learners acquire new skills by gradually reducing assistance as learners become more proficient (Bruner, 1996; Verenikina, 2010; James, 2008). The application of the ZPD principle in PBA tasks involves providing problem-solving activities that are beyond an individual's current abilities, then providing initial support, and gradually reducing it as the individual becomes more capable (Verenikina, 2010; James, 2008).

The use of PBAs in the ICT diploma course in TVET institutions aligns with this principle as they emphasize assessment tasks that require the application of knowledge and skills in problem-solving tasks that challenge trainees to exceed their current ability levels. Within this process, MKOs provide scaffolding through guidance, feedback, and modeling, enabling trainees to develop problem-solving skills and ultimately innovation skills. While MKOs in ICT diploma courses have traditionally been human actors such as trainers, resource persons, or peers, the rapid infiltration of AI technology tools presents new mediational possibilities. They demonstrate mediating MKOs' roles such as offering personalized feedback, real-time assistance, and adaptive resources that help trainees remain within their ZPD (Luckin, 2017; Holmes, Bialik & Fadel, 2019). This reinforces the critical need for empirical studies that examine the mediation role of AI technology tools in fostering innovation skills development through PBA tasks

2. Literature Review

Performance-based assessment refers to an assessment approach that embodies tasks that require test takers to apply their knowledge and skills to come up with a product or accomplish a specific performance (Dawson, 2017; Stoll & Schultz, 2019). Such tasks serve dual roles in education, as they can be utilized during the teaching and learning process as instructional tools, as well as in assessments to evaluate proficiency in specific skills or knowledge areas, and promote skill development (Mc Tighe, 2014; Stoll & Schultz, 2019). Unlike traditional assessments that heavily rely on written exams or multiple-choice tests, PBA tasks focus on trainees' ability to apply their learning to practical situations. They are an approach to evaluating trainees' knowledge, skills and abilities by assessing their performance of real-world tasks and projects (Komari, Aryanti & Sudjani, 2019; Salma & Prastikawati, 2021). By definition, therefore, PBA tasks offer more realistic and

comprehensive approaches to assessing trainees' practical capabilities as well as developing higher-order thinking skills such as innovation.

The development of innovation skills is viewed as a phased process. According to Dziallas and Blind (2019), it begins with the ability to recognize problems requiring innovative solutions, progresses through idea generation, and culminates in translating those ideas into practical and valuable products. Prior research on innovation skill development has operationalized this process to suit specific study contexts. For instance, Avvisati, Jacotin, and Vincent-Lancrin (2013) adapted them to higher education settings to examine graduates' contributions to innovation-driven economies. Likewise, Martin, Potocnik, and Frasn (2015) contextualized the indicators within university environments to investigate factors shaping undergraduate students' innovative behaviors. As such, this present study conceptualized innovations skill development as the process through which ICT diploma trainees acquire and strengthen their capacity to identify problems that need innovative solutions, then generate novel or enhanced ideas, processes, or artefacts that translate ICT knowledge into practical solutions.

Syahril, Nabawi, and Safitri (2021) front PBA tasks with appropriate levels of difficulty as critical elements for achieving positive educational outcomes among students. This is exemplified in their study that focused on Indonesian Mechanical Drawing course students' perceptions of project tasks designed to their potential. The results revealed that project tasks tailored to students' capabilities significantly enhanced their motivation (Mean = 4.61), interest (Mean = 4.57), real-world learning (Mean = 4.47), engagement with lecturers (Mean = 4.31), and enjoyment (Mean = 4.43). Additionally, these tasks improved students' soft skills (Mean = 4.47), such as teamwork, project management, communication, and interpersonal skills. However, although this study is useful for isolating varied outcomes of using project tasks in the learning process, its focus on teaching only limits the generalizability of the findings to PBA situations. This is because contextual factors in PBAs are different from those involved during teaching.

Green and du Plessis (2023) used a convergent mixed-method study approach to examine student perceptions of project-based learning in TVET education in South Africa. The study findings indicated that the use of project tasks was effective in enhancing students' acquisition of work-related skills, such as critical thinking and problem-solving, as well as fostering creativity and collaboration. In contrast, Turyatamba (2023) found that despite the implementation of project tasks as assessment and instructional tools in Uganda's TVET system, the quality of the TVET trainees was below the expectation and their products were of poor quality. The study attributed this to the inadequacy of materials needed to implement project tasks whose difficulty levels were at par with the industry needs. These contradicting findings suggest that findings from a TVET system in one country may have limited applicability to another country due to circumstantial variations. Additionally, the studies lack specificity regarding the difficulty of tasks used in PBA contexts and their linkage with innovation skill development.

Stoll and Schultz (2019) identify a major challenge in achieving the appropriate levels of difficulty in PBA tasks to be limitations in the PBAs implementers' expertise and inadequate resources. However, advancements in AI technologies such as simulations, virtual assistants, virtual reality, and generative AI could be potential solutions to these challenges. For instance, Vasconcelos and dos Santos (2023) explored the potential of generative AI tools in fostering reflective and critical thinking among learners in Science, Technology, Engineering and Mathematics (STEM) education in Brazilian secondary schools. The study employed case study methodology to analyse extensive interaction logs between students and AI systems in simulated STEM learning experiences. The study results indicated that generative AI, including ChatGPT and Bing Chat, could act as powerful objects to think within STEM education projects. They provided customized content, instant feedback, and adapted to individual needs, making learning engaging and relevant. However, this study was carried out among the secondary school population. Therefore, its generalizability to the TVET system population may be difficult, given the contextual differences between the two.

Hamilton's (2023) survey of 500 practising educators from the US, found 60% of the surveyed educators had used AI in their classrooms. 51% reported having used AI-powered educational games, 43% adaptive learning platforms, 35% chat bots for student support, while 29% had used intelligent tutoring systems. 55% of the teachers who responded to the survey said that they believed AI technology tools had improved educational outcomes, 18% opined that it hindered educational outcomes, while 17% said it had no significant impact. Although this study provides valuable insights, it examines education as a unified entity, ignoring the fact that it comprises different levels. As such, the study may not provide clarity on the extent to which AI technology tools mediate the relationship between PBA tasks difficulty and the development of innovation skills among trainees enrolled in the ICT diploma course.

Sandu and Gide's (2019) study was situated in higher education institutions in India. The study reported that a majority of students in these institutions (48.9%) expressed willingness to engage with Chatbots for assistance with their educational issues. From this use of Chatbots, they experienced significant benefits, such as improved communication, faster completion of research projects and taking online exams. Similarly, Olatunde-Aiyedun (2024), employing a mixed-methods approach, assessed the impact of AI integration in science education on learning outcomes, student engagement, and overall educational quality in Nigerian universities. Document analysis was used to give quantitative data, while interviews were used to obtain lecturer experiences with AI in classrooms, which formed the qualitative strand. Analysis of Covariance was the main inferential statistic for analysing quantitative data, while thematic analysis was used for qualitative data analysis. The study found that AI serves as a catalyst for improved academic performance and a deeper grasp of scientific principles. However, the study failed to provide a statistical mediation model for the mediating effect of AI technology tools on the relationship under study.

Studies in Kenya whose focus is related to PBA tasks difficulty and innovation skill development in TVET education are not succinct on the mediation role of AI technology tools on the relationship between the two constructs. For instance, Moindi and Nyatuka (2022) conducted descriptive survey research to examine the effectiveness of assessment modes used in entrepreneurship education in imparting requisite competencies among students in tertiary institutions in Kenya. The study showed that written examinations were the most prevalent mode of assessment of entrepreneurship education, followed by project tasks and industrial attachment. The regression model in the study showed that the mode of assessment adopted enhanced the acquisition of ideas and opportunities (0.313 units). However, although the study made an attempt of linking mode of assessments to skills development, the dependent variable was not explicit on the development of innovation skills; instead, it used the construct “acquisition of ideas and opportunities”, which is quite generic.

Musyimi, Orodho and Thuo’s (2021) study sought to establish the link between the frequency of PBA tasks and innovation capacity among secondary school Computer Studies students. The study discovered that the low frequency of project tasks and laboratory session-based tasks in Computer Studies curriculum negatively affected students' innovation capabilities. Although these findings are valuable, their nuance is constrained by their exclusive reliance on quantitative techniques. To bridge the methodological gap occasioned by the potential limitations associated with quantitative approaches, the present study incorporated focus group discussions. For the contextual gap, the present study was conducted among ICT diploma trainees.

Jepkemoi, Mulwa and Mwanda (2024) used a descriptive survey study design to examine the influence of artificial intelligence (ChatGPT) affordances on adaptive learning experiences among undergraduate religious education teacher trainees at the University of Nairobi. The linear regression analysis results revealed a statistically significant positive influence of the learning engagement of ChatGPT ($\beta = 0.44, p = 0.000$) on the undergraduate religious education teacher trainees’ adaptive learning experiences. This study, though illuminating on the subject under study, is challenging to isolate the development of innovation skills from the dependent variable, that is, adaptive learning experiences, since it is quite generic

Similar findings were reflected by Oranga’s (2023) study, whose aim was to explore the benefits of artificial intelligence (ChatGPT) in education in the Kenyan context. The study concluded that AI enhances learning through the provision of personalized learning, instant feedback and 24/7 availability. However, it should be used in conjunction with human guidance and supervision so that learners can receive a well-rounded and effective education. This study, although enlightening, relied on content analysis in which secondary data in the form of published text was reviewed. As such, its explanatory power on the relationship under study is therewith weakened as they carry along the weaknesses of solely using secondary data for research.

Taken together, the reviewed studies suggest that the value of PBAs lies not simply in their use, but by the extent to which they are designed in consideration to their difficulty level. These studies indicate that incorporating projects with difficulty levels aligned to learners' abilities can foster desirable learning outcomes. At the same time, literature indicates that AI tools have become common tools for educators and assessment professionals seeking to enhance teaching and learning experiences. However, from the global, regional and Kenyan contexts, not much has been done to show the mediating effect of AI tools on the relationship between PBA tasks difficulty and the development of ICT diploma trainees' innovation skills. The existing studies have focused on the integration of AI in education and its influence on various learning outcomes. As a result of the study designs, they adopted, they have not provided statistical mediation models coupled with nuanced explanations. This has resulted in methodological and knowledge gaps that the current study sought to address. Furthermore, the existing studies have focused on other contexts of education such as entrepreneurship education, universities, and STEM in secondary schools, but none focused on assessment in the ICT diploma course. This has resulted to contextual and population gaps that form the basis of this present study.

3. Materials and Methods

3.1 Study Design

This study employed a convergent parallel mixed methods design, whereby quantitative and qualitative data were collected simultaneously, analyzed separately, and integrated during interpretation (Creswell & Creswell, 2018). The quantitative strand statistically established the mediating effect of AI technology tools on the link between PBA tasks difficulty and innovation skill development. The qualitative strand explored trainees' experiences of engaging with cognitively demanding PBA tasks, use of AI tools in the execution of the tasks and their impact on innovation skill development. Integration of findings was achieved through side-by-side comparison to identify points of convergence, divergence, and complementarity between the two strands. This design was appropriate because it enabled a more comprehensive understanding of how measurable effects of AI technology tools relate to trainees' experiential accounts, thereby strengthening the explanatory power of the findings.

3.2 Target Population and Sample Size

The target population comprised 2,247 Module III ICT diploma trainees enrolled in six selected public TVET institutions in Kenya in 2024. The institutions were purposively selected from 118 accredited public TVET institutions offering the ICT diploma course. To ensure representation across institutional categories, four Technical Training Institutes, one National Polytechnic, and one University TVET centre were chosen. For the quantitative strand, a sample size of 339 trainees was calculated using Yamane's

formula. To draw the sample, stratified sampling with proportional allocation followed by simple random sampling techniques were used. Stratified sampling was used to ensure representation of each TVET category. Simple random sampling was used to minimize selection bias of the respondents (Creswell & Creswell, 2018). The sample size was considered adequate for regression analysis in line with established quantitative research guidelines by Jenkins and Quintana-Ascencio (2020). For the qualitative strand, seven participants were selected using convenience sampling. This sampling technique was considered apt as it ensured trainees who had substantial exposure to PBAs and were able to articulate their lived experiences in the FGDs. This approach is consistent with qualitative inquiry, where depth and relevance of participants' experience in the phenomena under study are prioritized over statistical representation (Patton, 2015).

3.3 Study Instruments

Quantitative data was collected using a structured questionnaire, while qualitative data was gathered through FGD schedule. The questionnaire was appropriate for this study due to its capacity to generate standardized data from a relatively large and geographically dispersed sample within a limited timeframe (Kothari & Garg, 2016). FGDs were employed to elicit rich, contextualized accounts of trainees' experiences with PBA tasks, thereby providing explanatory depth to complement the quantitative findings.

The questionnaire comprised four sections aligned to the study variables. Section A captured respondents' demographic information, including gender and prior exposure to PBAs. Section B included items measuring the difficulty of PBA tasks, while Section C had items that would measure the extent of the use of AI technology tools in handling PBA tasks. Section D sought data that would quantify trainees' innovation skill development, which corresponds to the study's dependent variable. The instrument consisted of closed-ended items for demographic data and Likert-type scale items to measure the independent, mediating, and dependent variables. The FGD schedule was designed to explore trainees' experiences with difficult PBA tasks, as well as their use of AI technology tools during assessment activities. This facilitated a deeper interpretation of how the difficulty of PBA tasks and AI technology tools shaped innovation skill development.

3.4 Data Analysis

3.4.1 Quantitative Data Analysis

Quantitative data obtained from the filled questionnaires were analyzed descriptively and inferentially. Descriptive analysis comprised computation of means and standard deviations to describe and compare responses across the study variables. Inferential analysis utilized Hayes PROCESS macro (model 4) mediation analysis to establish the existence of a mediation (Hayes, 2022). The computed and derived statistics included the coefficient of determination (R^2), which was used to determine the magnitude of

variation, and p-value, which was used for hypothesis testing. The study hypothesis was tested at a significance level of 0.05. Three models were used for mediation hypothesis testing while controlling for the study covariates:

$$AIEnv = \beta_{01} + C + a \text{ PBA_Diff} + \epsilon_1 \dots\dots\dots \text{Equation 1}$$

$$TISD = \beta_{02} + C + b \text{ AIEnv} + \epsilon_2 \dots\dots\dots \text{Equation 2}$$

$$TISD = \beta_{03} + C + a \text{ AIEnv} + c' \text{ PBA_Diff} + \epsilon_3 \dots\dots\dots \text{Equation 3}$$

Where:

TISD = Trainee Innovation Skill Development (dependent variable)

PBA_Diff = PBA task difficulty (independent variable)

AIEnv = AI technology tools (mediating variable)

$\beta_{01}, \beta_{02}, \beta_{03}$ = Constants

a, b, c' = Coefficients of regression

$\epsilon_1, \epsilon_2, \epsilon_3$ = Error terms

C = Control variables

Equation 1 examined the effect of the independent variable (PBA task difficulty) on the mediator variable (AI technology tools). Equation 2 examined the effect of the mediator variable (AI technology tools) on the dependent variable (innovation skill development) while controlling for PBA task difficulty. Equation 3 examined the direct effect of PBA task difficulty (independent variable) on trainee innovation skill development (dependent variable) while controlling for AI technology tools (mediator). The indirect effect of PBA task difficulty on innovation skill development through AI technology tools was computed by multiplying coefficients *a* and *b*. Mediation was established if the indirect effect was statistically significant. Where both the direct and indirect effects were significant, the mediation was considered partial otherwise full mediation was inferred (Hayes, 2017).

3.4.2 Qualitative Data Analysis

For qualitative data, thematic analysis was employed to systematically examine participants' accounts from the focus group discussions. Thematic analysis involved the identification, analysis, and interpretation of recurring patterns of meaning within the gathered dataset (Braun & Clarke, 2012). Audio-recorded discussions were transcribed and analyzed through iterative stages of familiarization, coding, theme development, and refinement. The final thematic write-up was supported by illustrative verbatim excerpts from trainees to enhance the credibility, trustworthiness, and transferability of the qualitative findings.

3.4.3 Data Integration and Interpretation

Qualitative and quantitative findings were integrated using a side-by-side comparison approach. This technique involved juxtaposing statistical results with corresponding qualitative themes to identify areas of convergence, divergence, and complementarity (Orodho *et al.*, 2016; Creswell & Creswell, 2018). Such integration enabled a more comprehensive interpretation of the findings by allowing qualitative insights to contextualize the quantitative relationship. This approach is consistent with the pragmatic orientation of mixed methods research, which emphasizes methodological complementarity to enhance interpretive depth and explanatory power.

4. Results and Discussion

4.1 Demographic Characteristics

Analysis of respondents' demographic data was done to assess their background characteristics. Additionally, this data was used to summarize the study's covariates. Specifically, the analysis comprised trainees' gender and their prior exposure to PBA tasks. The summary is presented in Table 1.

Table 1: Respondents' Demographic Characteristics

Demographic item	Characteristic	Frequency	Percent
Gender	Male	180	54.7
	Female	149	45.3
	Total	329	100.0
Prior exposure to PBA tasks	Yes	124	37.7
	No	205	62.3
	Total	329	100.0

Source: Survey data (2025).

Table 1 indicates that the total study's participants had a higher proportion of females (54.7%) compared to male respondents (45.3%). Although it does not depict equal parity, the presence of considerable representation of both male and female respondents shows that the data collected reflected views across both genders. With regard to trainees' prior exposure to PBA tasks, the highest percentage of trainees, 205 (62.3%), had not been exposed to PBAs before their present enrolment in the ICT diploma course. On the other hand, 124 (37.7%) reported having had previous experience with PBA tasks. From a contextual perspective, the presence of the majority of trainees without earlier exposure to PBA tasks points to the need to strengthen the inclusion of PBAs in lower levels of ICT training.

4.2 Quantitative Data Analysis

4.2.1 Descriptive Statistics of Study Variables

Descriptive statistics in this study were used to summarize the major characteristics of the data collected regarding the difficulty of tasks used in PBA (independent variable),

use of AI technology tools (mediating variable) and trainees' innovation skill development (dependent variable). Each item in the variables was scored on a 5-point Likert scale where 1 was strongly disagree, 2 was disagree, 3 was neutral, 4 was agree, and 5 was strongly agree. The results are presented in Tables 2, 3 and 4.

Table 2: Descriptive Statistics for PBA Tasks Difficulty

	Item	Mean	SD
TD1	PBA tasks in my institution's ICT diploma course always involve short tasks that can be completed in less than a week	3.50	1.29
TD2	PBA tasks in my institution's ICT diploma course always involve complex activities that require more than a week to complete	3.53	1.18
TD3	PBA tasks in my institution's ICT diploma course always involve simple activities that require basic ICT skills to handle them	3.91	1.12
TD4	PBA tasks in my institution's ICT diploma course always require me to use higher-order thinking skills such as critical thinking, logical reasoning, analysis, problem solving and synthesis	4.16	1.05
TD5	PBA tasks in my institution's ICT diploma course always involve activities that integrate various ICT concepts, technologies and methodologies to develop an ICT product	3.98	0.99
TD6	PBA tasks in my institution's ICT diploma course always require me to generate detailed, accurate and advanced ICT products or solutions	3.92	1.03
TD7	PBA tasks in my institution's ICT diploma course are always implemented in a step-by-step manner, such that I am able to receive feedback on each stage and use it to improve my work.	3.97	1.04
	Composite value	3.85	1.10

Source: Survey data (2025).

Table 2 shows that high ratings were recorded in the statements TD4 (Mean = 4.16, SD = 1.05) and TD3 (Mean = 3.91, SD = 1.12). Taken together, the high rating of the two statements implies that while PBA tasks generally required higher-order thinking skills to handle them, others were intentionally designed to take care of basic skills. Similarly, respondents reported high complexity levels of PBA tasks. This was demonstrated in the strong agreement with the statement TD6 (Mean = 3.92, SD = 1.03) and TD5 (Mean = 3.98, SD = 0.99). This implies that most PBA tasks require trainees to bring together diverse ICT skills, technologies and methodologies to come up with coherent ICT products. Likewise, there was strong agreement with statement TD7 (Mean = 3.97, SD = 1.04). This finding indicates that PBA tasks in most institutions are executed in a manner that provides avenues for trainees to iteratively refine their work through feedback. Respondents expressed closely equal ratings for statements assessing the variation in PBA tasks duration and workload intensity. This is exemplified in the respondents' level of agreement with the statement TD1 (Mean = 3.50, SD = 1.29) and TD2 (Mean = 3.53, SD = 1.18). These two findings collectively indicate that PBA tasks vary in duration and workload intensity, with some being brief and others extending over multiple weeks.

The composite mean score of 3.85 (SD = 1.10) reflects a generally high perception of PBA tasks difficulty across the sample. However, the relatively high standard deviations across items (ranging from 0.99 to 1.29) indicate variability in trainees' experiences. This points to differences in institutional practices or the scope of tasks across various TVET categories. These results contrast Moindi and Nyatuka (2022) survey, which found low utilization of project tasks assessments among business and ICT departments in selected tertiary institutions in Kenya.

Table 3: Descriptive Statistics for AI Technology Tools Usage

	Item	Mean	SD
AT1	I always use generative AI tools such as <i>ChatGPT</i> , <i>Bing Chat</i> , <i>GitHub</i> and <i>Copilot</i> , etc. to help address difficulties I encounter when working on PBA tasks for my ICT diploma course.	4.33	0.97
AT2	I always verify the accuracy of information and content I obtain from generative AI tools before including it in my PBA tasks execution	3.89	1.11
AT3	I always use AI powered virtual assistants to manage the execution of PBA tasks (e.g. <i>creating work plan</i> , <i>setting reminders</i> , <i>managing literature citations</i> etc.)	3.40	1.24
AT4	I always use AI-powered adaptive learning platforms like <i>Dream box</i> , <i>Knewton</i> , <i>AI-powered YouTube apps</i> etc. to ease the search for reference materials and content needed for PBA tasks executions in the ICT diploma course	3.64	1.23
AT5	I always use intelligent tutoring systems to gain personalized information and guidance on how to complete PBA tasks in the ICT diploma course	3.83	1.10
AT6	Using AI in PBA tasks enables me to think critically and improves my ICT innovation skills	3.95	1.23
	Composite value	3.84	1.15

Source: Survey data (2025).

The results in Table 3 reveal that statement AT1 was the highest rated item (Mean = 4.33, SD = 0.97). This indicates that a majority of respondents frequently relied on generative AI tools to overcome challenges encountered during PBA tasks. Closely related to this finding is the relatively high mean recorded for the statement AT2 (Mean = 3.89, SD = 1.11). This pattern suggests that while many trainees depend on generative AI tools for assistance, they also demonstrate a reasonable level of confirming the veracity of AI-generated content. However, the slightly higher standard deviation points to varying levels of training or awareness regarding the need for AI-generated content accuracy checks.

Lower mean ratings were observed in items involving the use of specialized AI applications. For instance, item AT3 had a mean of 3.40 and a standard deviation of 1.24. This suggests moderate use of AI tools for organizational and administrative aspects of PBA work. Similarly, item AT4 showed a comparable level of agreement (Mean = 3.64, SD = 1.23). This implies that their adoption of AI-powered adaptive learning platforms like *Dream box*, *Knewton*, and *AI-powered YouTube apps* was less extensive compared to generative AI systems. However, the use of intelligent tutoring systems was strong (Mean = 3.83, SD = 1.10), implying a fairly widespread adoption of AI tools that provide

personalized guidance and learning support in the execution of PBA tasks. Remarkably, despite the variations in the extent of use of the different AI tools, respondents largely perceived AI tools as instrumental in enhancing their critical thinking and innovation capacity. This is demonstrated in the strong rating of the statement AT6 (Mean = 3.95, SD = 1.23).

On a scale of 1-5, the composite average rating of the use of AI technology tools was found to be 3.84 and the SD of 1.15. The findings suggest that the use of AI technology tools in PBA tasks is prevalent. ICT diploma trainees appear to rely more on generative AI tools for problem-solving than on specialized systems for structured learning or task management. This is consistent with a survey by Manyukwe (2023) and Yonda Consulting (2023), which revealed that Generative AI was most popular in Kenya's higher education systems, with a usage rate of 63% in the year 2023.

Table 4: Descriptive Statistics for Trainee Innovation Skill Development

	Item	Mean	SD
ISD1	I always explore new and creative solutions to solve ICT tasks presented in the ICT diploma course PBAs	4.21	0.92
ISD2	I am always comfortable taking risks and experimenting with new ICT ideas and technologies.	3.95	0.99
ISD3	I regularly generate new ideas and suggestions to improve ICT processes and systems.	3.83	1.03
ISD4	I am always open and receptive to feedback given by my peers, course trainers and ICT experts when developing new ICT products	4.16	0.86
ISD5	I always use feedback from my peers, course trainers and ICT experts to refine and improve my ICT approaches to solving ICT problems	4.17	0.93
ISD6	I actively stay updated with emerging trends and advancements in the ICT field	4.23	0.88
ISD7	I always incorporate emerging technologies when creating new ICT products and solutions	3.85	0.97
ISD8	I have successfully showcased my own developed new ICT product(s) and solutions in ICT innovation promotion forums	2.84	1.28
ISD9	I have successfully implemented innovative ICT products and solutions that have positively impacted organizations and society	2.84	1.23
ISD10	I have successfully patented or copyrighted my new ICT products and solutions	2.26	1.14
	Composite value	3.63	1.02

Source: Survey data (2025).

Table 4 shows that generally, ICT diploma trainees demonstrate practice of innovative behaviors such as exploring creative solutions, adopting new technologies, and applying feedback. This is depicted by high mean ratings of items ISD6 (Mean = 4.23, SD = 0.88), ISD1 (Mean = 4.21, SD = 0.92), ISD5 (Mean = 4.17, SD = 0.93), ISD4 (Mean = 4.16, SD = 0.86), ISD2 (Mean = 3.95, SD = 0.99), ISD3 (Mean = 3.83, SD = 1.03) and ISD7 (Mean = 3.85, SD = 0.97). However, the changeover from conceptualization of ICT ideas to tangible and recognized innovative products remains low. This is demonstrated by the low ratings of the items ISD8 (Mean = 2.84, SD = 1.28), ISD9 (Mean = 2.84, SD = 1.23) and ISD10 (Mean =

2.26, SD = 1.14). On a scale of 1–5, the composite mean rating for trainee innovation skill development was 3.63 with a standard deviation of 1.02. This means that the level of innovation skill development among ICT diploma trainees was fairly strong. The SD value of 1.02 suggests moderate differences in responses. These findings closely align with Turyatamba's (2023) study, which found that despite the implementation of project tasks as assessment and instructional tools in Uganda's TVET system, the quality of the TVET trainees' products was of poor quality. They are also in congruence with findings of the TVET knowledge and key highlights report of 2022, mapping TVET data in Kenya, which found a significant mismatch (61.13%) between the innovative digital skills of TVET trainees and the demands of the labor market.

4.2.2 Effect of Covariates on Trainee Innovation Skill Development

The effects of the study's covariates were isolated to assess their influence on the dependent variable. The results indicated that trainees' gender had a non-significant negative effect on innovation skill development ($\beta = -0.064, p > 0.05$). However, prior experience with PBAs had a statistically significant negative effect on innovation skills development ($\beta = -0.136, p < 0.05$). This suggested that trainees with previous PBA exposure reported slightly lower innovation skill development scores compared to those without prior experience. Collectively, the control variables explained 2.2% of the variance in innovation skill development, and this effect was statistically significant ($p < 0.05$).

4.2.3 Hypothesis Testing

To analyze the mediating effect of AI technology tools on the relationship between PBA tasks difficulty and trainee innovation skill development, the following null hypothesis was tested while controlling for the study covariates:

H₀₁: There is no statistically significant mediating effect of AI technology tools on the relationship between PBA tasks difficulty and innovation skills development among ICT diploma trainees in public TVET institutions in Kenya.

Table 5: Results of the Mediating Effect of AI technology tools on the Relationship between PBA task difficulty and Trainee Innovation Skill Development

Model	Path	B	BootSE / SE	t	p	R ²	Boot LLCI/LLCI	Boot ULCI/ULCI	% Effect
PBA_Diff	Diff → AIEnv (a)	0.344	0.067	5.166	0.000	0.094	0.213	0.475	
	AIEnv → TISD (b)	0.118	0.040	2.936	0.004	0.202	0.039	0.197	
	Diff → TISD (c')	0.347	0.050	6.930	0.000	0.181	0.249	0.446	89.4
	Diff → AIEnv → TISD	0.041	0.018				0.009	0.082	10.6

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	Diff → TISD (c)	0.388	0.049	7.957	0.000	—	0.292	0.484	100.0
*Mediation models were estimated using Hayes' PROCESS Model 4 with 5,000 bootstrap samples with 95% Confidence Interval									

Notes: PBA_Diff/Diff = PBA task difficulty, TISD = Trainee Innovation Skill Development, AIEnv = AI tools

The mediation analysis followed the four-step procedure consistent with Hayes's PROCESS Model 4 framework (Hayes, 2022). The first step examined the effect of the independent variable (PBA task difficulty) on the mediator (AI technology tools), denoted by path *a*. Results from Model 1 indicated that PBA task difficulty significantly predicted the use of AI technology tools ($\beta = 0.344$, $t = 5.166$, $p < .05$). This implies that a one-unit increase in PBA task difficulty leads to a 0.344-unit increase in the use of AI technology tools. The model explained 9.4% of the variance in the use of AI technology tools ($R^2 = 0.094$), and this was statistically significant ($F = 11.292$, $p < .05$). This satisfied the first mediation condition.

The second stage examined the effect of the mediator on the dependent variable (trainee innovation skill development) while controlling for PBA task difficulty, denoted by path *b*. Model 2 results showed that the use of AI technology tools significantly predicted trainee innovation skill development ($\beta = 0.118$, $t = 2.936$, $p < .05$). This means that a one-unit increase in the use of AI technology tools results in a 0.118-unit increase in trainee innovation skill development. The model accounted for 20.2% of the variance in trainee innovation skill development ($R^2 = 0.202$), and the model was significant ($F = 20.592$, $p < .05$). This fulfilled the second mediation requirement.

The third stage, denoted by path *c'*, established the direct effect of PBA task difficulty on innovation skill development while holding the mediator constant. Model 3 results showed that PBA task difficulty had a positive and significant effect on innovation skill development ($\beta = 0.347$, $t = 6.930$, $p < .05$). This indicates that a one-unit increase in PBA task difficulty results in a 0.347-unit increase in trainee innovation skill development when controlling for the mediator. The model explained 18.1% of the variance in trainee innovation skill development ($R^2 = 0.181$), and the model was statistically significant ($F = 24.021$, $p < .05$). This satisfied the third condition for mediation.

The final stage examined whether mediation existed by assessing the indirect effect of PBA task difficulty on trainee innovation skill development through the use of AI technology tools. The indirect effect ($a \times b$) was 0.041, with a 95% bootstrap confidence interval that did not include zero (BootLLCI = 0.009, BootULCI = 0.082). This confirmed a significant mediation effect. As such, the null hypothesis was rejected, indicating that the use of AI technology tools mediates the relationship between PBA tasks difficulty and innovation skill development among ICT diploma trainees in public technical institutions in Kenya. Since both the indirect and direct effects ($\beta = 0.347$, $p < .05$) were statistically significant, the mediation effect was classified as partial mediation. Additionally, the mediation proportion of AI tools was 10.6%, indicating that while the use of AI technology tools explains a meaningful portion of the total effect of PBA task difficulty

on innovation skill development, the larger proportion of this influence operates through the direct effect of task difficulty itself.

4.2.4 Analysis of Qualitative Data for Integration with Quantitative Data

Qualitative data analysis procedures involved thematic analysis of trainee experiences of PBA tasks difficulty, use of AI technology tools and innovation skill development. This analysis yielded two themes. This includes: the impacts of tasks difficulty and the role of AI tools in shaping innovation skills. In relation to the impacts of PBA tasks difficulty, participants shared rich experiences demonstrating how engagement with challenging and demanding tasks nurtured critical thinking, resilience and problem-solving abilities. For example, one participant reflected, *“That challenge made me to open up... as I was repeating, I was saying, if I fail this, I don’t want to fail the next one... eventually, in the last one, I was able to terminate [the cables].”* (P3). Another participant echoed this by linking task difficulty to cognitive growth and perseverance, explaining that *“difficulty, at a larger percentage, makes you grow and open up your brain. Now... you can build skills like consistency and resilience.”* (P1).

Additionally, participants noted that struggling with difficult PBA tasks promoted technical skills growth. Through persistence and experimentation, trainees reported having developed new competencies that extended beyond classroom theory. One participant narrated, *“It was quite challenging... At some point, I felt like quitting... But after three days, I got a student from my network who taught me one or two things... From that time, I have been able to install any operating system.”* (P4). Similarly, others described how challenging PBA tasks led to innovation skill acquisition and satisfaction: *“I felt moved to exhibit my innovativeness because that challenge made me open up... So, I was happy and satisfied.”* (P3).

With regard to the role of AI tools acting as mediators between PBA tasks difficulty and innovation skill development, participants acknowledged the centrality of these tools in this process. AI tools were described to be functioning like “a second tutor”, helping trainees grasp complex coding logic that reinforces PBA task execution. Participant 7 articulated this clearly: *“AI can increase innovation and creativity... So, we are using AI to speed up the process and explain those big chunks of code blocks like a tutor.”* The trainee illustrated this AI’s step-by-step guidance through an experience in a programming task: *“There was a task... on programming using JavaScript... none of us was very conversant with JavaScript syntax, so we would ask the GPT on the program editor and it would give us the baby steps.”* (P7). This account highlights how AI tools fill instructional gaps by offering problem-solving assistance and fostering self-paced learning experiences that enhance innovation capacity.

At the same time, trainees emphasized that balanced use of AI tools promotes innovation more effectively. Several participants described AI tools as platforms that spark creativity when used to complement rather than replace human thought. As P3 explained, *“If I were to use AI, it would be because my ideas have hit a dead end... I go consult*

AI, get that small knowledge, then come back, add my ideas, and then I do the task." P3 further explained, "If I use it, it will give me a few ideas. So, for me, it will increase my innovativeness... I combine AI ideas with my ideas." (P3). For others, the relationship between AI and innovation was dependent on disciplined use: "AI, with proper usage, gives the utmost innovation." (P6). These insights underline that trainees perceive innovation as emerging from a process that blends AI-generated insights with personal ingenuity and critical interpretation.

However, participants also acknowledged that overreliance on AI tools hinders innovation and critical thinking. Time constraints and the convenience of automation often led to dependence on AI for task completion. As one participant reflected, "I can say that if you depend on AI a lot, you can be less innovative. You will find every time you come across a task you just have the push to use AI tools even for the very simple tasks." (P3). Similarly, another participant recounted, "Sometimes, it hinders my innovativeness... I have deadlines... I will be tempted, let me go to the GPT, it will do everything... I have not engaged my thinking capacity." (P2). P5 narrated an experience where AI tools had hindered her cognitive engagement. She explained, "...There is this time, we were told to create an information system. I was not very conversant with that. So, the teacher was to come to class at around 8, and I had arrived at school at around 8:05, so I had to move very fast and make sure that I have the assignment complete. So, in the end, AI made me not to think." These narratives reveal that without reflective use, use of AI tools may discourage personal cognitive engagement necessary for innovation skill development.

4.3 Data Integration, Interpretation and Discussion of Findings

In order to gain a more comprehensive interpretation of the study findings, qualitative and quantitative findings were integrated using a side-by-side comparison approach. This technique involved the use of a joint display table to juxtapose statistical results with corresponding qualitative themes to identify areas of convergence, divergence, and complementarity. The joint display table is presented in Table 6.

Table 6: Joint display table

Quantitative Finding	Qualitative Insight
Use of AI technology tools partially mediated the relationship between PBA tasks difficulty and trainee innovation skill development ($p < 0.05$, BootLLCI = 0.009, BootULCI = 0.082)	<p>"Difficulty of tasks... builds innovation skills but you need tools and knowledgeable people." (P7)</p> <p>"So, we are using AI tools to explain those big chunks of code blocks like a tutor." (P7)</p> <p>"If I use it [AI tools], it will give me a few ideas. So, ...it will increase my innovativeness... I combine AI ideas with my ideas." (P3)</p> <p>"Sometimes, it hinders my innovativeness... I have deadlines... I will be tempted, let me go to the GPT, it will do everything... so I end up not engaging my thinking capacity." (P2)</p>

Source: Survey data (2025).

Table 6 indicates that from the quantitative analysis, the use of AI technology tools partially mediates the relationship between PBA tasks difficulty and innovation skill development. This suggests that the influence of PBA tasks difficulty on innovation skill development is partly due to the use of AI technology tools. Qualitative insights offered a rich, contextualized explanation for this partial mediation. Some participants experiences described AI tools as useful cognitive and PBA tasks execution support system. Participant 7 explained that *"We use AI tools to explain those big chunks of code blocks like a tutor."* Similarly, *"It will give me a few ideas... I combine AI ideas with my ideas."* (P3). These accounts show that the difficulty of PBA tasks pushes trainees to use AI tools to get ideas and explanations which in turn leads to innovation skill development. This explains the quantitative finding that use of AI technology tools is a mediator through which PBA task difficulty transmits its effects to innovation skill development.

However, trainees also pointed out negative influences, which further explain why the mediation is partial: *"Sometimes, it hinders my innovativeness... I will be tempted... GPT will do everything... I have not engaged my thinking."* (P2). This suggests that overreliance on AI tools can reduce cognitive engagement and problem-solving, which partially may offset their positive effects. Basically, the findings complement each other by highlighting the enhancing and constraining dimensions of AI tools. This dual influence explains the quantitative pattern of partial mediation in that the use of AI tools shapes but does not fully explain the relationship between PBA tasks difficulty and innovation skill development.

This finding is consistent with Lev Vygotsky's Social Constructivism view of cognitive development as a mediated activity which occurs through active interaction of individuals with MKOs in their environment. Trainees described AI tools as providing step-by-step explanations, corrective feedback, and idea prompts when they encountered difficult PBA tasks. For instance, trainees noted that AI tools "explain big chunks of code like a tutor," offer "baby steps" when navigating unfamiliar tasks, and "give ideas" that enhance creativity. This means that by offering on-demand support, AI tools just like human MKOs stand as an intermediary through which difficult PBA tasks transmit their effect on trainees' innovation skills development. As such, the study findings position AI technology tools as a 21st-century MKO within the ICT diploma course. However, since the use of AI technology tools was found to be a partial mediator, human mediation and the difficulty of PBA tasks still remain critical. This underscores the importance of balanced integration of AI tools into PBA design and administration to maximize their mediating potential while preserving socially mediated cognitive development.

These findings align with Vasconcelos and dos Santos (2023) study, which found that that generative AI tools, could act as powerful objects to think within STEM education projects. They provided customized content, instant feedback, and adapted to individual needs, making learning engaging and relevant. Similarly, they are consistent with Olatunde-Aiyedun (2024), who found that AI serves as a catalyst for improved academic performance and a deeper grasp of scientific principles in Nigerian universities.

However, since these studies failed to provide statistical mediation models for the mediating effect of AI tools on the relationships under study, the present study bridges this gap by quantifying the mediating effects and providing nuanced explanations of the mediation from trainees' experiences.

Additionally, these findings bridge knowledge gaps in studies conducted in Kenya by Wang'ang'a (2024), Jepkemoi *et al.* (2024), Oranga (2023), Manyukwe (2023) and Wachira *et al.* (2023), whose aim was to explore the benefits and influences of AI in education in the Kenyan context. The present findings go beyond examining influences to bring out the mediating effect of AI on the relationship between PBA tasks difficulty and the development of trainees' innovation skills. This increases the clarity and explanatory power of literature in the area of AI integration in assessment practices.

5. Conclusions

The central purpose of this study was to assess the mediating effect of AI technology tools on the relationship between the difficulty of PBA tasks and innovation skill development among ICT diploma trainees at selected technical institutions in Kenya. To enhance the depth of interpretation, qualitative and quantitative findings were integrated using a side-by-side comparison approach. Based on the integrated findings, the study concludes that engaging trainees in cognitively demanding PBA tasks significantly promotes the development of innovation skills by stimulating resilience, experimentation, and problem-solving abilities. However, the effectiveness of such demanding tasks is dependent upon the availability of adequate support systems, including guidance from peers, trainers, and digital tools. Further, the study established that AI technology tools partially mediate the relationship between PBA task difficulty and innovation skill development. Consequently, the study concludes that the use of AI technology tools in the execution of difficult PBA tasks operates as an indirect pathway that supports innovation skill development through idea generation, clarification of complex concepts, and tutor-like support. Notably, the direct effect of PBA task difficulty on innovation skill development remained stronger than the indirect effect through AI technology tools. As such, AI technology tools do not substitute the direct role of challenging, designed PBA tasks. Rather, they function as scaffolds that enhance the execution of the difficulty PBA tasks, which ultimately leads to innovation skill development. However, the effectiveness of this scaffolding is contingent upon trainees' responsible and disciplined use of AI tools.

6. Recommendations

In line with the study's conclusions, the study recommends that technical institutions offering ICT diploma courses should establish structured support systems to ensure trainees can effectively engage with cognitively demanding PBA tasks. These systems should include peer support groups, routine tutor consultation hours, and AI-integrated

learning resources. Further, they should formulate and implement clear guidelines to govern AI tools use. The guidelines should outline acceptable AI integration during assessment tasks, provide ethical use standards, AI output verification and avoidance of over-reliance.

Acknowledgements

This article is based on data generated from the corresponding author's PhD research thesis at the School of Education, Moi University, Kenya.

Conflict of Interest Statement

The authors declare that they have no financial or personal interests that could influence the results of this paper.

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