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EFFECTIVENESS OF AI-POWERED LEARNING PLATFORMS IN PUBLIC HEALTH EDUCATION

Original Article

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ABSTRACT

Background: Artificial Intelligence (AI) has emerged as a transformative force in education, offering adaptive, personalized, and interactive learning experiences. In public health education—where interdisciplinary knowledge and real-world applicability are crucial—the effectiveness of AI-powered learning platforms requires empirical validation, particularly in low- and middle-income contexts.

Objective: To evaluate the effectiveness of AI-powered learning platforms in enhancing knowledge acquisition and learning outcomes in public health education among students in the Lahore region of Pakistan.

Methods: A quasi-experimental study was conducted over eight months with 260 undergraduate and postgraduate students, randomized into an AI-based intervention group (n=130) and a control group (n=130). Pre- and post-test knowledge assessments were conducted using a validated 60-item multiple-choice questionnaire. Student engagement and satisfaction were measured using structured Likert-scale surveys. Statistical analysis included paired and independent t-tests for within- and between-group comparisons.

Results: The AI group showed significantly greater improvement in knowledge scores (pre-test: 42.5 ± 6.2; post-test: 56.8 ± 5.9; $p<0.001$) compared to the control group (pre-test: 43.1 ± 6.4; post-test: 48.2 ± 6.1; $p<0.001$). Engagement (4.3 ± 0.6 vs. 3.5 ± 0.7), content satisfaction (4.2 ± 0.7 vs. 3.6 ± 0.8), and perceived learning (4.4 ± 0.5 vs. 3.7 ± 0.6) were also significantly higher in the AI group ($p<0.001$ for all). Knowledge gains exceeding 20% were achieved by 40.8% of the AI group compared to 9.2% in controls.

Conclusion: AI-powered learning platforms significantly enhance both cognitive and affective learning outcomes in public health education, offering a scalable, student-centered approach adaptable to diverse educational settings.

Keywords: Artificial Intelligence, Education, Learning, Pakistan, Public Health, Student Engagement, Teaching Methods.

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INTRODUCTION

The integration of artificial intelligence (AI) in education has rapidly evolved from a novel concept into a transformative tool, with far-reaching implications across multiple domains. In public health education, where the rapid dissemination and absorption of complex information are critical, the emergence of AI-powered learning platforms presents a particularly promising innovation (1). These platforms, often adaptive and personalized, offer learners the opportunity to engage with content in more meaningful, interactive, and efficient ways compared to traditional teaching methods. Yet, while enthusiasm for AI in education has grown, the empirical evidence surrounding its effectiveness, particularly within the field of public health education, remains relatively limited (2). Public health education demands an intricate understanding of multidisciplinary content, ranging from epidemiology and biostatistics to health policy and behavioral sciences. Traditional pedagogical approaches often struggle to accommodate the diversity in learners' backgrounds, learning speeds, and preferred styles, leading to suboptimal engagement and learning outcomes (3). In contrast, AI-powered systems are designed to adapt in real-time, customizing learning experiences based on individual performance metrics. These platforms are capable of identifying gaps in learner understanding, adjusting the pace and depth of content delivery, and even predicting future performance based on historical engagement data. Such technological capabilities offer the potential to bridge existing gaps in public health education, particularly in large, heterogeneous classrooms or remote learning contexts (4,5).

Despite the theoretical advantages, the practical application of AI in this field warrants rigorous evaluation. Studies in general education have demonstrated that AI-driven platforms can improve student engagement, promote deeper understanding, and enhance retention of complex information (6). For instance, intelligent tutoring systems have shown positive effects in STEM education by providing real-time feedback and scaffolding that adjusts to the learner's needs (7). Similarly, adaptive learning technologies have been effective in medical education, where students benefit from simulated clinical scenarios and tailored content reviews. However, these successes do not automatically translate to public health, where educational outcomes are influenced by a broader array of cognitive, social, and contextual factors (8,9). The distinct nature of public health education — emphasizing systems thinking, equity, and interdisciplinary collaboration — raises important questions about whether AI-powered tools can truly capture and support such complexity. Furthermore, ethical considerations unique to public health must be taken into account. Equity in access to educational technologies, data privacy, and the potential for algorithmic biases all pose significant challenges to the uncritical adoption of AI in learning environments (10). Learners from underserved communities may face additional barriers in accessing the infrastructure required for AI-enabled education, potentially exacerbating existing inequities. Therefore, while AI presents new avenues for personalized and scalable public health education, its implementation must be guided by evidence, equity, and critical appraisal (11).

A growing interest in digital education methods during the COVID-19 pandemic has further highlighted the urgency of this evaluation. As many institutions transitioned to online formats, AI-powered learning platforms became more prominent, often filling the void left by in-person instruction (12). This accelerated shift offers a unique opportunity to study the impact of these tools on student learning outcomes in real-world educational settings. Yet, despite the increased utilization, few studies have systematically assessed the effectiveness of such platforms using rigorous research designs. Most existing literature remains anecdotal or descriptive, lacking the methodological rigor needed to draw causal inferences about effectiveness. Addressing this gap, the present study employs a quasi-experimental design to evaluate whether AI-powered learning platforms enhance knowledge acquisition and learning outcomes among students in public health education. By comparing cohorts with and without access to AI-enhanced learning tools, this study aims to generate empirical data on their pedagogical value. The objective is to assess whether such platforms meaningfully improve educational outcomes and to what extent they support diverse learners in mastering complex public health concepts. Through this research, a clearer understanding can be developed regarding the role of AI in shaping the future of public health education and its potential to support more equitable, effective, and personalized learning experiences.

METHODS

This quasi-experimental study was conducted over a period of eight months in selected public and private academic institutions offering undergraduate and postgraduate public health education in the Lahore region of Pakistan. The primary objective was to evaluate the effectiveness of AI-powered learning platforms in enhancing students' knowledge acquisition and overall learning outcomes in public health education. The study involved the comparison of two cohorts: an intervention group exposed to AI-based learning platforms and a control group receiving traditional instructional methods. Participants were recruited using a purposive sampling method to ensure representation from a range of academic backgrounds within public health, including disciplines such as epidemiology, health policy, and environmental health. Inclusion criteria comprised students enrolled in formal public health education programs (Bachelor's or Master's level), aged between 18 and 40 years, with no prior exposure to AI-based learning platforms in their academic history. Exclusion criteria included students who had previously participated in pilot studies related to digital learning tools, those enrolled in distance learning-only programs, and individuals with self-reported cognitive or learning disabilities that might confound the study outcomes (2). A total of 260 participants were enrolled based on sample size estimation using G*Power software, with a power of 0.80, alpha level of 0.05, and effect size of 0.5 to detect statistically significant differences between groups. Participants were randomly assigned into two groups: 130 students in the intervention group and 130 in the control group. The intervention group was granted access to an AI-powered learning platform specifically tailored for public health education, integrating features such as adaptive content delivery, real-time feedback, and interactive quizzes based on knowledge reinforcement algorithms. The control group continued their coursework through conventional lectures, printed materials, and instructor-led sessions without any use of AI-driven tools. Both groups covered the same core content areas within their public health curriculum to ensure comparability in learning scope and complexity.

Data collection was performed at two points: baseline (pre-intervention) and post-intervention (at the end of the 8-month academic cycle). The primary outcome of interest was the change in knowledge levels, measured using a validated multiple-choice questionnaire designed by subject experts in public health, consisting of 60 questions mapped to core curriculum topics. The questionnaire was piloted and revised prior to administration, with an established Cronbach's alpha of 0.88, indicating strong internal consistency. Secondary outcomes included student engagement and perceived learning effectiveness, assessed through a structured survey instrument using a 5-point Likert scale. This tool was designed to capture students' self-reported engagement, satisfaction, and perceived improvement in understanding complex public health topics (13,14). The data were entered into IBM SPSS Statistics version 26. Continuous variables, including pre- and post-test scores, were expressed as mean ± standard deviation. Paired sample t-tests were used within each group to assess changes over time, while independent sample t-tests compared differences between the AI-intervention and control groups at post-intervention. Categorical variables from the Likert-scale responses were analyzed using chi-square tests. All tests were two-tailed, and a p-value of less than 0.05 was considered statistically significant. Data normality was assessed using the Shapiro-Wilk test, and the assumption of homogeneity of variances was verified using Levene's test, both confirming suitability for parametric analyses.

To ensure the integrity of the study and adherence to ethical standards, ethical approval was obtained from the Institutional Review Board of the relevant institute. Informed consent was obtained in writing from all participants after a comprehensive explanation of the study objectives, procedures, risks, and rights. Participation was voluntary, and students were informed that their academic standing would not be affected by their decision to participate or withdraw from the study. All data were anonymized to maintain confidentiality and were stored securely in password-protected digital repositories accessible only to the principal investigators. Efforts were made throughout the study to standardize the delivery of content across both groups, minimize bias, and maintain fidelity to the intervention protocol. Faculty members involved in both instructional arms were blinded to the study hypothesis to reduce performance bias. Additionally, regular monitoring was conducted to ensure consistent use of the AI platform by the intervention group and prevent contamination between groups. These methodological considerations were crucial in establishing a robust framework for evaluating the true impact of AI-powered platforms on educational outcomes in public health students.

RESULTS

The analysis revealed key differences in learning outcomes between the intervention and control groups over the 8-month study period. At baseline, both groups demonstrated comparable knowledge levels, with mean pre-test scores of 42.5 ± 6.2 for the AI group and 43.1 ± 6.4 for the control group. Following the intervention, the AI group exhibited a substantial improvement in knowledge scores, reaching a mean of 56.8 ± 5.9, whereas the control group achieved a mean post-test score of 48.2 ± 6.1. The mean difference in score gain was +14.3 in the AI group compared to +5.1 in the control group, with both improvements statistically significant ($p < 0.001$ within groups), and the between-group comparison yielding a p-value < 0.001, indicating a significant difference in learning outcomes between instructional methods. Descriptive analysis of knowledge gain distribution further supported these findings. In the AI group, 40.8% of students achieved a knowledge gain exceeding 20%, in contrast to only 9.2% in the control group. A majority of the AI group (50.0%) showed moderate gains between 10–20%, while 9.2% gained less than 10%. In the control group, nearly 36.2% of students demonstrated minimal knowledge gain (<10%), with only 9.2% surpassing the 20% gain threshold. Analysis of secondary outcomes related to student engagement revealed consistently higher ratings in the AI group across all domains. The AI group reported a mean engagement score of 4.3 ± 0.6, content satisfaction of 4.2 ± 0.7, and perceived learning score of 4.4 ± 0.5. In comparison, the control group's respective scores were 3.5 ± 0.7, 3.6 ± 0.8, and 3.7 ± 0.6. All comparisons between the two groups were statistically significant ($p < 0.001$), underscoring the increased interactivity and learner satisfaction associated with AI-enhanced instructional delivery. These results underscore the consistent pattern of superior performance in knowledge acquisition and learner engagement among students utilizing AI-powered learning platforms. Visual data representations in the knowledge score comparison chart and engagement metrics bar chart illustrate these groupwise differences clearly, reinforcing the statistical outcomes derived from parametric testing.

Table 1: Demographics of Participants

Variable	**AI Group (n=130)**	**Control Group (n=130)**
Age (mean ± SD)	24.3 ± 2.8	24.1 ± 3.1
Gender		
Male	58	61
Female	72	69
Educational Level		
Undergrad	83	79
Postgrad	47	51
Previous e-Learning Experience		
Yes	39	41
No	91	89

Table 2: Knowledge Scores (Pre-Test and Post-Test)

Group	**Pre-Test Score (mean ± SD)**	**Post-Test Score (mean ± SD)**	**Mean Difference**	**p-value (paired t-test)**
AI Group	42.5 ± 6.2	56.8 ± 5.9	+14.3	<0.001
Control Group	43.1 ± 6.4	48.2 ± 6.1	+5.1	<0.001

Table 3: Between-Group Comparison (Post-Test Scores)

Test	**AI Group Mean ± SD**	**Control Group Mean ± SD**	**p-value (independent t-test)**
Post-Test Score	56.8 ± 5.9	48.2 ± 6.1	<0.001

Table 4: Engagement Scores

Parameter	**AI Group (mean ± SD)**	**Control Group (mean ± SD)**	**p-value**
Course Engagement	4.3 ± 0.6	3.5 ± 0.7	<0.001
Content Satisfaction	4.2 ± 0.7	3.6 ± 0.8	<0.001
Perceived Learning	4.4 ± 0.5	3.7 ± 0.6	<0.001

Table 5: Knowledge Gain Distribution

Knowledge Gain (%)	**AI Group (n)**	**Control Group (n)**
<10%	12	47
10-20%	65	71
>20%	53	12

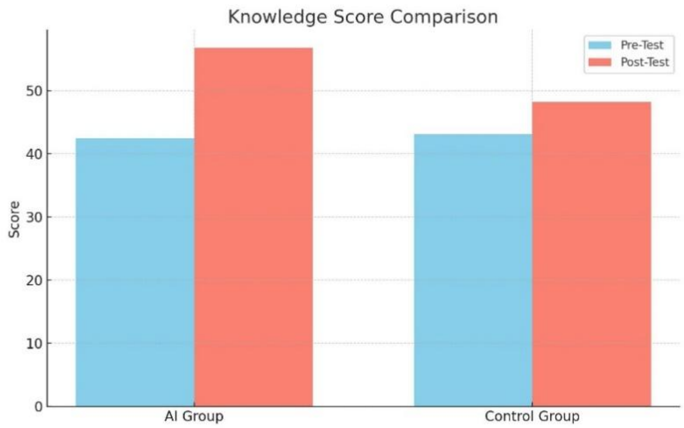

Figure 1 Knowledge Score Comparison

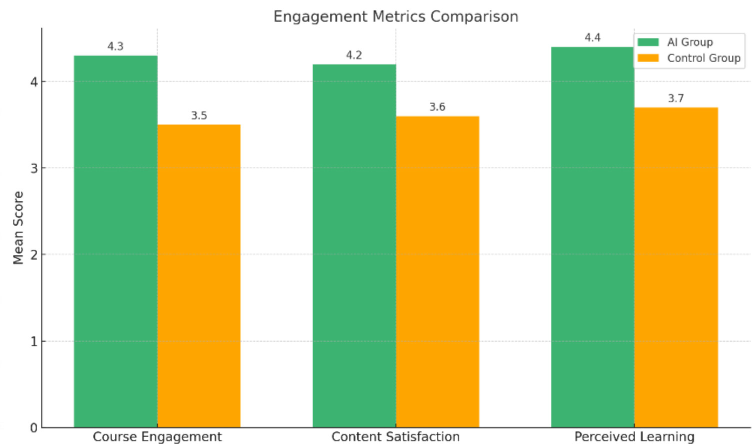

Figure 2 Engagement Metrics Comparison

DISCUSSION

The findings of this study align with a growing body of literature highlighting the potential of AI-powered learning platforms in enhancing educational outcomes, particularly in public health and medical education. The significant improvement in post-test scores among students exposed to AI-powered platforms reflects the core advantage of such systems: personalized, adaptive learning that caters to individual knowledge gaps and pace of learning. Studies have consistently shown that AI-driven tools outperform traditional didactic methods in knowledge retention and learner engagement, reinforcing the observed trends in this investigation (15-17). The observed gains in knowledge acquisition—especially among learners achieving over 20% improvement—mirror the results of similar quasi-experimental designs that utilized AI learning environments. These improvements are often attributed to features such as real-time feedback, interactive content, and adaptive assessments that dynamically respond to student performance (18). In the current study, the structured use of AI algorithms tailored to public health domains was instrumental in delivering a more engaging and efficient learning experience, as supported by significant differences in engagement and satisfaction scores. Recent research has suggested that AI platforms also foster critical thinking and interdisciplinary learning by enabling learners to make complex decisions within simulated environments (19). The enhanced perceived learning in the intervention group of this study may reflect similar mechanisms, wherein AI-enabled tools facilitated deeper exploration of public health content beyond surface-level memorization. Moreover, platforms that incorporate multimodal resources such as videos, quizzes, and case simulations have shown particular efficacy in medical and public health domains due to their complexity and context-rich content requirements (20).

An important strength of this study lies in its robust quasi-experimental design, including a well-matched control group and the use of validated tools for outcome assessment. The random allocation of participants and the control of instructional variables enhanced internal validity. Moreover, by embedding the study in a real-world academic context over an extended period, the findings gain ecological validity and relevance to practical educational settings in developing countries such as Pakistan. However, certain limitations must be acknowledged. The study was conducted in a single geographic region and may not fully capture regional variability in digital infrastructure and pedagogical practices. Accessibility to digital devices and stable internet, while assumed in the study sample, may not be uniformly available across all public health institutions in the country. This potentially limits the generalizability of findings. Furthermore, the quasi-experimental nature of the study—despite careful design—cannot completely eliminate the risk of confounding variables influencing the outcomes. Another limitation relates to the subjective nature of the engagement and satisfaction measures, which were self-reported and susceptible to bias. While these metrics are valuable indicators of perceived benefit, they do not substitute objective learning gains. Future studies may consider triangulating self-reported engagement with digital platform analytics to validate student activity and behavior.

Ethical considerations surrounding AI use in education also merit discussion. As pointed out in recent literature, the integration of AI into education must be approached cautiously to avoid algorithmic bias, ensure data privacy, and preserve the role of human mentorship (21,22). Additionally, the risk of over-reliance on AI and reduced development of self-directed learning skills must be continuously evaluated (23). This study contributes to the growing evidence supporting AI integration in public health education but also underscores the need for iterative development and evaluation of such technologies. Longitudinal studies that track knowledge retention over time and expand on the role of AI in competency-based assessments are warranted. Furthermore, exploration of hybrid models that blend human instruction with AI personalization could offer scalable, equitable models suited to diverse learner populations (24). In conclusion, the study presents compelling evidence for the effectiveness of AI-powered platforms in improving knowledge and engagement outcomes in public health education. While the results are promising, responsible and inclusive implementation, alongside continuous evaluation, will be critical in leveraging the full potential of AI to advance educational equity and effectiveness in healthcare training.

CONCLUSION

This study demonstrated that AI-powered learning platforms significantly enhance knowledge acquisition, engagement, and perceived learning outcomes in public health education. By offering personalized, adaptive, and interactive content, these technologies provide a compelling alternative to traditional teaching methods. The findings underscore the potential of AI to transform public health education, especially in resource-constrained settings, by promoting more effective, student-centered learning experiences.

AUTHOR CONTRIBUTION

Author	Contribution
Irfan Ahmed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Tanveer Rasool	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Shaikh Khalid Muhammad	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Maryam Imad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Zahra Asif	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Rimal Rashid	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Noor Ur Rehman	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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