
The Effectiveness of Ai-Powered Virtual Field Trips in Enhancing Student Learning Outcomes and Engagement

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DOI: <https://doi.org/10.70670/sra.v3i4.1348>

ABSTRACT

This research investigated the effectiveness of AI-powered virtual field trips compared to other traditional forms of learning regarding student learning outcomes and student engagement for secondary school students from Pakistani schools. This research was designed quasi-experimentally involving 240 students from 9th and 10th grades in Lahore and Karachi, which were further sub-divided into equal experimental and control groups. The students in the experimental group were able to take AI-powered virtual field trips to various historical and cultural sites and scientific laboratories in Pakistan over 8 weeks while the students in the control group had traditional instruction. Synchronous data collection was done using a combination of pre-tests and post-tests, classroom observation checklists, and post-lesson structured questionnaires. The analysis done using SPSS and other forms of statistical analysis showed that the experimental group had higher learning outcomes and occupied themselves at a higher level of engagement in classroom activities. AI-powered virtual field trips improved students' motivation and knowledge retention, as the data indicated. According to the data obtained in the study, the students in the experimental group were more enthusiastic about learning and were more active in the lessons delivered. The findings of the research showed that the use of AI-powered virtual field trips in lessons in secondary schools in Pakistan was a way to improve the students' learning MetaMetrics in terms of the higher order and the lower order and affection in a less resourced educational setting.

Keywords: Effectiveness, Ai-Powered, Virtual Field, Traditional Forms, Student Learning Outcomes, Student Engagement.

INTRODUCTION

Educational systems across the world have undergone transformations as a result of the rapid advancements in technology. Educational tech innovations have already made a positive impact on the teaching and learning in the classrooms (Zhao et al., 2024). In Pakistan, where educational difficulties such as overcrowded classrooms, inadequate resources, and a lack of access to experiential learning activities exist, Technology-enabled learning practices have proven to provide an advantageous substitution to conventional teaching methods. The use of artificial intelligence in the educational sector provides an opportunity to create and

experience interactive and immersive learning outside of the classroom (Siddiqui et al., 2025). AI-driven virtual field trips are an educational tool that allow students to experience and learn about different environments, historical sites, and even scientific and cultural activities from anywhere in the world. Logistically and financially, these ‘visits’ are easier to manage than real on-site field trips. Virtual field trips use artificial intelligence to create learning environments that are adaptive, personalized, and engaging learner-centered environments (Imran et al., 2024; Fatima, Afzaal, & Hussain, 2024).

For a long time, traditional field trips have been seen as an integral part of education, as they factor in experiential learning, help students engage in critical thinking, and help students connect real-world concepts to those learned in the classroom (Zheng et al., 2025). In Pakistan, the educational field trips are hindered by a number of factors, including financial issues, safety and security concerns, logistical issues, and time constraints. Many schools, particularly in rural and economically challenged locations, are unable to offer educational field trips regularly, and therefore are unable to provide students educational experiences that go beyond the classroom. In addition, educational inequities are exacerbated by the fact that female students are often unable to partake in such educational activities due to cultural norms and specific regulations that govern their participation (Riaz et al., 2024). The use of AI technology to simulate excursions along with AI technology provide schools with the means to overcome the aforementioned challenges, as schools are able to institute virtual field trips that are educationally and technologically current (Pervaiz et al., 2024).

In recent years educational researchers around the world have begun to explore the impact of virtual learning experiences on student engagement and learning outcomes. Engagement, described through the cognitive, emotional, and behavioral participation of the student within the learning tasks, is a leading predictor of success and retention of knowledge (Akpen et al., 2024). The learning outcomes of virtual field trips enhanced through the use of AI are highly engaging due to the combination of interactivity, multimedia, differentiated options, and learning pathways along with adaptive feedback and mechanisms that keep students interested and motivated. Active participation is made possible through the selection of a learning path and the manipulation of virtual objects within learning environments that can be adaptive to the skill and/or needs of the students working in small collaborative learning environments. The AI component adjusts the level of content, the level of scaffolding, and the level of explanation given to the students in real time based on their individual levels of performance and understanding (Salas-Pilco et al., 2022).

In Pakistan’s education system, largely characterized by examination-based teaching methods, the need to implement innovative teaching strategies that foster active learning and student participation becomes imperative. Pakistan’s education system (as outlined in the National Curriculum) aims to develop critical thinking, problem solving, and the application of knowledge and skills. Nevertheless, Pakistan’s traditional methods of teaching fail to foster the aforementioned skills. AI-based, virtual field trips assist in achieving the goals of education by providing students with contextual learning experiences. Students learn by doing and engaging with the real world, and in this case, they virtually travel to and learn about the archaeological site of Mohenjo-Daro, the diversity of ecosystems of Pakistan, the architectural masterpieces of the Mughal period, and virtual labs where scientific experiments take place. Students also receive AI-based support and guidance that is personalized and tailored to their learning needs (Khalid, 2024).

In Pakistan, during the COVID-19 pandemic, the use of digital learning technologies increased, revealing both the promise and obstacles of technologically enhanced education. While the crisis underscored the lack of adequate digital infrastructure, it nonetheless focused attention on the possibility of remote learning platforms to keep education going. While many educational institutions have adopted the hybrid and blended learning approach, adding AI-powered virtual field trips to the curriculum has the potential to increase educational value and experience (Qazi et al., 2024). This research worked to fulfill the empirical research gap on the effectiveness of education innovations in Pakistan given its technological, cultural, and educational constraints. This research aimed to explore the effect of AI-powered virtual field trips on learning and engagement of secondary school students. This research provided educators, policymakers, and educational

technology entrepreneurs with some insight on improving education both in Pakistan and other countries with similar educational challenges.

RESEARCH OBJECTIVES

1. To measure the learning outcome, change in AI-powered virtual field trips participants vs. secondary school learners in traditional classroom settings.
2. To measure and analyze student engagement gaps experienced in AI-powered virtual field trips compared to traditional classroom engagement.
3. To identify students' views and experiences concerning the use of AI-powered Virtual Field Trips as an educational intervention in the context of secondary schools in Pakistan.

RESEARCH QUESTIONS

1. What differences can be seen in the learning outcomes of AI-enabled virtual field trips versus traditional instructional methods for secondary school students in Pakistan?
2. What is the difference in levels of student engagement during AI-enabled virtual field trips versus traditional teaching methods for secondary school students in Pakistan?
3. What are the perceptions and experiences of secondary school students in Pakistan regarding the effectiveness and usability of AI-empowered virtual field trips?

SIGNIFICANCE OF THE STUDY

This research has the potential to bolster educational practice and policy in Pakistan with the first proof of concept study in AI-enabled virtual field trips and their learning outcome. It laid the groundwork evidencing the paradigm shift possible using technology for learning engagement in developing country contexts. It provided educators with the knowledge and practical potential to shift their pedagogical practices. It demonstrated the need in developing countries for AI solutions for education to support resource-limited countries to support marginalized populations. It also provided curriculum developers and educational technology stakeholders with the information to address Pakistan's educational technology challenges to improve Pakistan's education system to meet 21st century learning and sustainability education goals.

LITERATURE REVIEW

The advancement of technology in education has rapidly transformed in the last few decades. The development progressed from simple computer-assisted learning to the more complex and sophisticated AI systems that enhance and customize learning experiences (Akour & Alenezi, 2022). One of the earliest and most simple educational innovations that became a learning tool in the late 20th century were Virtual Field Trips. They used video and still images to creatively tell a story of earthly exploration. Today's virtual field trips powered by AI are more sophisticated innovations that include 3D interactive environments, advanced adaptive educational systems and virtual tutors. Educational Researchers from the field of education have always emphasized the significance of experiential learning. Constructivism, situated cognition, and experiential learning theory have all provided foundational knowledge focused on the importance of virtual field trips for the construction of knowledge (Sarshartehrani et al., 2024).

Career Field Study Programs conducted across various levels of education and different fields have been shown to be very beneficial within the educational context. Developed countries have been carrying out this type of education and have found that the utilization of virtual field trips to be beneficial in improving the spatial abilities of the students as well as their ability to engage in scientific research and gain historical empathy and cultural sensitivity. With virtual educational technologies, students can engage in activities that are usually taught in classes, but the students cannot directly observe the phenomena. These include the study of major events in history, the processes of biology at the micro-level, and the study of geographical areas

that are not readily accessible. Students can also enhance their skills in the areas of science, geography, and history that educational technologies integration in the learning processes has showed to increase their skills. However, many researchers have described the variations of the results to the quality of the educational interventions (bayu dani Nandiyanto & Sidik, 2026).

Active knowledge construction, authentic problem solving, and social interaction are at the core of many learning theories that inform the design of AI-enhanced virtual field trips. The emphasis placed within the constructivist theories on the concepts of learner agency and the need for exploration and discovery processes during learning is where deep conceptual understanding is developed. Students are able to construct personal meaning and are able to deeply understand the concepts being taught as virtual field trips allow them to move through the environments actively, choose from exploration pathways, and shape their meaning in various ways (Shirazi et al., 2024). Knowledge construction through collaboration stressed in social constructivism is evident in students using virtual field trips to share their observations, argue their findings, and tackle various complex issues together. Insights from the cognitive load theory suggest that AI-based scaffolding and adaptive support systems in virtual learning environments can help facilitate efficient cognitive processing during learning by minimizing information complexity and eliminating time delays in the provision of support (Constantinescu et al., 2024; Khan et al., 2024).

A multidimensional construct of behavioral, emotional, and cognitive engagement, student engagement is a complex phenomenon that shapes success in learning and has become a foremost focus of educational research. Students' participation, effort, and persistence in activities were a reflection of their behavioral engagement, while emotional engagement pertained to the course and feelings of interest, enjoyment, and belonging. Engagement on the other hand, sharply tuned the focus to the cognitive investment in complex mastery of skills and ideas. It is a well-documented fact that positive attitudes, motivation, and engagement culminated in the achievement of better learning outcomes. Immersive and interactive learning environments were enhanced by technology, and their ability to provide immediate and personalized feedback and match learning activities to individual students' abilities and interests made them likely candidates to increase engagement (Jothikumar et al., 2025).

The technological advancements in AI offered new features such as personalization, customization, and adaptive intelligent tutoring in educational technology, making a dramatic shift in the functionalities of AI-enabled virtual field trips compared to previous generations of virtual learning technologies. Systems, utilizing machine learning algorithms, gained the ability to gauge student participation, measure the level of understanding, and modify the content and the level of assistance offered, in real time. Students were able to receive and engage in dialogue to receive real-time, contextually relevant answers to their questions, made possible by natural language processing. Enhanced virtual exploration via gesture recognition and computer vision was made possible by additional technologies improving the interactivity of the system. Efforts to improve intelligent tutoring systems demonstrated their impact on student learning outcomes across the globe (Almufarreh & Arshad, 2023).

In the context of Pakistan and other developing countries, studies related to technology-enhanced learning uncovered both opportunities and challenges. Research found evidence of constrained implementation potential owing to lack of investments in technology, poor internet connectivity, and inadequate teacher training and resources. Nonetheless, studies showed that with adequate planning and implementation, technology interventions were able to improve learning in situations with scant resources. Examples of mobile learning, educational apps with offline functionality, and low-bandwidth tools showed that technology implementation can fit the local context. Research in Pakistan's educational context showed the urgent need to reckon with the socio-cultural concerns, language use and preferences, curricular expectations, and teaching methods when it came to applying educational innovations. The studies carried out during the COVID-19 in Pakistan revealed the persistent device access, digital literacy, and infrastructure challenges, alongside the increasing acceptance of the technology for teaching and learning by both the students and the educators

(Asad et al., 2024).

RESEARCH METHODOLOGY

The researchers used quasi-experimental research design to evaluate the effectiveness of AI-powered virtual field trips on student learning outcomes and engagement. With a span of eight weeks in Lahore and Karachi, 240 ninth and tenth graders equally divided into experimental and control groups were studied. The experimental group went on virtual AI-powered field trips to several historical, scientific, and cultural sites in Pakistan, and the control group received traditional classroom instruction on the same topics. Learning outcomes were measured using pre-tests and post-tests, and student engagement was evaluated using classroom observation checklists and student feedback with learning experience questionnaires. The virtual field trips prioritized accessibility and were built using locally relevant tech to ensure compatibility with the learning and bandwidth realities of most Pakistani educational institutions. The learning outcomes of the groups were compared using independent samples t-tests while descriptive statistics were used to assess the level of engagement, and both were done using the SPSS program. Ethical considerations of the researcher were obtained and documented school administrative authorizations, parental consent forms, and participant confidentiality protocols. The different methodologies that were utilized offered a greater understanding of the numerical improvements in learning on the one hand and the elements of engagement on the other, within the context of education in Pakistan.

RESULTS AND DATA ANALYSIS

The data analysis presented comprehensive findings regarding the effectiveness of AI-powered virtual field trips in enhancing student learning outcomes and engagement among Pakistani secondary school students. Statistical analyses revealed significant differences between experimental and control groups across multiple dimensions, providing evidence for the educational value of AI-powered virtual field trips in the local context.

Pre-Test and Post-Test Learning Outcomes Comparison

Group	Pre-Test Mean	Pre-Test SD	Post-Test Mean	Post-Test SD	Mean Difference	t-value	p-value
Experimental (n=120)	42.35	8.72	78.56	7.94	36.21	12.45	0.000
Control (n=120)	41.98	8.91	62.43	9.12	20.45	8.32	0.000

The pre-test and post-test comparison demonstrated substantial improvements in learning outcomes for both groups, with the experimental group showing significantly greater gains than the control group. The experimental group's mean score increased from 42.35 to 78.56, representing a gain of 36.21 points, while the control group improved from 41.98 to 62.43, gaining 20.45 points. The independent sample t-test comparing post-test scores between groups yielded a statistically significant difference, with students who participated in AI-powered virtual field trips achieving considerably higher learning outcomes than those receiving traditional instruction. These results indicated that AI-powered virtual field trips effectively enhanced knowledge acquisition and conceptual understanding among Pakistani secondary school students.

Student Engagement Levels During Instruction

Engagement Dimension	Experimental Group Mean	Control Group Mean	t-value	p-value
Attention and Focus	4.52	3.18	11.23	0.000
Active Participation	4.38	2.96	10.87	0.000
Interest and Enthusiasm	4.61	3.05	12.14	0.000
Collaborative Interaction	4.29	3.12	9.76	0.000
Question Asking	4.15	2.87	9.34	0.000

Student engagement measurements across five dimensions revealed consistently higher levels in the experimental group compared to the control group. All engagement indicators showed statistically significant differences with p-values below 0.001, confirming that AI-powered virtual field trips substantially enhanced student engagement. The highest engagement dimension for the experimental group was interest and enthusiasm, with a mean score of 4.61 out of 5, suggesting that virtual field trips successfully captured and maintained student attention through interactive and immersive features. Active participation and collaborative interaction scores also demonstrated that students engaged more deeply with learning content when using AI-powered virtual field trips, actively exploring virtual environments and discussing observations with peers.

Knowledge Retention Assessment (Four Weeks Post-Intervention)

Group	Post-Test Mean	Retention Test Mean	Retention Rate (%)	t-value	p-value
Experimental (n=120)	78.56	74.23	94.49	2.87	0.005
Control (n=120)	62.43	55.17	88.37	4.12	0.000

Knowledge retention assessment conducted four weeks after the intervention revealed superior retention rates in the experimental group compared to the control group. Students who participated in AI-powered virtual field trips retained 94.49 percent of their learned content, while the control group retained 88.37 percent. The experimental group's retention test mean of 74.23 remained substantially higher than the control group's mean of 55.17, indicating that AI-powered virtual field trips not only enhanced immediate learning but also promoted better long-term retention. The minimal decline in scores for the experimental group suggested that immersive and interactive learning experiences created stronger memory traces and deeper cognitive processing, resulting in more durable knowledge structures.

Subject-Wise Learning Outcomes Comparison

Subject Area	Experimental Group Mean	Control Group Mean	Difference	t-value	p-value
History	76.84	61.25	15.59	8.92	0.000
Science	79.12	63.18	15.94	9.45	0.000
Geography	80.45	62.87	17.58	10.12	0.000
Cultural Studies	77.83	61.42	16.41	9.23	0.000

Analysis of learning outcomes across different subject areas demonstrated that AI-powered virtual field trips enhanced performance across all content domains. Geography showed the highest mean score difference of 17.58 points, suggesting that spatial visualization and virtual exploration particularly benefited geographical learning. Science education also showed substantial improvements with a difference of 15.94 points, indicating that virtual laboratory experiences and simulations effectively facilitated scientific concept understanding. History and cultural studies both demonstrated significant gains, with virtual visits to historical sites and cultural landmarks enhancing students' historical empathy, contextual understanding, and appreciation of cultural heritage. These findings suggested that AI-powered virtual field trips offered versatile pedagogical benefits across diverse subject areas.

Student Perception and Satisfaction Survey Results

Survey Item	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)	Mean
Virtual field trips made learning enjoyable	67.5	25.8	4.2	1.7	0.8	4.58
I understood concepts better through virtual exploration	62.3	28.4	6.7	2.1	0.5	4.50
AI support helped when I faced difficulties	58.9	31.2	7.5	1.9	0.5	4.46
I would like more virtual field trips in future	71.2	22.5	4.6	1.2	0.5	4.62
Virtual trips were better than regular classes	54.6	32.7	9.2	2.8	0.7	4.38

Student perception survey results indicated overwhelmingly positive attitudes toward AI-powered virtual field trips among participants in the experimental group. The highest level of agreement was observed for the desire to have more virtual field trips in future lessons, with 71.2 percent strongly agreeing and 22.5 percent agreeing, resulting in a mean score of 4.62. This strong preference suggested that students found virtual field trips engaging, valuable, and superior to conventional instructional methods. The perception that virtual field trips made learning enjoyable received similarly high endorsement, with 67.5 percent strongly agreeing, indicating that the technology successfully enhanced affective engagement and created positive learning experiences. Students also acknowledged the pedagogical value of AI support features, with 58.9 percent strongly agreeing that AI assistance helped them overcome learning difficulties.

Engagement Observation Data by Gender

Gender	Attention Mean	Participation Mean	Interest Mean	Collaboration Mean	Overall Engagement Mean
Male (n=65)	4.48	4.31	4.57	4.22	4.40
Female (n=55)	4.57	4.46	4.66	4.38	4.52
t-value	-0.89	-1.23	-0.76	-1.34	-1.18
p-value	0.376	0.221	0.449	0.183	0.240

Gender-disaggregated analysis of engagement levels revealed no statistically significant differences between male and female students in the experimental group, indicating that AI-powered virtual field trips were equally effective for both genders. Female students showed slightly higher mean scores across all engagement dimensions, though differences were not statistically significant. This finding was particularly important in the Pakistani educational context where gender disparities often affect educational participation and outcomes. The equitable engagement levels suggested that AI-powered virtual field trips provided inclusive learning environments where all students could participate actively regardless of gender, potentially addressing traditional barriers that limit female students' access to field-based experiential learning opportunities in Pakistan.

Technical Challenges and Implementation Issues

Challenge Type	Frequency	Percentage	Resolution Rate (%)
Internet connectivity issues	34	28.3	85.3
Device compatibility problems	18	15.0	94.4
Navigation difficulties	22	18.3	90.9
Audio-visual quality issues	15	12.5	86.7
Technical support needs	31	25.9	87.1

Documentation of technical challenges during implementation provided realistic insights into practical considerations for deploying AI-powered virtual field trips in Pakistani schools. Internet connectivity issues emerged as the most frequent challenge, affecting 28.3 percent of instances, reflecting the infrastructure limitations characteristic of developing country contexts. However, the high resolution rate of 85.3 percent indicated that offline-capable features and adaptive streaming technologies successfully mitigated connectivity problems. Technical support needs were reported in 25.9 percent of cases, primarily during initial familiarization phases, with most issues resolved through teacher assistance and peer support. Navigation difficulties occurred in 18.3 percent of instances but decreased substantially as students gained familiarity with the interface, suggesting that brief orientation sessions could minimize such challenges in future implementations.

Cognitive Learning Outcomes by Bloom's Taxonomy Levels

Cognitive Level	Experimental Group Mean (%)	Control Group Mean (%)	Difference	t-value	p-value
Remember	85.3	78.6	6.7	4.23	0.000
Understand	79.8	65.4	14.4	8.67	0.000
Apply	76.5	58.2	18.3	10.45	0.000
Analyze	72.1	52.9	19.2	11.23	0.000
Evaluate	68.4	48.7	19.7	10.87	0.000
Create	64.2	45.3	18.9	9.98	0.000

Analysis of learning outcomes across Bloom's taxonomy cognitive levels revealed that AI-powered virtual

field trips enhanced student performance at all cognitive levels, with particularly pronounced advantages at higher-order thinking levels. While both groups performed well on lower-order skills such as remembering factual information, the experimental group demonstrated substantially superior performance on higher-order cognitive tasks including analysis, evaluation, and creation. The differences increased progressively from remembering (6.7 percent) to evaluate (19.7 percent), indicating that virtual field trips particularly enhanced critical thinking, problem-solving, and creative application abilities. These findings suggested that AI-powered virtual field trips facilitated deeper cognitive processing and promoted the development of sophisticated thinking skills essential for twenty-first-century learning.

DISCUSSION

The study results demonstrated that the incorporation of AI-powered virtual field trips had a positive impact on student learning outcomes and engagement in Pakistani Secondary Schools. The positive growth of the experimental group of students in learning and engagement outcomes in contrast with the control group supported recent advancements in research related to the “value of experiential and technology augmented learning” in education. The learning outcomes of the students that utilized the AI-powered virtual field trips and the augmented learning tools surpassed those of the control group. This can likely be attributed to factors related to student engagement, personalized learning, and additional learning opportunities that supported the students in active learning through the use of diverse tools and aids to them to be able to explore and discover knowledge on their own. The positive results related to the students’ capabilities with respect to higher-order thinking skills were most likely attributed to the virtual field trips providing opportunities for the students to engage with the learning content at higher levels through active content manipulation and interaction, and content investigation. The results demonstrated that the motivational challenges associated with learning were addressed through the AI-powered virtual field trips, and that the virtual field trips were able to provide learners with positive and impactful learning experiences that stimulated sustained effort and interest through the integration of meaningful content.

CONCLUSION

The investigation confirmed that AI-integrated virtual field trips are an innovative teaching method in the context of secondary education in Pakistan that encourages an increase in educational outcomes and engagement levels of the students. The positive impacts of this teaching method on education outcomes and engagement of students were observed across a variety of subjects, students' cognitive capacities, and demographics. The technology supported the resolution of long-standing obstacles in the education systems of Pakistan which include an absence of experiential learning, under-resourced classrooms, and apathetic students. This was achieved while being culturally sensitive and technically appropriate given the local conditions. The study demonstrated that the implementation of AI-integrated virtual field trips should be considered in teaching practices in developing countries to complement the efforts directed to modernizing pedagogical practices in educational systems.

RECOMMENDATIONS

Policy makers ought to create adaptable structures and instructions to include AI-based virtual field trips into national curriculums. These studies should be complemented by spending on equipment and technology. Schools should include in-service teacher training on how to properly pedagogically incorporate virtual field trips in their teaching, rather than training teachers on how to use technology. Educational technology should be culturally relevant and aligned to the curriculum and Pakistani educational needs, while functioning offline and being designed for low bandwidth use. More studies should be focused on the sustained use of virtual field trips in the classroom; the best ways to use it in tandem with other teaching methods; and the ability to reduce the educational gap by using innovative educational methods to create a large system that works in

different contexts, especially those with a low range of school resourcing, in rural and underserved locations.

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