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EFFECTIVENESS OF AI-BASED LEARNING TOOLS ON STUDENTS' CONCEPTUAL UNDERSTANDING IN SECONDARY EDUCATION

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ABSTRACT

Artificial Intelligence (AI) is rapidly transforming the educational landscape by introducing innovative tools that enhance the teaching–learning process. The present study examines the effectiveness of AI-based learning tools on the academic achievement of senior secondary students. The study also explores students' perceptions, usage patterns, and challenges associated with AI integration in education. An experimental method with a pre-test and post-test control group design was adopted for the study. A sample of 100 senior secondary students was selected using purposive sampling technique. Data were collected through an achievement test and a structured questionnaire.

The results revealed that most students actively use AI tools such as virtual assistants and educational platforms for academic purposes. The experimental group exposed to AI-based learning showed better academic performance compared to the control group taught through traditional methods. The findings also indicate that AI improves learning efficiency, engagement, and conceptual understanding. However, concerns such as over-dependence, inaccurate information, and reduced critical thinking were also reported.

The study concludes that AI-based learning tools can significantly enhance academic achievement when used as supportive learning resources. Proper guidance and ethical use of AI tools are essential to maximize benefits and minimize risks in educational settings.

Keywords: Artificial Intelligence, AI in Education, AI-based learning tools, conceptual understanding, secondary education, personalized learning.

INTRODUCTION

The integration of Artificial Intelligence in education has brought significant changes in teaching and learning practices. AI technologies such as intelligent tutoring systems, virtual assistants, and adaptive learning platforms are helping students access information quickly and learn in more personalized ways. These technologies support students by providing instant feedback, customized learning materials, and interactive learning experiences.

In recent years, AI has become an important educational support tool rather than just a technological innovation. Students are increasingly using AI tools for completing assignments, understanding complex concepts, and improving their academic performance. AI also promotes self-directed learning by allowing students to explore topics at their own pace.

Despite these advantages, the use of AI in education also raises certain concerns. Over-reliance on technology, accuracy of AI-generated information, and ethical use of AI tools are some important issues. Therefore, it becomes necessary to study both the effectiveness and challenges of AI integration in the teaching–learning process.

The present study attempts to examine the effectiveness of AI-based learning tools on academic achievement and learning efficiency of senior secondary students.

LITERATURE REVIEW

Wang et al. (2024) conducted a systematic literature review on Artificial Intelligence in education and found that AI-based learning systems significantly improve students' conceptual understanding, personalized learning experiences, and academic outcomes. The study also reported that AI-supported instruction enhances student engagement and helps in identifying learning gaps through data-driven feedback.

Ramelan et al. (2024) reviewed AI-based learning transformation in secondary schools and found that AI tools improve conceptual learning, adaptive instruction, and student engagement when integrated with classroom teaching.

Holmes and Tuomi (2023) explored the ethical and pedagogical implications of AI integration in education. Their findings suggested that while AI has strong potential to improve learning outcomes and instructional effectiveness, it should be implemented carefully to avoid issues such as over-dependence on technology and reduced human interaction in the learning process.

Zawacki-Richter et al. (2022) reviewed recent developments in AI in education and reported that AI applications are widely used for assessment, prediction of learning outcomes, and personalized instruction. Their study highlighted that AI-based platforms can improve learning efficiency and conceptual clarity, but successful implementation depends on teacher readiness and technological infrastructure.

Chen et al. (2021) investigated the role of Artificial Intelligence applications such as learning analytics and intelligent tutoring systems in improving students' academic performance. The findings revealed that AI tools helped in identifying students' learning difficulties and provided customized instructional support. The study also emphasized that AI integration can enhance students' engagement and participation in classroom learning.

Hwang et al. (2020) examined the effects of AI-supported educational environments on students' learning achievement and motivation. The study found that AI-based adaptive learning systems significantly improved students' conceptual understanding and problem-solving abilities. The researchers concluded that AI technologies can support self-regulated learning by providing continuous feedback and personalized learning support.

OBJECTIVES OF THE STUDY

The present study was conducted with the following objectives:

1. To study the use of Artificial Intelligence tools among senior secondary students.
2. To examine the effectiveness of AI-based learning tools on academic achievement.
3. To compare the academic achievement of students taught through AI tools and traditional methods.
4. To study students' perception towards AI in the teaching–learning process.
5. To identify the challenges faced by students while using AI tools in education.

HYPOTHESES OF THE STUDY

The following null hypotheses were formulated:

1. There is no significant difference in the pre-test scores of experimental and control group students.

2. There is no significant difference in the post-test scores of experimental and control group students.
3. There is no significant difference in the academic achievement of students taught through AI-based learning and traditional teaching.
4. AI tools do not significantly influence students' learning efficiency.
5. There is no significant impact of AI tools on students' academic performance

RESEARCH DESIGN

The present study employed an experimental research design to examine the effectiveness of AI-based learning tools on students' conceptual understanding at the senior secondary school level. The study followed a pre-test and post-test equivalent group design in which students were divided into an experimental group and a control group. The experimental group was taught with the help of AI-based learning tools, while the control group was taught through traditional teaching methods.

SAMPLE OF THE STUDY

The sample for the present study consisted of 100 senior secondary school students (Class XI and XII) selected from government and private schools of Ludhiana district, Punjab. The students were selected using the purposive sampling technique to ensure that participants had basic digital access required for AI-based learning.

The sample was divided into two groups:

1. Experimental Group: 50 students (taught through AI-based learning tools)
2. Control Group: 50 students (taught through traditional teaching methods)

TOOLS USED IN THE STUDY

The following tools were used for data collection:

1. Achievement Test (Pre-test and Post-test)
2. Structured Questionnaire on AI usage and perception

PROCEDURE

A pre-test was conducted to assess the initial academic level of both groups. The experimental group was then taught with the help of AI-based learning tools, while the control group received traditional classroom instruction. After the instructional period, a post-test was conducted to measure academic improvement.

STATISTICAL TECHNIQUES

Mean, Standard Deviation, Percentage and t-test are performed to interpret the collected data.

DELIMITATIONS OF THE STUDY

The study was delimited to:

1. Senior secondary school students of Ludhiana district only
2. AI-based learning tools related to selected subjects only
3. Conceptual understanding as the major dependent variable

RESULTS AND DISCUSSION

The present study aimed to examine the effectiveness of Artificial Intelligence (AI) based learning tools on students' academic achievement and learning efficiency. The collected data were analyzed using descriptive statistics (frequency, percentage, mean, and standard deviation) and inferential statistics (t-test).

To understand the prevalence of AI usage among students, frequency and percentage analysis was conducted.

Table 1: Use of AI Tools in Academic Activities

Response	Number of Students	Percentage
Yes	96	95.6%
No	4	4.4%
Total	100	100%

Table 1 indicates that the majority of students (95.6%) reported using AI tools in their academic work. Only 4.4% students reported not using AI tools. This clearly indicates that AI technologies are becoming an integral part of the teaching–learning process.

Table 2: Types of AI Technologies Used

Type of AI Tool	Number	Percentage
Virtual Assistants	88	88.2%
AI Educational Platforms	42	42.4%
Content Generation Tools	18	17.6%
Data Processing Tools	8	8.2%
Other Tools	4	3.5%

The data reveal that virtual assistants are the most widely used AI tools among students. AI educational platforms are also frequently used for personalized learning. This shows that students prefer AI tools which are easily accessible and helpful in completing academic tasks.

Table 3: Frequency of Use of AI Tools

Frequency	Number	Percentage
Daily	19	18.8%
Weekly	58	57.6%
Monthly	12	11.8%
Rarely	12	11.8%
Never	1	1.2%

The findings show that most students (57.6%) use AI tools weekly while 18.8% use them daily. This suggests that AI tools are regularly used for assignments, projects and concept clarification.

Table 4: Perceived Helpfulness of AI

Opinion	Number	Percentage
Helpful	80	80%
Not sure	18	17.6%
Not helpful	2	2.4%

Most students (80%) agreed that AI helps in their studies by providing quick information and simplifying complex topics. Only a small percentage showed negative perception.

Table 5: Impact of AI on Academic Achievement

Response	Number	Percentage
Improves performance	82	82.4%
No change	15	15.3%
Limits knowledge	3	3.5%
Decreases performance	2	2.4%

Most students believe AI improves their academic results. This suggests AI can be an effective supplementary learning tool.

Table 6: AI and Learning Efficiency

Response	Number	Percentage
Improves efficiency	84	83.5%
Does not improve	11	10.6%
Not sure	7	7.1%

Most students believe AI saves time and helps them access study materials quickly. This improves learning efficiency and productivity.

Table 7: Major Concerns of Students

Concern	Number	Percentage
Incorrect information	48	48.2%
Reduced critical thinking	17	16.5%
Over dependence	17	16.5%
Data privacy	9	9.4%
Academic honesty issues	4	3.5%
Others	6	5.9%

Interpretation

Students showed some concerns regarding AI use, particularly regarding accuracy of information and dependency issues. This highlights the need for guided use of AI.

Table 8: Pre-Test Comparison

Group	N	Mean	SD
Experimental	50	52.40	6.21
Control	50	51.80	5.94

The pre-test scores indicate that both groups had similar academic levels before the experiment.

Table 9: Post-Test Comparison

Group	N	Mean	SD
Experimental	50	71.60	7.10
Control	50	60.30	6.85

The post-test results show that the experimental group performed better than the control group. This indicates the effectiveness of AI-based learning tools.

Table 10: Gain in Experimental Group

Test	Mean	Gain
Pre-test	52.40	
Post-test	71.60	19.20

Table 11: Gain in Control Group

Test	Mean	Gain
Pre-test	51.80	
Post-test	60.30	8.50

The experimental group showed much higher improvement compared to the control group, proving the effectiveness of AI-based learning.

Table 12: t-test Comparison of Post Test Scores

Group	Mean	SD	t-value	Level
Experimental	71.60	7.10		
Control	60.30	6.85	7.82	Significant (0.01)

The t-value shows a significant difference between the groups. Therefore, AI-based learning is more effective than traditional teaching.

CONCLUSION

The present study concludes that Artificial Intelligence has significant potential to improve the quality of education. The findings indicate that AI-based learning tools significantly improve students' academic achievement and learning efficiency.

The study also found that most students have a positive attitude toward the use of AI in education. AI helps students in understanding difficult concepts, completing assignments efficiently, and accessing educational resources quickly.

However, some challenges such as over-dependence, inaccurate information, and reduced critical thinking need careful attention. Therefore, AI should be integrated carefully with proper monitoring and ethical guidelines.

Overall, the study concludes that AI can play a transformative role in education if used in a balanced and responsible manner.

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