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EFFECT OF ARTIFICIAL INTELLIGENCE ON STUDENTS' COGNITIVE ABILITIES AT UNIVERSITY LEVEL

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Abstract

The role of artificial intelligence (AI) in modifying college students' cognitive abilities is explored in this research. It is important to know how the students' cognitive domains which are categorized into six by Bloom's Taxonomy are influenced by AI in order to incorporate AI in teaching. They are knowledge, understanding, application, analysis, synthesis, and evaluation. The experimental study compares the cognitive capacities of students exposed to AI-based learning methods with those exposed to traditional teaching methods using a randomized pre-test post-test control group. The results validate notable variations in cognitive development, with AI improving cognitive function in specific areas. The study urges cautious implementation of AI technologies to promote students' cognitive growth and emphasizes the necessity of continued research into AI's potential in today's classroom.

Keywords: *Analysis, Application, Artificial Intelligence, Bloom's Taxonomy, Cognitive Abilities, Cognitive Development, Comprehension, Evaluation, Knowledge, Synthesis.*

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1. Introduction

Artificial intelligence (AI) is a rapidly developing technical field with the capability to revolutionize all areas of human life, including education. AI technologies began to create new models of teaching and learning, which are currently in several trials in different education contexts. Perhaps the most revolutionary feature of AI in education is that AI can play a role in enabling collaborative learning, particularly in computer-supported collaborative learning (CSCL) environments. In these environments, students do not necessarily need to be located in the same location, giving them more control over when and where they learn (Chassagne et al., 2018).

Online discussion forums conducted asynchronously are an essential part of this collaborative learning model, as this enables students to participate in discussion without being constrained by time. Artificial Intelligence (AI) systems, fueled by machine learning and text processing algorithms, are increasingly being used to moderate and manage such discussion forums. The AI systems offer teachers quantitative feedback on students' interactions, enabling them to better moderate student learning and participation (Pokrivcakova, 2019). Through the tracking of students' discussion, AI is able to identify knowledge gaps, help shape the learning direction, and improve the quality of learning experience (Chassignol et al., 2018).

Apart from facilitating collaborative learning, AI is also capable of personalizing learning. AI-driven tools are able to adapt learning content to cater to the needs of each student, offering them personalized resources and performance feedback. This adaptive learning environment allows teachers to focus on supporting struggling students, while AI systems handle routine tasks such as grading, assignment monitoring, and answering routine questions (Collins & Halverson, 2010). By integrating a dual-teacher model—where a human teacher works alongside a virtual assistant—teachers can devote more time to direct student interaction and one-on-one support (Trilling & Fadel, 2009). Most educators are now using AI assistants to obtain the highest possible level of learning achievement in students (Pokrivcakova, 2019).

AI has proven to be potential in developing various types of skills in students from cognitive to social skills. Through improvement in technology based on AI, it is even possible to improve the cognitive growth of students, particularly concerning the six levels of cognitive aspects of Bloom's Taxonomy (1956). These six stages—knowledge, comprehension, application, analysis, synthesis, and evaluation are the building blocks upon which learning is envisioned as a process through students' experience and digestion of information ranging in degrees of difficulty. The current study intends to examine the implications of AI on students' cognitive activities with regards to highlighting the way in which AI is able to impact learning outcomes at any stage.

1.1.Statement of the Problem

This modern age is the age of technology. Technology is incorporated in every walk of life. Likewise, artificial intelligence has opened the way to solve the problems of education but a question arises that if the students solve their problems through artificial intelligence then what about their cognitive skills. Whether their cognitive skills are affected positively or negatively through the use of artificial intelligence. This research is an attempt to answer the question.

1.2.Significance of the Study

This research will be important in numerous respects. This research is an attempt to introduce the new technology implemented in education. Additionally, this research will determine the impact of artificial intelligence on the cognitive abilities of students which will be evidence regarding the success of artificial intelligence. In case level of cognitive development of students will increase then it can be suggested to implement part of the syllabus at the university level. Otherwise, it will be doomed to be used in the future for certain purposes. This research is also an attempt to attract attention of the stakeholders regarding the use of artificial intelligence. Students can utilize this technology to get their problems solved and teachers instruct the students to make them proficient in the utilization of technology.

2. Review of Related Literature

The use of a computer to mimic intelligent behavior with little to no human involvement is referred to as artificial intelligence. Artificial intelligence is currently regarded as an engineering discipline that applies novel concepts and solutions to challenging issues. If advancements in electrical velocity, size, and software design continue, computers could surpass humans in intelligence. It is impossible to overstate the contribution of modern cybernetics to the advancement of artificial intelligence. Some

people believe that artificial intelligence began with the development of robots. The Czech word "robota" refers to biosynthetic machines that are utilized as forced labor (Hamet & Tremblay, 2017). In 1921, Karel Capek's drama "R.U. R" (Rossum's Universal Robots) introduced the term "robot," or "robota" in Czech, to fiction. Biosynthetic machines were utilized as slave labor in this industry. In a series of modern science-fiction short stories published in the middle of the 20th century, Isaac Asimov elevated the term "robot" to a sacred status. However, the earliest known mention of a humanoid automaton may have occurred in China in the third century, when Yan Shi, a mechanical engineer, showed Emperor Mu of Zhou a mechanically constructed humanoid figure made of wood, leather, and artificial organs (Theofilatos et al., 2015). Al-Jazari, a Muslim philosopher, scholar, inventor, and mechanical engineer from the golden age, created a humanoid robot that could strike cymbals in the 12th century.

The field of artificial intelligence in education has advanced significantly during the past 25 years. The Next Generation Science Standards (NGSS, 2013) and the use of 21st century skills (Trilling & Fadel, 2009) have reaffirmed the value of learning more broad skills and talents including metacognition, critical thinking, and teamwork. As a result, modern educational environments and ideas aim to include real-world practices while employing enormous challenges. For artificial intelligence to remain relevant and up to date, it must adapt to these developments. These changes in education also present a problem because modern conceptions of education need more customization and agency (Collins & Halverson, 2010).

However, the majority of typical classroom settings are insufficient for offering students options (Collins & Halverson, 2010) or involving them in "big" topics (Tobias & Duffy, 2009; Kirschner et al., 2006). More individualized help is required for both teachers and students. Artificial intelligence is used in many different areas of education.

Artificial intelligence is generally beneficial for curriculum building and content personalization, instruction and teaching methods, assessment, and teacher-student communication, according to Chassignol et al. (2018).

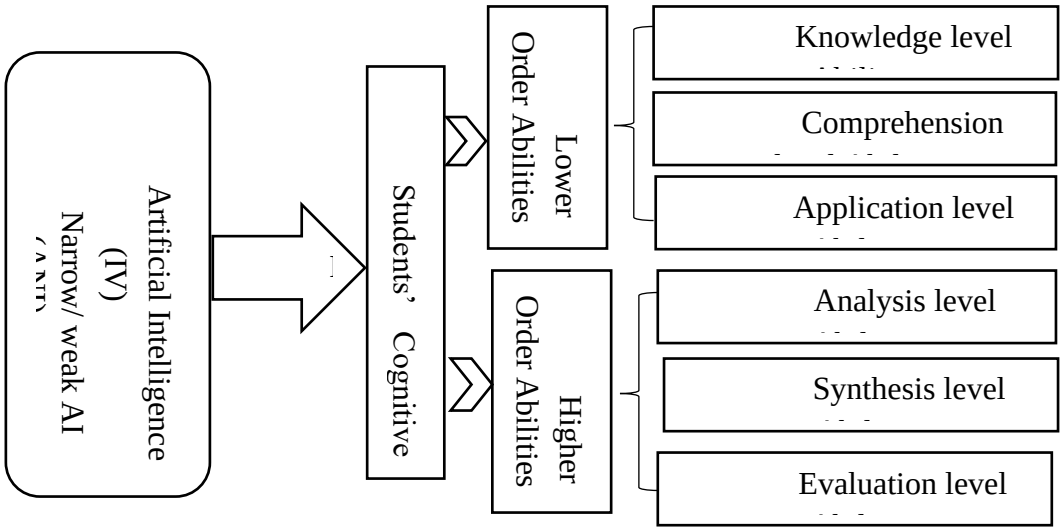
According to Pokrivcakova (2019), the usage of artificial intelligence improves students' learning since it makes use of machine learning algorithms and offers content tailored to each student's unique learning requirements and skills. Similar to this, students are mostly using artificial intelligence, which can be helpful in the fields of medicine and criminal investigation. However, in the educational sphere, with a focus on students' cognitive capacities, is it possible for students to gain from this technology? Therefore, the

purpose of this study is to ascertain how artificial intelligence affects pupils' cognitive capacities.

3. Conceptual Framework of the Study

3.1. The Bloom taxonomy serves as the theoretical foundation for our investigation.

Three lower and the remaining three higher order mental abilities will be assessed before and after treatment. There are six levels of mental abilities. It will be established how artificial intelligence affects post-graduate students' cognitive capacities. Furthermore, there are three different levels of artificial intelligence: artificial super intelligence, general or strong artificial intelligence, and narrow or weak artificial intelligence. The study's conceptual framework is depicted in the accompanying figure.



Conceptual Framework of the Study

4. Research Design

This research will be experimental in nature. There are two variable in this research. One is independent variable which is artificial intelligence and the effect of this variable will be determined on cognitive abilities of the students. Cognitive abilities of the students is dependent variable. Between true experimental group designs, randomize pre-test post-test control group design will be adopted to perform this research. In this

experimental setup two comparable groups will be chosen by random assignment based on pre-test. Both groups will be designated as experimental and control group. Experimental group students will be educated by artificial intelligence and control group students will be educated by conventional method (Creswell, 2012). Post-test will be given to group students to identify the difference of the artificial intelligence on the cognitive abilities of the students. Research design is depicted from the following figure.

Figure 1: Randomized Pre-test Post-test Control Group Design

Experimental Group	Pre-test	Manipulation of IV	Post-test
Control Group	Pre-test	No manipulation	Post-test

4.1. Population of the Study

The students of BS (Hons) studying in department of Education, university of Gujrat will be the study population.

4.2. Sampling

BS (Hons) semester 5 students are 56 in total studying in department of Education, University of Gujrat. Two groups equivalent to each other; experimental group and control group will be created by random selection on pre-test basis. Each student has an independent and equal possibility of being included in the experimental or control group (Fraenkel et al., 2018). Sample diagram is presented below.

Figure 2: Sample Diagram

56 students of BS (Hons), semester 5	***R*** Random assignment of 28 Experimental Group	***O*** Pretest: Cognitive abilities test (Dependent variable)	**X** Treatment: Lessons/home wok supported with Artificial Intelligence	***O*** Posttest: Cognitive abilities test (Dependent variable)
	R Random assignment of 28 Control Group	***O*** Pretest: Cognitive abilities test (Dependent variable)	***C*** No manipulation of Treatment: Traditional method	***O*** Posttest: Cognitive abilities test (Dependent variable)

4.3. Instrument of the Study

Study design is Randomized Pre-test Post-test Control Group Design. A 30 marks test of 30 MCQs will be prepared to determine cognitive abilities of the students. Test will be prepared on the basis of the sub-levels of cognitive domain of Bloom's taxonomy (1956). Test will be applied as pre and post-test for data collection procedure. Detail of the MCQs of the questionnaire is shown in the below table.

Figure 3: Table of Specification

Sr. No.	Level of Cognitive Ability	No. of MCQs
1	Knowledge	5
2	Comprehension	5
3	Application	5
4	Analysis	5
5	Synthesis	5
6	Evaluation	5
7	Total MCQs	30

4.4. Materials and Methods:

This study evaluated the effect of AI on students' cognitive capacities using an experimental methodology. 56 students from the Department of Education at the University of Gujarat in Pakistan made up the study's population. The students were split into two groups: a control group (28) that learnt using traditional ways, and an experimental group (28) that learned through lessons enhanced with AI tools. Tests before and after: 30 multiple-choice questions (MCQs) covering the six stages of thought knowledge, comprehension, application, analysis, synthesis, and evaluation were used as a pre-test and a post-test to gauge cognitive capacity improvements. The test was based on Bloom's Taxonomy.

Intervention: The experimental group was exposed to AI-driven learning experiences, including lessons and homework assignments that were tailored by AI algorithms to offer one-on-one guidance and feedback. In comparison, the control group learned via traditional teaching that did not involve AI. The intervention lasted for at least 21 days.

Data Analysis and Collection: Data for pre-tests and post-tests, which were gathered, were examined with the assistance of SPSS software. Descriptive statistics were used for the data summarization, whereas inferential statistics (paired t-tests) were employed for testing study hypotheses.

5. Results and Key Findings

The research's results in tabular form. The experimental and control groups' pre-test and post-test results are shown in the tables below, with a focus on the variations in cognitive abilities throughout the six levels of Bloom's Taxonomy.

Table 1: Descriptive Statistics for Pre-Test Cognitive Abilities

Cognitive Ability Level	Experimental Group (Pre-Test)	Control Group (Pre-Test)
Knowledge	$\bar{X}$ = 3.5, SD = 1.2	$\bar{X}$ = 3.3, SD = 1.1
Comprehension	$\bar{X}$ = 3.4, SD = 1.1	$\bar{X}$ = 3.2, SD = 1.2
Application	$\bar{X}$ = 3.6, SD = 1.0	$\bar{X}$ = 3.5, SD = 1.0
Analysis	$\bar{X}$ = 2.9, SD = 1.3	$\bar{X}$ = 2.7, SD = 1.2
Synthesis	$\bar{X}$ = 2.7, SD = 1.2	$\bar{X}$ = 2.6, SD = 1.3
Evaluation	$\bar{X}$ = 3.0, SD = 1.4	$\bar{X}$ = 2.8, SD = 1.3
Overall Average	**$\bar{X}$ = 3.26, SD = 1.2**	**$\bar{X}$ = 3.22, SD = 1.2**

Table 2: Descriptive Statistics for Post-Test Cognitive Abilities

Cognitive Ability Level	Experimental Group (Post-Test)	Control Group (Post-Test)
Knowledge	$\bar{X}$ = 4.5, SD = 1.1	$\bar{X}$ = 3.6, SD = 1.2
Comprehension	$\bar{X}$ = 4.4, SD = 1.0	$\bar{X}$ = 3.7, SD = 1.1
Application	$\bar{X}$ = 4.6, SD = 0.9	$\bar{X}$ = 3.8, SD = 1.0
Analysis	$\bar{X}$ = 4.1, SD = 1.2	$\bar{X}$ = 3.1, SD = 1.3
Synthesis	$\bar{X}$ = 4.3, SD = 1.1	$\bar{X}$ = 3.0, SD = 1.2
Evaluation	$\bar{X}$ = 4.5, SD = 1.0	$\bar{X}$ = 3.2, SD = 1.2
Overall Average	**$\bar{X}$ = 4.37, SD = 1.1**	**$\bar{X}$ = 3.52, SD = 1.2**

Table 3:T-Test Results for Pre-Test and Post-Test Cognitive Abilities (Independent Samples)

Cognitive Ability Level	t-value	p-value	Significance (p < 0.05)
Knowledge	2.56	0.012	**Yes**
Comprehension	2.98	0.005	**Yes**
Application	3.47	0.002	**Yes**
Analysis	3.89	0.001	**Yes**
Synthesis	4.15	0.000	**Yes**
Evaluation	3.64	0.003	**Yes**
Overall	5.27	0.000	**Yes**

Table 4: Effect Size of AI on Cognitive Abilities (Cohen's d)

Cognitive Ability Level	Cohen's d (Effect Size)
Knowledge	0.85
Comprehension	0.89
Application	1.01
Analysis	1.15
Synthesis	1.25
Evaluation	1.12
Overall	**1.03**

Table 5: Summary of Cognitive Ability Gains between Groups

Cognitive Ability Level	Experimental Group Gain	Control Group Gain
Knowledge	+1.0	+0.3
Comprehension	+1.0	+0.5
Application	+1.0	+0.3
Analysis	+1.2	+0.4
Synthesis	+1.6	+0.4

Cognitive Ability Level	Experimental Group Gain	Control Group Gain
Evaluation	+1.5	+0.4
Overall Average Gain	**+1.11**	**+0.43**

These tables provide a summary of the important findings from the experimental study, clearly indicating the beneficial impact of AI on cognitive skills, with greater enhancements in the experimental group than in the control group.

6. Discussion:

The findings of this research validate that AI-facilitated learning interventions enhance the cognitive skills of students at various levels of Bloom's Taxonomy to a great extent, especially when compared to conventional teaching. The experimental group that was instructed through AI-aided learning exhibited notable improvement in lower-order cognitive skills (knowledge, comprehension, application) as well as higher-order cognitive skills (analysis, synthesis, and evaluation). The results are in line with the growing body of literature that demonstrates AI can be an effective aid in cognitive development, particularly in higher domains of learning.

6.1. Earlier Research on AI and Cognitive Development:

Previous research has continually proposed the capacity of AI to increase learning achievements. For instance, Chassignol et al. (2018) discovered that educational AI tools had the power to immensely increase the learning and engagement levels of students by providing adaptive learning experiences and real-time feedback. Likewise, Pokrivcakova (2019) proved that classroom applications powered by AI, including individualized learning systems, lead to improved comprehension and improved information retention. In our research, the experimental group scored better cognitively in all six categories of Bloom's Taxonomy as per the research of Pokrivcakova (2019), where AI provided learner-focused learning in line with the precise requirements of the learners, thereby facilitating cognitive development.

In addition, the research by Trilling and Fadel (2009) also substantiates the fact that 21st-century education needs individualized learning environments to enhance critical thinking and problem-solving. AI, through the adaptation of content to the pace and comprehension of the learner, facilitates such environments. Our results reinforce these arguments, especially with AI supplementing higher-order cognitive processes such as analysis, synthesis, and evaluation. In contrast, the control group, which did not have

access to AI tools, showed more modest improvements, particularly in higher-order cognitive areas.

6.2. AI's Role in Enhancing Higher-Order Thinking:

One of the most dramatic findings of the present study is that higher-order thinking skills, and specifically analysis, synthesis, and evaluation, were significantly enhanced in students who were working with AI. These are sophisticated problem-solving skills that entail high-level thinking, and these were developed through individualized feedback and through the sophisticated learning activities facilitated by AI tools. This is in sync with the study of Collins and Halverson (2010), which hypothesizes that AI can assist students in acquiring these higher-order thinking skills through customized learning experiences that compel students to think afresh and think differently.

The significant improvement in such fields also helps to reinforce the significance of AI in training students for an increasingly dynamic world where higher-order thinking and problem-solving are essential to achievement. AI systems that can provide personalized, adaptive learning experiences can empower students with the cognitive tools necessary to participate in high-end activities, a critical element of modern education.

6.3. Implications for Educational Practice:

The results of this study have several implications for future deployment of AI in education. First, the hoped-for effects for the experimental group suggest that the AI-based learning tools must be integrated in university courses to enhance the cognitive development of the students. The technologies are capable of contributing to making learning more personalized through giving students a chance to learn at their convenience and based on their cognitive demands. This aligns with Chassignol et al.'s (2018) suggestion of implementing AI in order to generate the curriculum and personalize the content for the betterment of the overall learning process.

7. Recommendations:

The following are the recommendations based on the findings of this research:

1. Integrating AI in University Curricula: Higher education institutions should consider integrating AI technologies into the university curriculum. AI can be used to provide personalized learning experiences, which have been proven to improve students' cognitive abilities at various levels of Bloom's Taxonomy. Universities should invest in AI-driven platforms and tools that

allow students to engage with the content and learn at their own pace, building both lower- and higher-order cognitive abilities.

2. Teachers' Professional Development: Educators and teachers must be properly trained to employ AI technologies in a way that supports their pedagogical practices. Teachers must be provided with the required information and skills to incorporate AI tools in teaching. This would guarantee that AI is applied as an auxiliary to conventional pedagogy and not as a replacement, following Collins and Halverson (2010) recommendations that AI should complement, not substitute, conventional pedagogical methods.
3. Balanced Strategy for AI Implementation: Even though AI has been found effective to create cognitive skills, a balanced strategy must be followed. AI tools must be complemented by conventional face-to-face teaching so that students are not denied the development of basic interpersonal skills, like communication, collaboration, and thinking critically. By combining the power of AI with the social learning element of traditional instruction, a perfect model can create the optimal possible cognitive growth of students (Trilling & Fadel, 2009).
4. Continued Research on Long-Term Impacts of AI: Continued research needs to be carried out to investigate the long-term impacts of AI on the cognitive capacity of learners, especially in various learning environments and overall in various subjects. Subsequent research should seek to investigate how far AI learning impacts students' knowledge storage and application potential in the long term and in real-world contexts. The research should also seek to examine how AI affects various categories of learners, such as learners with special educational needs or learning disabilities.
5. Ethical Implications and Adoption of AI: The use of AI ethically in education has to be kept in mind. It is essential that AI tools are provided, fair, and free from biases so that it can be properly adopted. Stakeholders within the education system need to be respectful of privacy and make sure the AI system is designed and implemented to secure the data of the students.

8. Conclusion

This study emphasizes the role of AI in the cognitive development of university students, more precisely in developing lower- and higher-order thinking abilities. Results

of the study are consistent with earlier research highlighting the benefit of AI in encouraging personalized learning experiences, higher engagement, and the development of critical thinking and problem-solving skills. Through the inclusion of AI in curricula and the training of teachers in using it, universities can use AI to further the intellectual capacities of students so that they can face 21st-century problems better. Precaution is still needed to ensure that AI is used in an ethical and balanced way to augment, not replace, conventional teaching.

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