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# INTEGRATION OF EDUCATIONAL ROBOTICS IN HIGHER EDUCATION: IMPACT ON STUDENT ENGAGEMENT, CRITICAL THINKING, AND LEARNING WELL-BEING

FARIHA SOHIL<sup>1</sup>, EMAN<sup>2</sup>, SOBIA TASNEEM<sup>4</sup>, MUHAMMAD UMAIR SOHAIL<sup>3\*</sup>, AYESHA SULTAN<sup>2</sup>, MUATTAR ZAFAR<sup>2</sup>

<sup>1</sup>ASSISTANT PROFESSOR, DEPARTMENT OF EDUCATION, THE WOMEN UNIVERSITY MULTAN, MULTAN PAKISTAN.

<sup>2</sup>MPHIL SCHOLAR, DEPARTMENT OF EDUCATION, THE WOMEN UNIVERSITY MULTAN, MULTAN PAKISTAN.

<sup>3</sup>ASSISTANT PROFESSOR DEPARTMENT OF STATISTICS, EMERSON UNIVERSITY MULTAN, MULTAN PAKISTAN. (umairsohailch@gmail.com)

<sup>4</sup>PHD SCHOLAR, DEPARTMENT OF EDUCATION, THE WOMEN UNIVERSITY MULTAN, MULTAN PAKISTAN.

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## Abstract

This study integration of Integration of Educational Robotics in Higher Education: Impact on Student Engagement, Critical Thinking, and Learning Well-Being. In this paper, literature review, the researcher will examine the impact of learning environments that involve robots on the cognitive and psychological development of higher students. Educational robotics favors active learning as students are expected to collaborate in order to solve problems and apply their learned knowledge in the real world. The recent studies have indicated that robots encourage practical and interactive labor, which makes individuals more curious and interested, which results in increased participation. Moreover, since activities connected with robotics require the use of repeated design and programming, students need to analyses, assess, and syntheses knowledge, which is also listed among the critical types of thinking. The quality of integration of robotics depends on institutional support, teacher preparedness, and teaching methods even though it possesses a massive potential. In order to reap the maximum of the pedagogical benefits of robots in universities, this paper concludes by offering recommendations for curriculum development and future research to maximize the educational and psychological benefits of robotics-based learning in higher education institutions.

**Keywords:** Educational Robotics, Higher Education, Student Engagement, Learning Well Being

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## INTRODUCTION

The world of higher education is becoming fast, and it is necessary to use the newest technology to make teaching more efficient and prepare students to face the difficulties of the twenty-first century. Programmable robots as a teaching tool, or educational robotics, because they might enable students to be more engaged in school and more skilled at critical and problem-solving thinking, have attracted the interest of a good number of people. By means of robotics in the classroom, this teaching innovation bridges the gap between the things that students learn in theory and the things that they can do in the real life. This allows students to experiment, collaborate, and find solutions to real-world issues (Wang et al., 2023). Learning through educational robotics extends beyond the conventional lecture-based learning to interactive and inquiry based learning, which encourages active learning, collaboration and self-guided exploration. According to Yolcu and Demirer (2023), robotics projects in higher education institutions significantly enhance the level of programming and computational thinking among students as well as motivating them to work hard, and take interest. These tools, besides assisting in higher order thinking and analysis, synthesis, and assessment which are at the core of critical thinking, also allow individuals to study at their own pace and in the manner that best suits them. Recent studies have been conducted to analyses the social and motivational factors of learning with robots. According to Karagounis (2023), educational robots do not only promote academic engagement but also emotional and behavioral engagement because of collaborative learning spaces, which include team-based problem solving tasks and gamified activities. As an example, Karagounis (2023) discusses the use of the simulation as a learning tool that involves the use of robots to help students enhance their problem-solving, creativity, and critical thinking skills. Students are more likely to learn and remember STEM concepts through designing, building, and programming robots. In addition, it has been found that, joining a robotics club is associated with a stronger urge to succeed in school and acquisition of skills that could be applied elsewhere. According to Flores et al. (2024), students who are participating in these groups supplement their

theoretical knowledge with their problem-solving, creative, and collaborative abilities. It is a dynamic and cooperative learning environment with which students are motivated to do more research and academic work; logically, and enjoy learning. An article in *Computers and Education*. Also, robotics in education plays a significant role in enhancing access and diversity in higher education. Holthaus (2023) considers the potential use of interactive robots as non-discriminating tools to include students of every background into engineering, technology, and computer classes. This will contribute to resolving the issue of the lack of pupils representing various backgrounds and make the classroom more equitable. According to Miller and Doering (2014) and Ching et al. (2020), jointly working on creating and repairing robots can also aid individuals in engaging with one another, learning and other people, and feel more connected to the learning environment. The skill of critically thinking is the capability to evaluate information, evaluate supporting facts, come up with alternative options, and make logical conclusions. It is often considered to be one of the most important educational goals in higher education. Individuals in the present day must know how to think, not desire to. The reason is that complex issues such as climate change and the ethics of AI have to be solved on a higher level and require sophisticated problem-solving and moral judgement. Educational robotics also implies critical thinking, as it is the method of education based on trial and error. Before students can design and code a robot to perform a task, they must think of the problem, come up with a plan, test their code or building and examine the results. Students are required to discover what is wrong with the robot, repair it, and modify their plans in case it does not function as intended. It is simply a mode of thinking and occurring repeatedly. They are exercises quite similar to design thinking and scientific inquiry, the two methods that are used to enhance your ability to think critically (Lai, 2011; Ioannou and Makridou, 2018). In addition, a lot of robotics projects lack an articulate finish point and require individuals possessing a wide range of varied skills in order to complete them. Due to this fact, students are forced to consider various arguments and potential solutions. These practices enhance critical and analytical thinking in students and they also result in the students saying and explaining what they think (Chalmers, 2020). Simply put, robots in education are an excellent learning method as they not only make higher students more interested, diverse, and capable of thinking critically. Schools are seeking alternative methods of teaching, and by incorporating robots into the classroom, this may render the classroom exciting and welcoming. Put simply, educational robots are not only another method of teaching but a new method of assisting children to learn in accordance with the contemporary aims due to the increasing data volume. This motivates students to attend thus making them think critically and acquire various cognitive and non-cognitive skills which are essential to succeed in school and work environments. The intelligent application of robotics will become increasingly very important towards determining the future of education as universities continue to evolve and expand.

### **Statement of the Problem**

Educational institutions are always on a search of novel and innovative methods of involving children into learning and enabling them to acquire valuable skills such as critical thinking. Although it may be the case that technology use in higher education is increasingly becoming more prevalent, there are still numerous teaching approaches that do not provide students with active learning experiences. Robotics in education offers a creative and challenging approach to teaching by solving problems and practical lessons. It may stimulate children to get more engaged and think critically. Yet, we are not yet aware of the effectiveness of instructional robots in schools. It has not been studied extensively yet and various schools employ it in many different ways, so it is difficult to develop a single way of applying it and make it effective. The role of educational robotics in developing the critical thinking skills of students and their enrollment in post-secondary education is necessary, as well as factors that make it easier or more challenging to integrate successfully in the classroom.

### **Significance of the Study**

The research is valuable because it examines the possibility of educational robots enhancing the critical thinking capabilities of university learners and their overall involvement in learning. In the contemporary world, students should be capable of critically thinking about a problem, problem-solving, and cooperating with others, besides remembering facts. Educational robotics allow students to learn through practical activity and may increase the interest and meaning of learning. Through its impacts, the present study can guide teachers, administrators, and learning institutions to understand how to use robots in manners that will truly benefit learners. It also can guide the future decisions regarding the application of technology in time, the investigation can help to enhance educational prospects and provide students with the e classroom as it can help improve teaching approaches. Or instruments must be able to flourish in the work place and in life. Due to the entertaining nature of the activities, their challenging nature and the fact that they involve teamwork, application of robots in the classroom would help in raising the level of engagement among the students. These activities also develop important life skills in the students such as communication, creativity, problem-solving, and critical thinking. These skills will be needed by them in their everyday life and at the workplace. Through this study, teachers and university administrators will have a higher understanding of the benefits of educational robotics and how it can be applied in the classroom. Also, it would be able to help schools make improved decisions about investments in technology and training their teachers. In addition, the findings can guide future research regarding ways to improve learning using new instructional tools. In a nutshell, this research can be useful in enhancing learning through showing how robotics and other technological advancements can make learning more interesting, entertaining, and meaningful in higher learners.

### Objectives of the Study

The Objectives of the study were to be:

1. To access the impact of AI in educational robotics on improving university
2. Student's engagement during learning activities.
3. Evaluate how AI driven robotics influences the development of critical thinking skills among university students.

### Research Questions

1. How effective are educational robotics in improving student engagement at the university level?
2. To what extent do educational robotics enhance students' critical thinking skills?
3. How can AI be utilized to evaluate the effectiveness of educational robotics?
4. What are the key indicators of student engagement and critical thinking that AI can measure?

### Research Design

The investigation would include both quantitative data—numbers—and qualitative data—opinions or experiences—because it employed a mixed-methods research technique. Gaining a deeper and more thorough knowledge of how educational robots affect critical thinking and student involvement in higher education is the aim of this design. The researcher will first collect quantitative data using multiple-choice questionnaires to see how involved students are in class and how they view their own critical thinking skills. The experiences and opinions of teachers and students about the usage of robots in the classroom will then be gathered qualitatively through open-ended surveys or interviews. By taking a mixed approach, the researcher will be able to determine not just what is happening but also why, which can lead to more comprehensive and helpful findings for enhancing university teaching practices.

### Population of the study

The population of the study consisted of public sector universities of Multan region.

### Sample

Five universities were selected as a sample. First was university of Education Multan campus. Second one was (BZU), The Bahia-Uddin-Zakariya university Multan. Third one was Women university of Multan. Fourth one was Virtual University Multan. And the last one was Emerson University Multan.

### Data Collection

In order to gather the data required in this study the researcher relied on two major instruments; questionnaire and interview. To begin with, a questionnaire will be administered to students of universities that have been taught educational robotics during classes. Simple multiple-choice and rating scale questions will be used in the questionnaire to determine the interest and involvement of the students during the robotics activities, and their perception that the activities assist them to think critically and solve problems. This will be followed by the selection of few students and teachers to be interviewed. In the interviews, they will be provided with open-ended questions by way of letting them tell their personal experiences, thoughts, and suggestions regarding the use of robotics in learning. The hybrid of the questionnaire and the interviews will provide not only quantifiable outcomes but also more insights as the researcher will be able to perceive the impact of the educational robotics on student in detail during Pre-testing of the research instrument.

### Pre-testing of the research instrument

#### Validity of research instrument

The tool was forwarded to Department of Education experts at The Women University Multan for approval. Then the improved questionnaire followed professional advice.

#### Reliability of research instrument

The survey was first tested from the research area. The instruments reliable coefficient was computed using Cronbach's Alpha. Engagement and critical thinking.

### Results: ANOVA Test

**Objective.1** To access the impact of AI in educational robotics on improving university student's engagement during learning activities

**Table 1:** Learning Activities, Gamified Learning, Data-Driven Robotics Learning

	Sum of Squares	df	Mean Squares	F	Sig
Between Groups	1.009	9	.126	.63	.977
Within Groups	101.223	211	.480		
Total	102.232	220			

The table no 1 show that the ANOVA results shown in the table show that Learning Activities, Gamified Learning, and Data-Driven Robotics Learning are not significantly different from each other. The variance across groups (SS = 1.009, MS = 0.126) is much smaller than the variance between groups (SS = 101.223, MS = 0.480). The F-value of 0.63 with a significance level of 0.977 is far higher than the 0.05 threshold. This means that the differences

we saw are not statistically significant. This means that the kind of learning activity did not have a big effect on how well the students did in this sample.

**Objective.2:** Evaluate how AI driven robotics influences the development of critical thinking skills among university students.

**Table 2:** Critical Thinking of educational robotics, Observation, Problem Solving.

	Sum of Squares	df	Mean Squares	F	Sig
Between Groups	19.873	8	2.484	4.543	0.96
Within Groups	115.377	212	.547		
Total	135.250	220			

The table no 2 show that the presents the results of a one-way analysis of variance (ANOVA) conducted to examine the differences in students' perceptions of critical thinking, observation, and problem-solving as influenced by educational robotics. The analysis compared responses across multiple groups (df = 8) with a total sample size of N = 220. The results indicate a statistically significant difference between groups, as evidenced by an F-value of 4.543 and a significance level (Sig) of 0.006, which is below the commonly accepted alpha level of 0.05. This suggests that students' perceptions of how educational robotics impacts their critical thinking, observational skills, and problem-solving abilities vary significantly across the different groups.

The between-group sum of squares was 19.873, with a mean square of 2.484, while the within-group sum of squares was 115.377, with a mean square of .547. The total variance in the data was 135.250.

**Table 3:** Use of gadget-Wise Distribution of the Respondents (N=220)

Use of gadget	Frequency	Percentage
Mobile	83	37.7
Laptop	23	10.5
Both	114	51.8
Total	220	100.0

The table no 3 shows that the spread of gadgets use among the respondents with mobile devices, laptops, or both being their favorite. Out of all 220 respondents, most respondents (51.8%) mentioned using both the mobile phones and laptops meaning that they like using more than one device to carry out their tasks or studies. The respondents who use mobile phones comprised 83 (37.7%) of the sample out of the total and those who use laptops only had 23 (10.5%) respondents.

**Table 4:** Use of AI-Wise Distribution of the Respondents

AI tool	Frequency	Percentage
AI-meta	87	39.5
Chatgpt	103	46.8
Gemini	30	13.6
Total	220	100.0

The table no 4 show that the displays the distribution of respondents based on their use of different AI tools. Out of the 220 participants, 87 individuals (39.5%) reported using AI Meta Tools, 103 respondents (46.8%) indicated using ChatGPT, and 30 individuals (13.6%) used Gemini.

**Table 5:** Use of Search engine-Wise Distribution of the Respondents (N=220)

Search engine	Frequency	Percentage
Google scholar	34	15.5
Google	145	65.9
YouTube	41	18.6
Total	220	100.0

The table no 5 show that how the respondents are spread as per the search engines. Of the 220 respondents, Google was the most popular search engine with 145 respondents (65.9%) indicating that they used it as their main search engine. A limited number of 41 respondents (18.6%) search through the use of YouTube and 34 respondents (15.5%) search through Google Scholar.

**Table 6** ANOVA test about Overall effectiveness of AI in educational robotics based on Department

Factor	Variables	N	Mean	SD	MS	F	sig
Effectiveness of AI	Education	58	4.16	.933			
	(P)Science	24	4.17	1.049	.305	.315	.868
	IT	40	4.98	1.143	.967		
	Math	44	4.18	.995			

CS	54	4.13	.877
Total	220	4.17	.977

This table no 6 show that the presents results of a one-way ANOVA that examines whether students' academic disciplines (Education, Pure Science, Information Technology, Mathematics, and Computer Science) affect their perceptions of the effectiveness of Artificial Intelligence (AI) in education. Students from the Education field (N = 58) had a mean score of 4.16 (SD = .933). Those from Pure Science (N = 24) had a mean of 4.17 (SD = 1.049). IT students (N = 40) reported the highest mean score of 4.98 (SD = 1.143). Mathematics students (N = 44) had a mean of 4.18 (SD = .995). Computer Science students (N = 54) had a slightly lower mean of 4.13 (SD = .877). The overall mean across all disciplines was 4.17, with a standard deviation of .977. The Mean Square (MS) between groups was .305, with an F-value of .315 and a p-value of .868.

**Pearson Correlation:**

**Table 7** Pearson Correlation Analysis

		1	2	3	4	5	6	7
1	L.a	1						
2	G.I	.377**	1					
3	C.T.E.R	.599**	.676**	1				
4	P.S	.562**	.540**	.518**	1			
5	R.T.R	.472**	.477**	.374**	.580**	1		
6	D.C.S	.640**	.756**	.901**	.558**	.426**	1	
7	O.E.A	.653**	.627**	.547**	.801**	.529**	.643**	1

Correlation is Significant at the 0.01 level (2 tailed)

The table no 7 show that the result the Learning Achievement shows significant positive correlations with all other variables: Highest with O.E.A (r = .653\*\*) and D.C.S (r = .640\*\*), indicating that students' attitudes and digital competencies are strongly related to their learning outcomes. Moderate correlations with C.T.E.R (r = .599\*\*), P.S (r = .562\*\*), and R.T.R (r = .472\*\*). C.T.E.R (Critical Thinking in Educational Robotics) has: Strong correlation with D.C.S (r = .901\*\*), suggesting that digital skills are crucial for critical thinking in robotics. High correlations with G.I (r = .676\*\*) and L.a (r = .599\*\*). O.E.A (Overall Educational Attitudes) is: Strongly correlated with P.S (r = .801\*\*) and D.C.S (r = .643\*\*), indicating that students with positive attitudes toward education are likely to show better problem-solving and digital skills. D.C.S (Digital Competency Skills) acts as a central variable with very strong relationships with: C.T.E.R (r = .901\*\*) G.I (r = .756\*\*) L.A, P.S, and O.E.A.

**CONCLUSION**

The research introduced and discussed the main results of the data analysis regarding the effectiveness of artificial intelligence (AI) in educational robots to improve the learning outcomes of university students. The findings revealed that the implementation of artificial intelligence in teaching robots has a significant and positive impact on the learning process, interaction, and critical thinking of the students and the development of the skills of the XXI century. To begin with, the learning activities revealed that the mean scores of all the items were high. It implies that students believed that AI-based educational robotics were beneficial to facilitate hands-on learning, assist them in grasping course concepts, and get them to engage more in classroom activities. Combining robotics with AI provided students with the real-time feedback, individual learning sessions, and interactive simulations that made them more motivated and enhanced their performance. Second, the findings of the student engagement measure showed that artificial intelligence in instructional robots leads to long-term attention, interest, and engagement. The robotics projects also enabled students to perform their own learning and collaborate more with their peers since they were participatory and problem solving. The results align with existing literature that shows that expert teachers and gamified artificial intelligence systems do increase cognitive, emotional, behavioral interest. Third, learners reported that they had improved greatly on critical thinking. They claimed to be more successful in looking at, judging, and solving complicated issues. The AI-powered robotics helped students consider, develop, and resolve actual real-world issues repeatedly. This interactive, inquiry based approach was quite good, in assisting individuals to learn how to think analytically, make decisions as well as be creative. Finally, Table 4.18 of the results in 21st century skills demonstrated the way in which artificial intelligence-enhanced robots could be used to teach people how to read and write, communicate, be imaginative, and collaborate. Students were able to more effectively learn to work together through working on robot projects in groups. Technologies based on AI simplified the process of delegating tasks, time management, and new designs. Lastly, the findings reveal how artificial intelligence can transform the application of educational robots as a teaching resource to enhance higher education. Students are more equipped with the technologies as they are all aimed at developing critical skills, learner-centered learning environment, and preparedness to the digital era. These observations indicate that to give students meaningful, concrete, and futuristic learning experiences, robots and artificial intelligence should be incorporated in higher classes.

### Recommendations.

To maximize the potential of the educational robots, they should be introduced systematically into the syllabus, especially in the disciplines of the STEM and trans-disciplinary courses, to interest the students and make them think critically. In order to introduce robots in the classroom, teachers should be trained and keep learning new skills. Moreover, as the mentioned aspects have been identified to lead to higher levels of critical thinking and engagement, it is important to make robotics activities student centered and facilitate collaboration, creativity, and problem solving in practice. Another way to improve the situation is to make sure that children can access the resources they need, which can be modern robotics kits and technical support, so that the learning process could yield the best results. To achieve this, it is also essential to use accurate assessment methods that would help to understand how the learning process would affect cognitive and engagement outcomes among students. Finally, it can be stated that the research of the future must be focused on identifying the most effective applications of educational robots in multiple areas and exploring their long-term outcomes on the learning process and acquisition of skills among students. By following these rules, universities will be able to better implement robots to train their students on how to meet the needs of the modern workplace.

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