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Unveiling the Veil: University Students' Insights on Robotic Teaching in Saudi Arabia

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Abstract **Objective:** Rapid advances in digital technology are reshaping education, with robotic teaching emerging as a promising tool for personalized learning and academic support. This study explores university students' perceptions of robotic teaching and examines its potential integration into higher education. **Methods:** A cross-sectional descriptive survey was conducted at Northern Border University, Saudi Arabia, between January and September 2024. Using convenience sampling, 423 students aged 18 years and above participated. Data were collected through an online questionnaire distributed via social media platforms. Statistical analysis was carried out using STATA/SE and MS Excel, with significance set at $p < 0.05$. **Results:** Among the participants, 72.1% were between 18-22 years old and 79.67% were female. The largest group of respondents were enrolled in the Faculty of Medicine (28.84%) and nearly one-third were in their fourth year of study (30%). Overall, 69.27% supported the integration of robots in teaching. However, opinions were mixed on whether robots could replace human instructors. More than 65% demonstrated awareness of both the benefits and challenges of robotic teaching and 70.21% expressed interest in receiving further training. Notably, gender differences were statistically significant regarding perceptions of robot inclusion ($p = 0.04$). **Conclusion:** The findings highlight a strong understanding among students, particularly young women, of both the advantages and limitations of robotic teaching. While most students support the integration of robots into education, there remains hesitation about replacing human teachers entirely. The substantial interest in further training underscores the importance of preparing students for a future where robotic teaching may play an increasingly significant role in higher education.

Key Words Digital Technologies, Higher Education, Learning Experience, Robotic Teaching, Student Perspectives, Saudi Arabia

INTRODUCTION

In today's digital era, artificial intelligence (AI) driven robotic teaching assistants are gaining increasing attention in the field of education. These systems not only support personalized learning but also ease administrative workloads, thereby improving overall efficiency [1-2]. Their use offers a range of advantages, including enhanced productivity, improved communication and greater teaching effectiveness. Robots can deliver customized lessons, provide instant feedback and create an engaging, low-stress learning environment for students [3-4]. Despite these benefits, it is vital to examine the enablers and barriers that influence their adoption within educational institutions.

The past decade has witnessed a remarkable technological revolution that has significantly reshaped teaching and learning processes in educational settings [5-7]. Educators and stakeholders must be prepared to embrace these changes and adopt innovative tools to foster collaborative, interactive and meaningful learning experiences. Consequently, teaching methodologies must continuously evolve and adapt to the rapid digital transformations occurring globally [8-9].

As AI continues to advance, robotic teaching is emerging as an indispensable component of modern education, supporting and enhancing both teaching and learning practices. Several countries have already introduced or are actively experimenting with the use of robots at primary and secondary school levels [10-13]. This has prompted researchers to carefully analyse the potential benefits and challenges of robotic teaching, as concerns about

its future role in education remains [14-15]. Colleges and universities must also prepare for the integration of robotic teaching systems, which requires a deep understanding of both the promoting factors and the barriers to implementation [16-18].

Research in this area is crucial for guiding education planners in designing effective policies and strategies to ensure the meaningful integration of robotic teaching into higher education. Such efforts can raise awareness about the best practices for its use and maximize its potential benefits for students and teachers alike. However, to date, limited evidence is available from the Kingdom of Saudi Arabia regarding the role of robotic teaching in colleges and universities [19-20]. To address this gap, the present study aims to explore university students' perceptions of robotic teaching and evaluate its potential incorporation into higher education systems.

METHODS

Study Setting and Design

This study adopted a cross-sectional descriptive survey design and was conducted in Saudi Arabia between January and September 2024.

Sample Size and Sampling Method

A convenience sampling technique was used. The minimum required sample size was determined to be 386, calculated using the following formula:

$$\text{Sample size} = \frac{Z_{1-\alpha/2}{}^2 \, P(1-P)}{d^2} \quad (1)$$

Where:

Z1-α/2 : The standard normal variate at 5% type 1 error (p<0.05); it is 1.96

P : The expected proportion based on previous studies

D : The absolute error (0.05)

Research Tool

Data were collected using a structured, pre-designed questionnaire that assessed participants' perceptions of robotic teaching and their prior educational exposure. Awareness levels were categorized as high if more than 50% of the perception-related questions were answered correctly.

Inclusion and Exclusion Criteria

The study included both male and female students aged 18 years and above. Individuals not enrolled in higher education, as well as those residing outside the study area, were excluded.

Statistical Analysis

Data analysis was performed using STATA/SE version 11.2 (StataCorp, College Station, Texas, USA) and Microsoft Excel. Results were presented as frequencies and percentages. Comparative analyses were conducted using the Chi-square test (χ^2) and Fisher's Exact Test (FEET). A p-value of less than 0.05 was considered statistically significant.

RESULTS

Out of the total 423 participants, the majority (72.1%) were in the 18-22 age range, with 79.67% being female. Detailed demographic information is presented in Table 1.

While most participants (69.27%) supported the inclusion of robots in teaching, their opinions were divided on whether robots could replace human instructors. Participants demonstrated a strong awareness of the advantages and disadvantages of robotic teaching, with over 65% providing correct responses for both categories. Nevertheless, 70.21% expressed a desire for additional training sessions. Figure 1 provides responses to all perception questions. However, as shown in Table 2, there were no significant differences in perceptions across age groups.

However, significant gender differences were observed in opinions regarding the inclusion of robots in educational settings (p = 0.04) and whether robots could replace human teachers (p = 0.04) (Table 3).

Regarding prior exposure to robotic teaching, 70.2% of participants had already attended one or two educational sessions. The full data on these sessions is illustrated in Figure 2.

DISCUSSION

The demographic analysis of this study revealed that the majority of participants (72.1%) were between 18-22 years of age, with females representing a significant proportion (79.67%). This suggests a strong engagement with emerging technologies, including robotic teaching, particularly among young women. Similar global trends have been reported; for instance, research from the United States shows that young girls increasingly take part in robotics programming

Table 1: Sociodemographic characteristics of the study participants

Variable		No.	%
Age (year)	18-22	305	72.10
	23-27	71	16.78
	≥28	47	11.11
Gender	Male	86	20.33
	Female	337	79.67
College	Faculty of Medicine	122	28.84
	College of Business Administration	57	13.48
	Faculty of Home Economics (Girls)	7	1.65
	Faculty of Education and Arts	34	8.04
	College of Nursing	47	11.11
	College of Science	25	5.91
	Faculty of Applied Medical Sciences	11	2.60
	Arar Community College	16	3.78
	College of Engineering	11	2.60
	College of Sciences and Arts (Rafha)	5	1.18
	College of Pharmacy (Rafha)	39	9.22
	College of Computing and Information Technology (Rafha)	13	3.07
	College of Science and Arts in (Turaif)	36	8.51
Academic Year	Preparatory	52	12.29
	First Year	35	8.27
	Second Year	44	10.40
	Third Year	67	15.84
	Fourth Year	127	30.02
	Fifth Year	41	9.69
	Sixth Year	17	4.02
	Internship	40	9.46

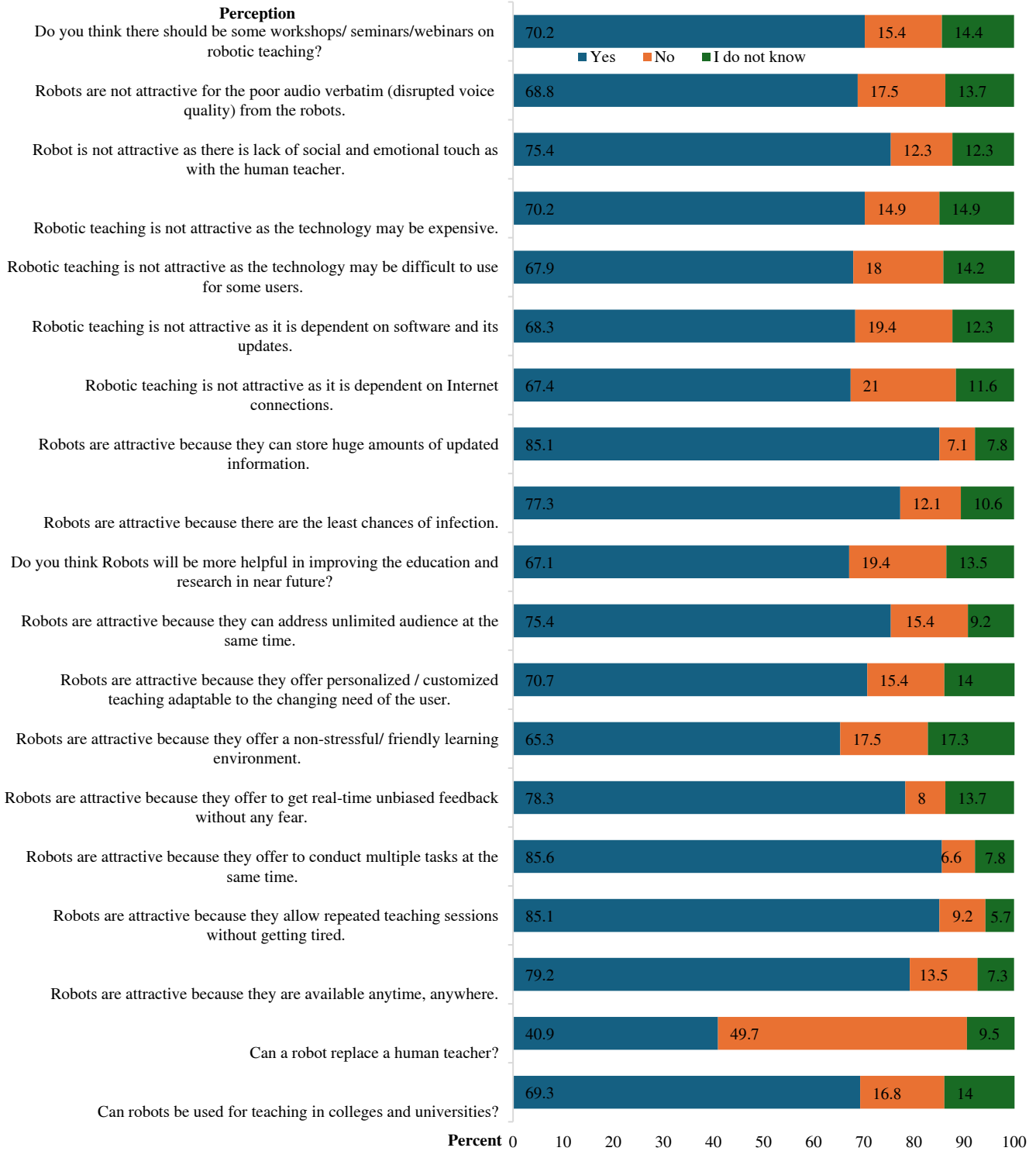

Figure 1: Students' perception of robotic teaching

competitions, highlighting their growing confidence and interest in technological innovation [21]. Such enthusiasm is likely driven by broader access to STEM education and targeted initiatives that encourage female participation in technology-oriented fields.

Support for the inclusion of robotic teaching in higher education was expressed by 69.27% of respondents, reflecting students' openness toward adopting innovative educational tools. This positive outlook can be attributed to an increased awareness of technology's role in education, particularly in the post-pandemic era where digital platforms and hybrid models have become integral to learning. However, participants expressed divided opinions on whether robotic systems could entirely replace human

instructors. These perspectives mirror findings in existing literature, which emphasize the efficiency, consistency and scalability of AI-driven teaching but simultaneously underscore the irreplaceable value of human educators in providing emotional intelligence, mentorship and adaptive guidance [22-24]. The observation that approximately 71% of students were interested in expanding their knowledge of robotic teaching indicates a genuine curiosity and readiness to embrace this evolving field. In Saudi Arabia, robotics has already been introduced at school levels, largely inspired by Vision 2030 initiatives that prioritize technology, innovation and youth empowerment. Although robotics is not yet a formal

Table 2: Variations in students' perception about robotic teaching by age (n.=423)

Variable	Age (year)	Yes		No		I do not know		χ^2	p
		No.	%	No.	%	No.	%		
Can robots be used for teaching in colleges and universities?	18-22	210	71.67	53	74.65	42	71.19	0.30	0.99
	23-27	50	17.06	11	15.49	10	16.95		
	≥28	33	11.26	7	9.86	7	11.86		
Can robots replace human teachers?	18-22	119	68.79	159	75.71	27	67.50	FET	0.20
	23-27	37	21.39	27	12.86	7	17.50		
	≥28	17	9.83	24	11.43	6	15.00		
Robots are attractive because they are available anytime, anywhere.	18-22	238	71.04	42	73.68	25	80.65	FET	0.67
	23-27	58	17.31	8	14.04	5	16.13		
	≥28	39	11.64	7	12.28	1	3.23		
Robots are attractive because they allow repeated teaching sessions without getting tired.	18-22	256	71.11	29	74.36	20	83.33	FET	0.75
	23-27	63	17.50	5	12.82	3	12.50		
	≥28	41	11.39	5	12.82	1	4.17		
Robots are attractive because they offer to conduct multiple tasks at the same time.	18-22	259	71.55	21	75.00	25	75.76	FET	0.73
	23-27	64	17.68	4	14.29	3	9.09		
	≥28	39	10.77	3	10.71	5	15.15		
Robots are attractive because they offer to get real-time unbiased feedback without any fear.	18-22	241	72.81	24	70.59	40	68.97	FET	0.42
	23-27	58	17.52	4	11.76	9	15.52		
	≥28	32	9.67	6	17.65	9	15.52		
Robots are attractive because they offer a non-stressful/ friendly learning environment.	18-22	200	72.46	51	68.92	54	73.97	2.76	0.60
	23-27	49	17.75	11	14.86	11	15.07		
	≥28	27	9.78	12	16.22	8	10.96		
Robots are attractive because they offer personalized / customized teaching adaptable to the changing needs of the user.	18-22	211	70.57	52	80.00	42	71.19	4.02	0.40
	23-27	54	18.06	9	13.85	8	13.56		
	≥28	34	11.37	4	6.15	9	15.25		
Robots are attractive because they can address to unlimited audience at the same time.	18-22	232	72.73	45	69.23	28	71.79	FET	0.95
	23-27	53	16.61	12	18.46	6	15.38		
	≥28	34	10.66	8	12.31	5	12.82		
Do you think Robots will be more helpful in improving the education and research in near future?	18-22	203	71.48	58	70.73	44	77.19	3.16	0.53
	23-27	45	15.85	17	20.73	9	15.79		
	≥28	36	12.68	7	8.54	4	7.02		
Robots are attractive because there are the least chances of infection.	18-22	231	70.64	41	80.39	33	73.33	3.83	0.43
	23-27	55	16.82	8	15.69	8	17.78		
	≥28	41	12.54	2	3.92	4	8.89		
Robots are attractive because they can store huge amounts of updated information.	18-22	255	70.83	23	76.67	27	81.82	FET	0.46
	23-27	62	17.22	6	20.00	3	9.09		
	≥28	43	11.94	1	3.33	3	9.09		
Robotic teaching is not attractive as it is dependent on Internet connections.	18-22	198	69.47	71	79.78	36	73.47	8.67	0.07
	23-27	56	19.65	6	6.74	9	18.37		
	≥28	31	10.88	12	13.48	4	8.16		
Robotic teaching is not attractive as it depends on software and its updates.	18-22	202	69.90	66	80.49	37	71.15	6.63	0.16
	23-27	55	19.03	6	7.32	10	19.23		
	≥28	32	11.07	10	12.20	5	9.62		
Robotic teaching is not attractive as the related technology may be difficult to use for some users.	18-22	205	71.43	57	75.00	43	71.67	5.40	0.25
	23-27	52	18.12	7	9.21	12	20.00		
	≥28	30	10.45	12	15.79	5	8.33		
Robotic teaching is not attractive as the related technology may be expensive.	18-22	215	72.39	45	71.43	45	71.43	4.78	0.31
	23-27	51	17.17	7	11.11	13	20.63		
	≥28	31	10.44	11	17.46	5	7.94		
Robots are not attractive as there is a lack of social and emotional touch as with the human teacher.	18-22	225	70.53	39	75.00	41	78.85	6.81	0.15
	23-27	59	18.50	4	7.69	8	15.38		
	≥28	35	10.97	9	17.31	3	5.77		
Robots are not attractive for the poor audio verbatim (disrupted voice quality) from the robots.	18-22	210	72.16	55	74.32	40	68.97	5.91	0.21
	23-27	51	17.53	7	9.46	13	22.41		
	≥28	30	10.31	12	16.22	5	8.62		
Do you think there should be some workshops/ seminars/webinars on robotic teaching?	18-22	213	71.72	46	70.77	46	75.41	3.92	0.42
	23-27	46	15.49	14	21.54	11	18.03		
	≥28	38	12.79	5	7.69	4	6.56		

Table 3: Variations in students' perception of robotic teaching by gender

Variable	Gender	Yes		No		I do not know		χ^2	p
		No.	%	No.	%	No.	%		
Can robots be used for teaching in colleges and universities?	Male	69	23.55	11	15.49	6	10.17	6.66	0.04
	Female	224	76.45	60	84.51	53	89.83		
Can a robot replace a human teacher?	Male	54	31.21	28	13.33	4	10.00	21.63	<0.001
	Female	119	68.79	182	86.67	36	90.00		
Robots are attractive because they are available anytime, anywhere	Male	67	20.00	12	21.05	7	22.58	0.14	0.93
	Female	268	80.00	45	78.95	24	77.42		
Robots are attractive because they allow repeated teaching sessions without getting tired	Male	72	20.00	10	25.64	4	16.67	FET	0.64
	Female	288	80.00	29	74.36	20	83.33		
Robots are attractive because they offer to conduct multiple tasks at the same time	Male	67	18.51	9	32.14	10	30.30	5.18	0.07
	Female	295	81.49	19	67.86	23	69.70		
Robots are attractive because they offer to get real-time unbiased feedback without any fear	Male	62	18.73	10	29.41	14	24.14	2.77	0.25
	Female	269	81.27	24	70.59	44	75.86		
Robots are attractive because they offer a non-stressful/ friendly learning environment	Male	62	22.46	14	18.92	10	13.70	2.85	0.24
	Female	214	77.54	60	81.08	63	86.30		
Robots are attractive because they offer personalized / customized teaching adaptable to the changing needs of the user	Male	59	19.73	13	20.00	14	23.73	0.49	0.78
	Female	240	80.27	52	80.00	45	76.27		
Robots are attractive because they can address to unlimited audience at the same time	Male	66	20.69	12	18.46	8	20.51	0.17	0.92
	Female	253	79.31	53	81.54	31	79.49		
Do you think Robots will be more helpful in improving the education and research in near future?	Male	59	20.77	17	20.73	10	17.54	0.32	0.85
	Female	225	79.23	65	79.27	47	82.46		
Robots are attractive because there are the least chances of infection	Male	64	19.57	12	23.53	10	22.22	0.54	0.76
	Female	263	80.43	39	76.47	35	77.78		
Robots are attractive because they can store huge amounts of updated information	Male	70	19.44	9	30.00	7	21.21	1.92	0.38
	Female	290	80.56	21	70.00	26	78.79		
Robotic teaching is not attractive as it is dependent on Internet connections	Male	64	22.46	13	14.61	9	18.37	2.71	0.26
	Female	221	77.54	76	85.39	40	81.63		
Robotic teaching is not attractive as it depends on software and its updates	Male	63	21.80	12	14.63	11	21.15	2.05	0.36
	Female	226	78.20	70	85.37	41	78.85		
Robotic teaching is not attractive as the related technology may be difficult to use for some users	Male	63	21.95	12	15.79	11	18.33	1.58	0.45
	Female	224	78.05	64	84.21	49	81.67		
Robotic teaching is not attractive as the related technology may be expensive	Male	61	20.54	14	22.22	11	17.46	0.47	0.79
	Female	236	79.46	49	77.78	52	82.54		
Robots are not attractive as there is a lack of social and emotional touch as with the human teacher	Male	66	20.69	9	17.31	11	21.15	0.34	0.84
	Female	253	79.31	43	82.69	41	78.85		
Robots are not attractive for the poor audio verbatim (disrupted voice quality) from the robots	Male	55	18.90	19	25.68	12	20.69	1.68	0.43
	Female	236	81.10	55	74.32	46	79.31		
Do you think there should be some workshops/seminars/webinars on robotic teaching?	Male	65	21.89	9	13.85	12	19.67	2.15	0.34
	Female	232	78.11	56	86.15	49	80.33		

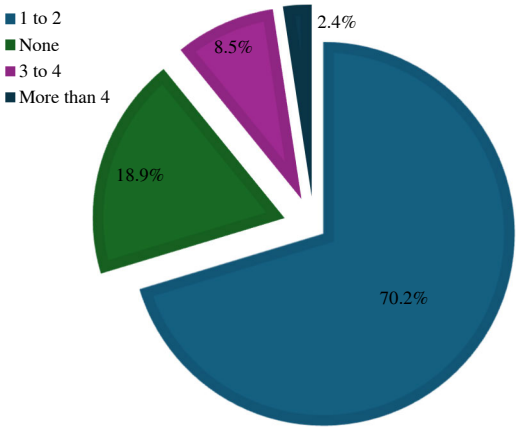

Figure 2: Robotic teaching education sessions attended by studied students

component of the national curriculum, initiatives and competitions are increasingly promoted to strengthen critical thinking, problem-solving and technological literacy among students [25-26]. This context may explain the strong interest observed among university students, who recognize the potential benefits of integrating robotic systems into higher education.

Additionally, the study found that 70.2% of respondents had attended one or two sessions on robotic teaching. Such exposure likely contributed to the relatively high awareness levels observed in this cohort. Early engagement with educational technologies helps demystify robotics, reduces apprehension and cultivates positive attitudes toward its use. Incorporating similar introductory experiences into higher education curricula could further enhance students' preparedness and receptiveness to robotic teaching.

Overall, the findings suggest that students are highly receptive to robotic teaching, though cautious about the idea of fully replacing human educators. A hybrid model, where robotic systems complement rather than replace human instructors, may provide the most effective and balanced approach, combining the efficiency of AI with the mentorship, empathy and adaptability that only human teachers can offer.

CONCLUSIONS

This research provides important insights into university students' perceptions of robotic teaching, highlighting both their awareness of its advantages and acknowledgment of its challenges. The findings underscore a strong interest in the subject, particularly among young female students and emphasize the need for further training opportunities in this emerging field.

Based on these results, higher education institutions are encouraged to design and implement structured training programs on robotic teaching to align with students' interests and prepare them for future academic and professional demands. In parallel, policymakers should work toward developing frameworks that ensure the ethical, responsible and sustainable integration of robotics into education.

The study's main limitations include the gender imbalance of participants and its single-institution scope. To strengthen the evidence base, future research should involve more balanced and diverse student populations across multiple universities, thereby enhancing generalizability and capturing a broader range of perspectives.

Strengths

A key strength of this study lies in its focus on a highly relevant and timely topic, exploring the integration of robotic teaching in higher education. The research also benefits from a relatively large sample size, which enhances the robustness of its findings. Another strength is the inclusion of participants from different faculties and academic years, ensuring a more comprehensive and representative overview of student perspectives.

Limitations

Despite its contributions, the study has some limitations. The reliance on self-reported data introduces the possibility of response bias, as participants' answers may not always reflect their true knowledge or attitudes. Additionally, the notable gender imbalance within the sample restricts the generalizability of the results. Finally, as this was a single-institution study, the findings may not be fully applicable to other universities or regions with different contexts and educational systems.

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Ethical Statement

Ethical approval was obtained from the Local Committee of Bioethics at Northern Border University (Approval No: 112/23/H). Informed consent was secured from all participants, with assurances of confidentiality, anonymity and voluntary participation. Participants were informed of their right to withdraw at any stage and all data were handled in compliance with strict security and privacy protocols.

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