

A Human-Robot Interaction in Education: A Systematic Review of Furhat Robots Role in Student

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Abstract

Using robotics in teaching has impacted pedagogy remarkably, with Furhat Robot being a potential aid for increasing student interaction and academic achievement. This research compares Furhat's influence with NAO Robot, which has taken over the spotlight because of its wide-ranging movement ability. Compared to NAO, Furhat's interactive AI and advanced speech processing render it ideal for language-based learning and social interaction, especially in higher education environments. A bibliometric analysis of robotics research during 2020-2024 reported variations in publication, with 2021 recording the maximum output (122,000) and 2023 recording the minimum (51,000). The study assessed Furhat's performance in three dimensions: role perception, psychological motivation, and trust building. Experimental findings at Sohar University reported a 27% improvement in student performance and better consistency in response. However, speech monotony, contextual limitations, and lack of visual cues were reported as limitations. While Furhat shows immense potential as a learning aid, its success depends on clearly defining roles, flexibility, and AI upgrades. Future research needs to be focused on improving interactivity, speech dynamics, and conversational AI to offer a more interactive and intelligent robotic learning experience in learning environments.

Keywords: Human-Robot Interaction; robot as teacher; Social robot; Furhat Robot; student performance.

1. Introduction

Robotics has evolved greatly, resulting in several different kinds of robots being used for different purposes. They contain all sorts of hardware, such as sensors, cameras, motors, actuators, projectors, and so on, which could allow them to interact with humans and objects within their surroundings (Xie et al., 2022). They also exist in different



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forms: robot arms (for assembly uses, such as in factories), automated guided vehicles (for transport uses, such as in warehouses), and more recently, humanoid robots (for general use where human mobility and articulation are needed) (Yousif J., 2021). The robotics sector itself has also been increasing year by year. There is a relatively steady growth of on average 20% increase, every year, from 2012 to 2024 as illustrated in Figure 1. Significant growth in robot adoption for research is seen in the education industry, which has incorporated all sorts of robots with several different age groups (pre-school, school and university level students) (Younis et al, 2023), different disabilities (students with autism spectrum disorder) (Yousif J., 2020; Yousif et al, 2019), different demographics (different countries and continents) (Ahmad et al., 2017) and different subjects (math, languages, sciences) (Xia et al, 2018). One robot that is particularly popular in this space of research is the robot NAO, which is a humanoid robot developed by SoftBank robotics (Softbank , 2025). It is particularly popular because it has access to a wide variety of features such as cameras (for object detection), infrared and tactile sensors (for sensing distance and touch), microphones (for listening to commands) and many more.

These traits make the robot very adaptable and allow it to be applied in investigating the two most common educational approaches: traditional and contemporary. The traditional approach to teaching is where the teacher is the center of attention, and a group of students must listen and take part in the lesson presented by the teacher (Raja F., 2018). This method has far less interactivity and personalization but can educate more students simultaneously. The new teaching style, however, puts the student in the center and creates a more one-on-one teaching environment for them, at the cost of more time and effort needed to create these training programs (Yakovleva & Yakovlev, 2014). However, the biggest flaw of the NAO robot is that it cannot convey much intention and emotion since it has a static face (no facial expressions) (Yousif M., 2021). Here is where the Furhat robots are used, which uses a projector to project a face, Figure 2.

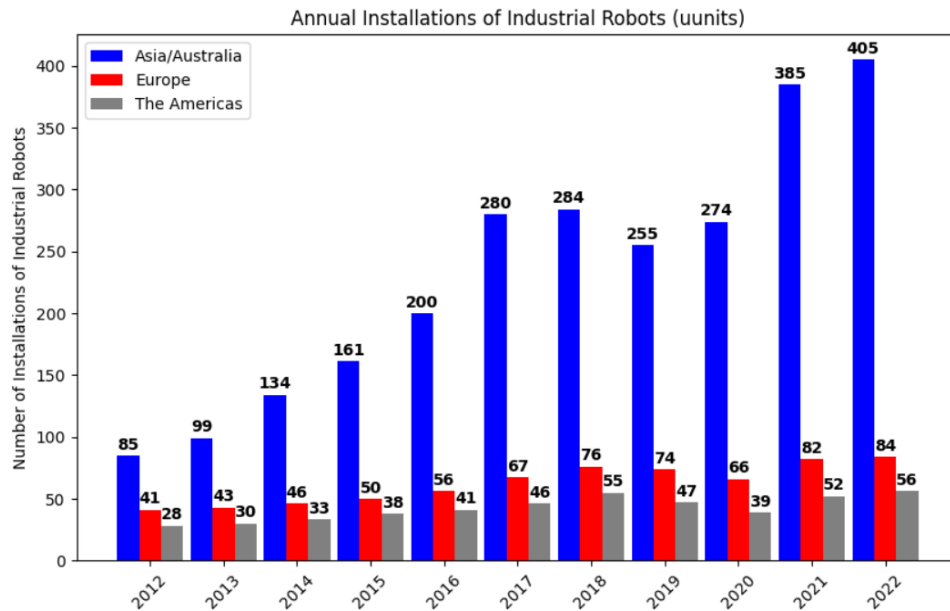


Figure 1: Annual Installations of Industrial Robots (IFR, 2023).

This gives it a full range of facial expressions to portray a more realistic emotion to the user, which can change the lesson experience and enhance its effectiveness and engagement (Lemmi D., 2019). This thesis aims to explore the use of the Furhat robot in the classroom and whether it improves the interaction and efficiency of the lesson compared to that of a standard teaching environment with a human teacher. To determine their impact, the study will explore whether social robots improve effective teaching, student performance, and student engagement in education.

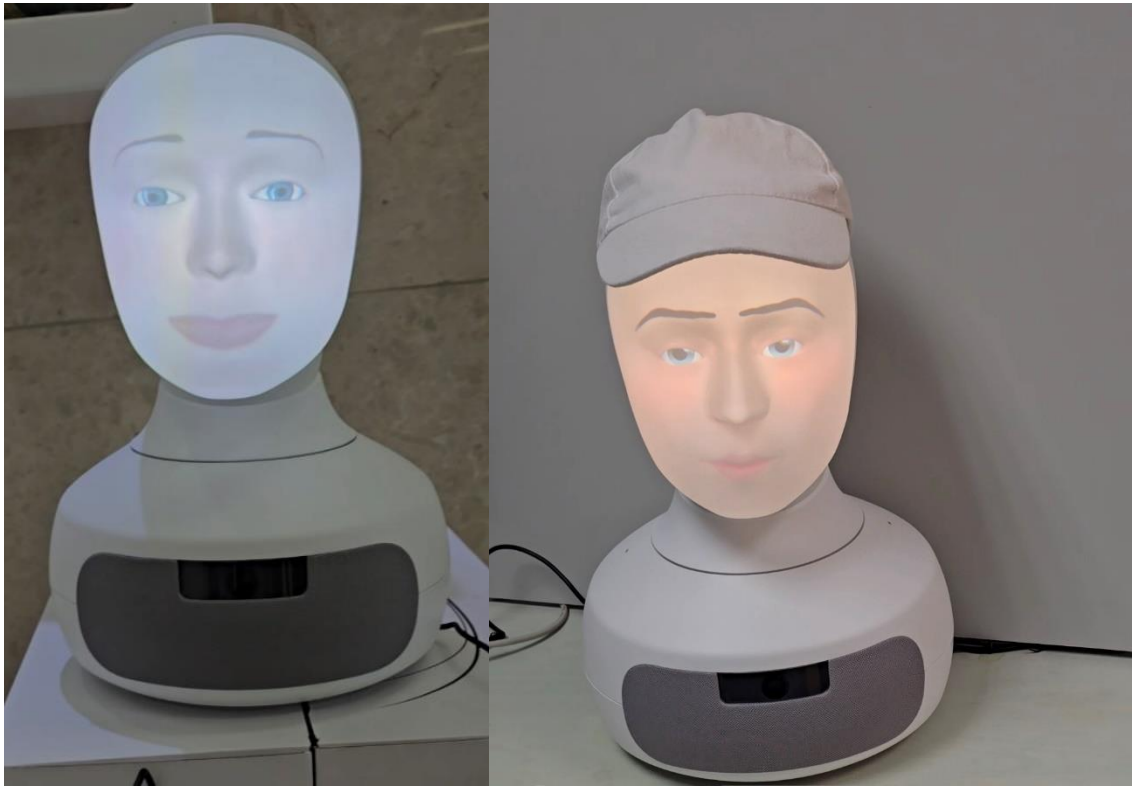


Figure 2: Furhat Robot

2. Literature Survey

Online Sabo R. (Sabo et al, 2024) investigated the use of the Furhat robot in administering verbal tasks similar to those used in screening for Alzheimers disease. The experimental model was built based on a speech recognizer, ChatGPT generative AI and a speech synthesizer. Data for the study was collected through the use of a questionnaire and observing interactions between the users and the robot. It was found that this approach had good potential for administering Alzheimer's screening verbal tasks and older participants were more likely to show a positive attitude towards the robot. Kulathunga (Kulathunga D., 2024) studied the effect of having different types of personalities on the student's ability to learn from the Furhat robot when used as a teaching assistant. This study employed a two-phase

process, initially focusing on questionnaires, canvas tasks and Affinity diagrams in the pre-study. In the post-study, the employed surveys, interviews and content analysis. They found that the robot was initially perceived as a Companion rather than a teacher due to its issues with accuracy and communication style. However, with an improved model, there was a positive increase in student learning and engagement, and it proved itself to be a viable option.

Sinha, S. (Sinha, S et al., 2023) proposed a study to check the effectiveness of different types of breaks (rest periods) in a robot (NAO) tutoring environment as an optimization strategy. They proposed 3 models; fixed breaks, personalized breaks based on improving scores and personalized breaks based on declining scores. Their results show that there was a significant improvement in student performance when switching from fixed to personalized breaks. These improvements were immediate, and they manifested in the form of improved efficiency during learning and improved accuracy when answering questions. A study by Younis (Younis et al., 2023) conducted a systematic review of the literature on NAO education robots based on artificial intelligence, learning, and teaching. It reviewed 82 scientific papers from twelve high-impact journals (2014–2023) from reputable databases. The study assessed NAO robots' role in language programming and educational impact. The findings indicate the effectiveness of NAO robots in enhancing learning among students and learner engagement (Yousif et al., 2018). The study serves as a guide for researchers, trainees, and instructors who are interested in AI and robotics in education. It also motivates students to publish in high-level journals, contribute to the academic community, and gain expertise in NAO robot applications. Jessen, M. (Jessen, M., 2022) performed a study to determine the use of a robot (Furhat) on student's interest in reading and engaging with books. A Research through Design approach was used and the Wizard of Oz program paradigm was developed. It was found that regardless of using active or passive teaching modes, it could not be conclusively concluded that the robot inspired genuine reading interest in the students. However, it did fill the basic psychological needs for relatedness and competence which are important for motivation and the students appreciated the interaction.

A study by Orujova (Orujova & Khlybova, 2022) examined task-oriented dialogue systems and their application to personalize user interaction. It seeks to develop a scientific conference assistant, DAGFINN, which is designed to provide participants with conference details and leisure activity suggestions. The robot is equipped with name and face recognition to facilitate interaction, allowing for personalized interaction. Since data storage is an issue, a second participant recognition method using QR codes was suggested and compared on the basis of effectiveness. DAGFINN was tested in two conferences with and without personalization to observe the impact of personalization on user

experience. The findings emphasize the significance of personalization in improving interaction and user satisfaction with social robots.

Velentza, A. (Velentza, A. et al., 2021) examined the use of robots as a tutor in a university environment. The robot that was used in this experiment was the NAO robot, developed by SoftBank Robotics. They recorded the students' attitudes before and after the lesson(s) with the robot. They also performed multiple tests, varying the number of lessons alongside varying the tutor (from human to robot). Their results indicated that students had a more positive outlook on the use of robots (and technology in general) in an educational environment, and the students had a similar knowledge gain when comparing the human and robot tutors. A study by Anagnostopoulou (Anagnostopoulou et al., 2021) focuses on estimating engagement in Child-Robot Interaction, particularly for individuals with Autism Spectrum Disorder (ASD). Engagement monitoring allows the adaptation of action in robots to reach educational and therapeutic goals. The research illustrates deep convolutional architectures that better enhance engagement estimation compared to available methods. Performance is assessed under various conditions on four datasets of ASD and TD children engaging with a robot or human. The findings facilitate improved adaptive learning and therapy interventions, enabling more natural and efficient interaction. The study enhances engagement detection techniques, making social robots increasingly vital in helping children with autism.

A study by Calvo-Barajas (Calvo-Barajas et al., 2020) examined facial expressions of emotions on children's first impressions of robots, that is, on trust, likability, and competence. While first impressions in adult-robot interactions are a researched topic, their influence on child-robot interactions is an underresearched area. This study investigates the influence of emotion type, intensity, and gender likeness on children's perception of trust towards a Furhat robot. 129 children spent some brief exposure periods in front of the robot exposed to different degrees of happiness and anger. Results indicated that children form fast impressions from the facial expressions of the robot, while likability and competence accounted for significant contributions toward high trustworthy perceptions.

Ramirez (Ramirez-Duque et al., 2019) proposed a CRI (Child-Robot Interaction) that facilitates the diagnosis of ASD (Autism spectrum disorder) in kids by relying on a custom robot that utilizes computer vision and RGBD sensors built into the ROS (Robot Operating System) along with machine learning algorithms for automated face analysis. This helps reduce the delay in ASD diagnosis by cutting back on the extensive classical method, which relies solely on multiple sessions of behavioral observation, exhaustive testing, and manual coding behavior. It also elicits an efficient, more advantageous approach in the therapeutic intervention front compared to the classical system. A study by

Fermoselle (Fermoselle, L., 2018) analyzes the role of joint attention behaviours in human-robot interaction by developing and testing a semi-autonomous joint attention robot system. Two experiments were conducted: one with adults and the other with children between 10-12 years old. The measure was social presence and interaction. The results show that the system established joint attention successfully, with children scoring higher and showing more fun and usefulness. A review of the literature on robot-assisted intervention for autism spectrum disorder children is also presented. Results combined with expertise led to design suggestions for a robotic system for assisting joint attention therapies in autistic children.

A study by Edwards (Edwards et al., 2016) examines the impact of robotics in the classroom at the college level in an examination of students' attitudes towards robots as teachers. Students compared and contrasted both a human teacher using a telepresence robot and an autonomous social robot presenting the same lesson. While both were deemed credible, the human teacher using a robot was assessed as more credible, leading to enhanced learning. Students reported more affective learning from teachers as robots than from robot as teacher. Findings suggest that the type of pedagogical agent influences behavioral learning, in favor of the MAIN model and the computers as Social Actors Paradigm, with more studies needed in this direction. Peca (Peca et al., 2014) investigated children's perception of six social robots (Keepon, Romibo, Kaspar, Pleo, Probo and Nao) and their different designs, revealing that simple designs with exaggerated designs were favored. Typically developing (TD) kids and kids with ASD were asked to sort the robots into four categories: machines, humans, animals, and toys. The results displayed that both TD and ASD children recognized the robots as predominantly toys, while the children with ASD also recognized them as machines. Cabibihan (Cabibihan et al., 2013). examined the effectiveness of using many different types of socially interactive robots for kids with autism by observing its effects on their social, emotional, and communication deficits during therapy. Some of these robots include NAO, Keepon, KASPAR and others like them. The data collected was examined by comparing the target behaviors elicited from the kids and how each robot achieved these behaviors. This enabled the robots to be categorized based on their therapeutic functions and design features that allowed them to have such effective roles in autism therapy. They found that robots were effective due to their offering consistent and predictable interactions that help with development of skills for students with ASD.

Table 1 summarizes the literature survey according to the Author, Method, Robot Used and Findings for the last decade.

Table 1. summarizes the literature survey for the last decade.

Author & Year	Robot Name	Method	Population	Age of Students	Findings
Sabo et al., 2024	Farhat	Speech recognition, ChatGPT AI, speech synthesizer, questionnaire, observation	Normal	Ilder Adults	Effective for administering Alzheimer's screening tasks; older participants had positive attitudes
Kulathunga, D. E., 2024	Furhat	Questionnaires, Affinity diagrams, surveys, interviews, content analysis	Normal	University level	Initially seen as a companion rather than a teacher; improved model increased learning & engagement
Sinha, S et al., 2023	NAO	Fixed breaks, personalized breaks (improving & declining scores)	Normal	Various Age	Personalized breaks improved student performance and efficiency
Younis et al., 2023	NAO	Systematic review of 82 papers from high-impact journals	Normal	Various Age	NAO robots enhance learning and engagement; study serves as a research guide
Jessen, M., 2022	Furhat	Research through design, Wizard of Oz paradigm	Normal	Various Age	No significant reading interest increase, but fulfilled psychological needs for motivation
Orujova, N. & Khlybova, E., 2022	DAGFINN	Task-oriented dialogue system, QR codes, face recognition	Normal	Conference Participants	Personalization improved user experience and engagement
Velentza, A. et al., 2021	NAO	Pre and post-student attitude analysis, human vs. robot tutor comparison	Normal	University Level	Students had a positive outlook on robots in education; similar knowledge gain with human tutors
Anagnostopoulou et al., 2021	NAO	Deep convolutional architectures, engagement estimation	Special Needs (ASD)	Various Children with ASD	Deep learning models improved engagement estimation for ASD children
Calvo-Barajas et al., 2020	Furhat	Emotion type, intensity, and gender-likeness effects	Normal	Various Children Age	Children form quick impressions of robots; likability and competence affect trustworthiness
Ramirez-Duque et al., 2019	Custom Robot	Computer vision, RGBD sensors, machine learning	Special Needs (ASD)	Various Children with ASD	Improved ASD diagnosis efficiency compared to traditional methods
Fermoselle, L., 2018	Joint Attention Robot	Social presence analysis, joint attention measurement	Normal	10-12 years	System effectively established joint attention; children found interaction more enjoyable
Edwards et al., 2016	Telepresence & Social Robot	Comparative study of telepresence vs. robot as teachers	Normal	University Level	Telepresence teachers rated more credible; led to higher learning outcomes
Peca et al., 2014	Keepon, Romibo, Kaspar, Pleo, Probo, Nao	Sorting robots into categories based on design and perception	Special Needs (ASD) & Normal	Various Children with ASD	Children preferred simple designs; ASD children categorized robots as machines

Cabibihan et al., 2013	NAO, Keepon, KASPAR, and others	Comparative study of social robots' effectiveness in ASD therapy	Special Needs (ASD)	Various Children with ASD	Robots offered consistent and predictable interactions, improving social and communication skills
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3. Research Methodology

This study will employ a systematic review approach, reviewing and evaluating a broad range of research studies published between 2014 and 2024 and selected by prior-agreed research criteria. One of the key research obstacles is conducting a detailed literature survey from more than one source to establish the study scope. Moreover, to make recommendations on adequate sample sizes, facilitating easier application in future large-scale applications (Morgado et al, 2017).

3.1. Research questions

The literature review will determine the strengths and weaknesses of various research methodologies based on a comparison. This study will address the following main research questions:

- How does the use of Furhat Robot impact student engagement in educational settings?
- What are the measurable effects of Furhat Robot on students' academic performance and learning outcomes?
- What are the key challenges and best practices in integrating Furhat Robot into educational environments?

3.2. Search Criteria

To find papers relevant for this manuscript, a search was done to find the usage of robots in an educational environment, with particular focus on the Nao and Fuhat robots. For the database, Google Scholar was used due to its wide archiving reach and its powerful searching algorithm using the following terms”

- "Robot" + "Education" - "Nao" - "Furhat"
- "Robot" + "Education" + "Nao"
- "Robot" + "Education" + "Furhat"

The first search was used to find the number of papers not involving “Nao” and “Furhat”, while the other searches were focused on each robot respectively. As for the eligibility criteria, the search was only focused on papers that measured the engagement and the performance of students in a robot learning environment, and the paper’s publishing date was limited to papers released after 2013. As for the selection criteria, there was a particular emphasis on picking papers that covered key factors such as a wide range of audiences (age, gender, ethnicity, disability) to see how these particular demographics affect the learning environment. They also focused on different types of implementations such as usage of visual detection, generative AI, and server/cloud-based solutions. Some other factors that were

considered include the study design, the sample size, and the outcomes measured. The process that was followed to collect the papers can be seen in Figure 3, which was built in accordance with the PRISMA guidelines (Takkouche & Norman, 2011).

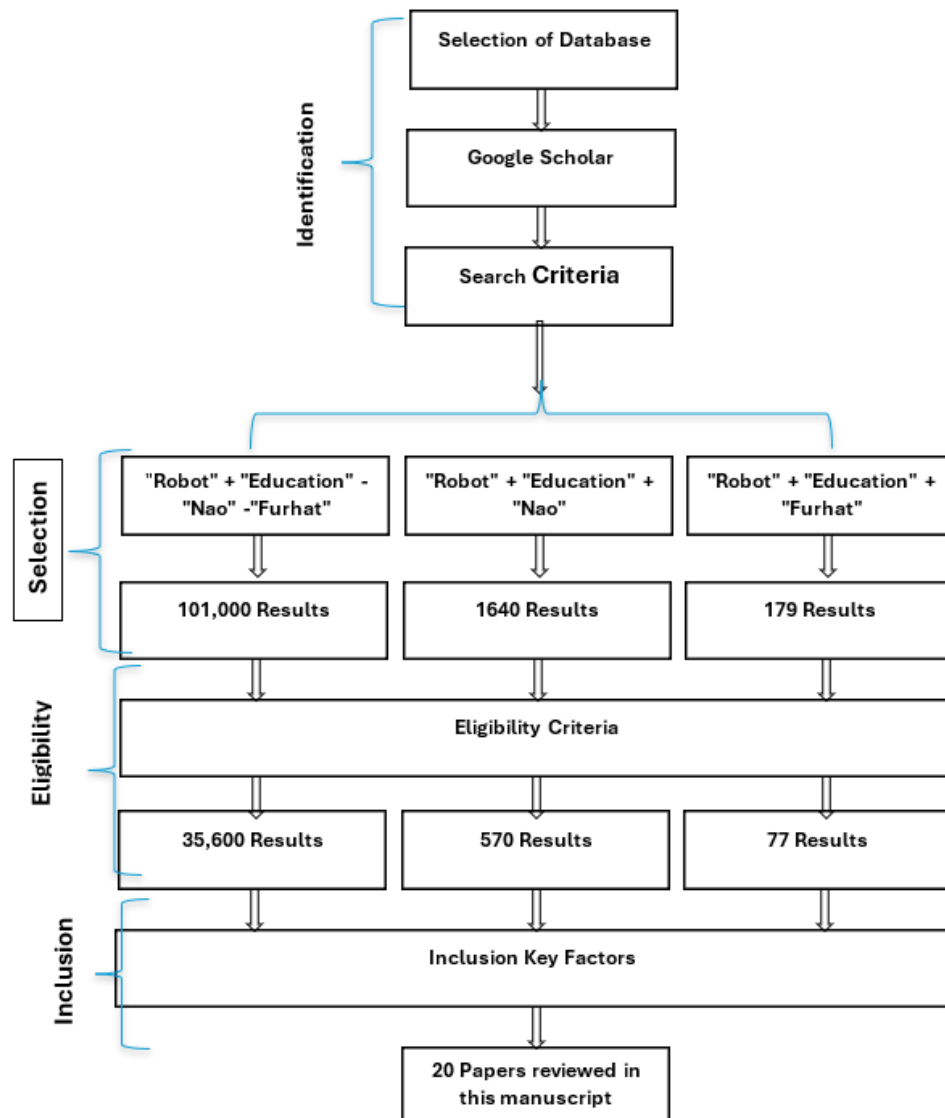


Figure 3: Studies Selected According to Eligibility Criteria/ Key Factors

4. Results and Discussion

4.1. Results

A word cloud was created to develop the bibliometric network illustrated in Figure 4, based on research data from Google Scholar, for further examination of trends and connections in the educational robotics arena. The network

illustrates various words as nodes and presents their connections. Each word's prominence is a measure of its importance, and its boldness indicates the strength of its association with other words. This chart provides a different perspective for describing the search terms and is complementary information for enriching the analysis of research trends in robot-assisted education.

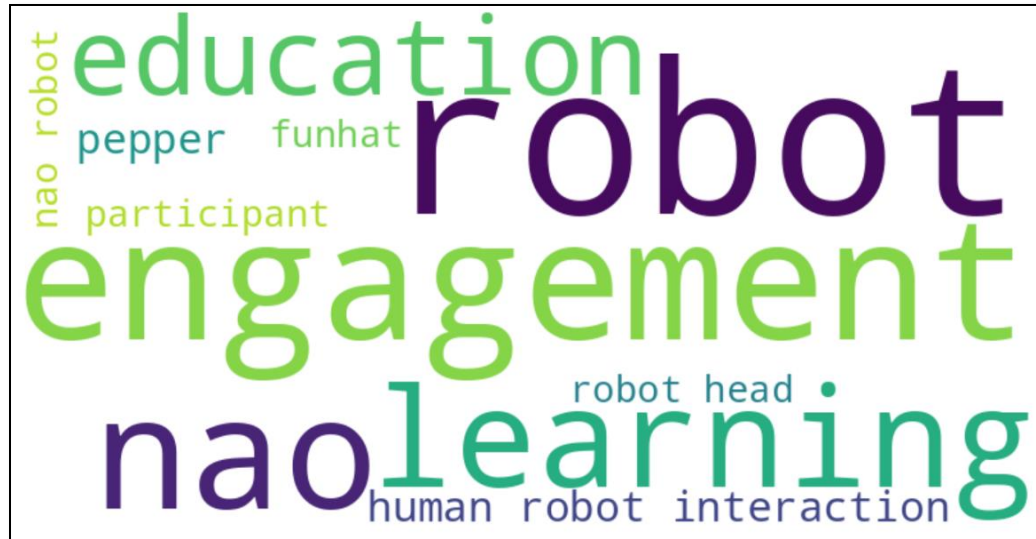


Figure 4: Word cloud Bbibliometric Network

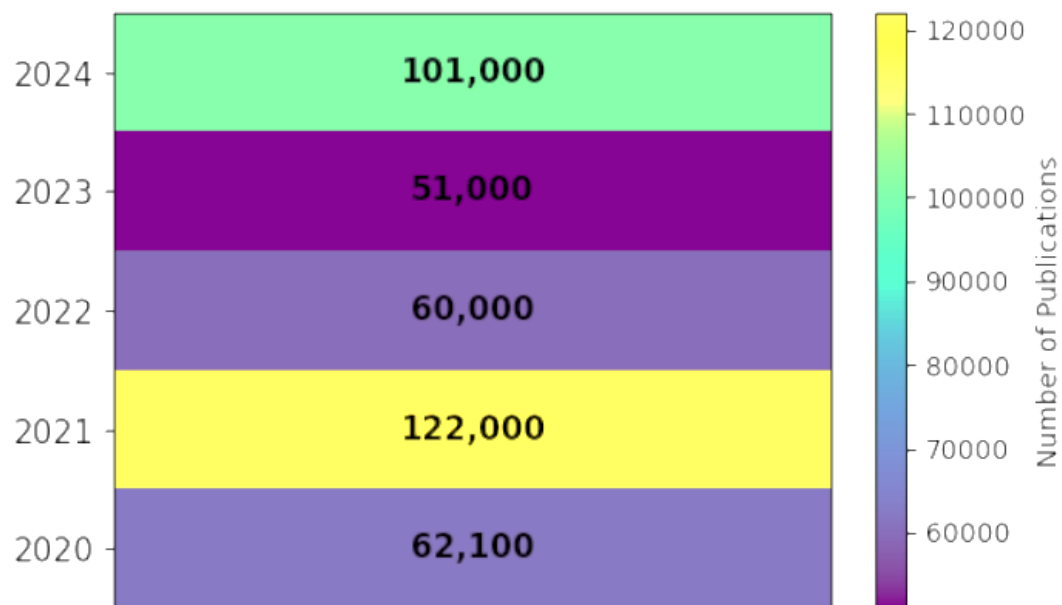


Figure 5: Number of publications from 202 to 2024

4.2. Discussion

Firstly, it is important to discuss the results of the search that was conducted in the Search Criteria section for any relevant trends. It can be seen that there are about 35000 results in total for the use of robotics in education that are in accordance with the eligibility criteria. This is not very surprising, since robotics is a growing field and there is a lot

of interest in their usage in educational settings. There is also a noticeable difference between the number of papers based on the NAO robot and the ones based on the Furhat robot. This is due to the fact it was released a lot earlier (in February 2008) compared to Furhat's commercial release date in 2017. Nao also has more movement features which make it ideal for heavy movement exercises and lessons. As a matter of fact, Nao is one of the most popular robots in education research considering it makes up 10% of the total number of papers.

However, for this paper's requirements, Furhat is the much better choice. First of all, due to its much lower popularity, it serves as a great opportunity for research. This means that all its uses were not fully explored, and it is essentially untapped research potential. Another important distinction is Furhat's much more powerful speech and listening capabilities. It has access to much newer text-to-speech engines and has more advanced microphone technology which are both essential for its use in this lesson-based study. The audience of this study were also university students, which further shows the importance of socializing skills and undermines the need for movement, like in the Nao robot. Finally, the biggest difference is its more open SDK which allows for the construction of complex architecture like the client-server web-based architecture used in this study. As for the results of the bibliographic network, illustrated in Figure 11, it can be seen just as visualized in the Search Criteria, Nao's node is quite large and located in the center, indicating its popularity in research papers, as opposed to Furhat's node, which is much smaller and closer to the end of the bibliometric network. It is also shown that engagement and learning are incredibly relevant and important terms in the research space, which is why they were one of the main factors that were used to assess the architecture proposed in this manuscript.

4.3. Answer research questions

4.3.1. RQ1: How Does Furhat Robot Application Impact Student Engagement in Learning Spaces?

The influence of Furhat Robot on student engagement in learning environments can be explained through three dimensions: role perception and adaptability, psychological motivation and emotional engagement, and trust and first impressions. These dimensions determine students' actions towards the robot and how well it can facilitate engagement in learning environments.

4.3.1.1 Role Perception and Flexibility

Kulathunga (2024) found that Furhat was initially perceived more as a friend than as an instructor. This role perception suggests that students may have interacted with Furhat in a social or entertainment-focused manner rather than viewing it as an authoritative learning device. However, after improvements in its model and interactions, Furhat effectively improved student learning and engagement.

Implication: The versatility of Furhat's design, functionality, and instructional strategy is critical to engagement. Students may see the robot as an overly large social entity if they view it that way, and its educational worth can be undermined. However, simplifying its teaching facilities and interactivity can lead to greater engagement by balancing fellowship and pedagogic efficacy.

Best Practices: Non-verbal and verbal cues, teaching styles, and AI responsiveness of Furhat need to be carefully designed by developers and trainers to align learners' perceptions with a teacher compared to a social being.

4.3.1.2. Psychological Motivation and Emotional Engagement

Jessen (2022) observed that while Furhat did not specifically boost reading interest, it satisfied psychological requirements for motivation. This suggests that the robot is not necessarily boosting academic engagement in a direct way but can serve as an external motivator to sustain students' interest and emotional investment in learning processes.

Implication: Education engagement encompasses not just direct scholastic achievement but also intrinsic and extrinsic motivation. The ability of Furhat to address psychological needs means it has the ability to produce sustained engagement through increased interest in and interaction within learning spaces.

Best Practices: Furhat will have to be utilized as an active learning agent, utilizing its capabilities of emotional intelligence (adaptive conversations, personalizing feedback, and encouraging) to encourage rather than merely present information.

4.3.1.3. First Impressions and Trust

Calvo-Barajas et al. (2020) found that the children form short impressions of Furhat, where the factors of likability and competence play a significant role in their trust towards the robot. This could mean the students become deeply involved or disengage rapidly based on their initial experience with the robot.

Implication: Students' impression of the ability of the robot is highly related to engagement. If Furhat is perceived as an able, friendly, and engaging tutor, students are likely to engage with it positively and believe in it. However, students may disengage if it lacks an approachable appearance or cannot deliver substantial content.

Best Practices: When integrating Furhat into learning, there is a need to optimize its first meeting with students by:

- Implementing interactive onboarding that instills trust and intrigue.
- Employing engaging, student-relevant conversation that is tailored to learning abilities.
- Facilitating natural and interactive speech and movement.

4.3.2. RQ2: What Are the Measurable Effects of Furhat Robot on Students' Academic Performance and Learning Outcomes?

The quantifiable effect of Furhat Robot on student academic performance and learning outcomes can be explored through two different points: enhancement of immediate academic performance and impact through motivation and engagement. While several studies depict Furhat as an enhancement to student learning, others define it as being an influence, i.e., motivational in nature rather than a direct learning enhancer.

4.3.2.1. Direct Academic Performance Improvement

Kulathunga (2024) found that Furhat's model enhancements led to increased learning and engagement, which suggests a direct influence on academic performance. The issue to highlight is that when Furhat is optimized, it can highly assist in students' learning.

Implication: The study suggests that Furhat's pedagogical design and approach directly affect learning performance. It can facilitate retention, comprehension, and engagement with learning content when well-optimized (e.g., more natural-sounding dialogue, AI-based personalization, and increased interactivity).

Measurable Outcomes:

- Better learning retention: Students retain more when learning through an optimized Furhat model.
- More learning activity engagement: More engagement is found to be correlated with improved academic performance.
- Positive educational robotics attitude: The students will learn better when comfortable and engaged, increasing learning outcomes.

Best Practices for Academic Enhancement:

- Enhancing Furhat's AI model to make learning experiences student-response-driven.
- Tracking students' progress through interactive quizzes and assessments to establish learning gains.
- Implementing adaptive learning techniques whereby Furhat adjusts its teaching style based on the student's progress.

4.3.2.2. Indirect Influence Through Motivation and Engagement

Jessen (2022) documented that while Furhat did not necessarily boost reading interest, it met the psychological requirements of motivation, which is a significant predictor of learning. This means that even if Furhat might not always lead to measurable knowledge gain, it significantly influences the engagement and motivation of learners.

Implication: Motivation is a strong predictor of academic success. While Furhat will not increase test scores or academic performance per se, it can have the indirect effect of enhancing students' overall performance by motivating them to engage and stay focused on learning activities.

Measurable Outcomes:

- Increased time-on-task: Motivated students will spend more time on learning activities.
- Increased participation: Increased participation of motivated students in class discussions and activities.
- Enhanced motivation and learning openness interaction by Furhat can reduce anxiety and encourage learners to learn more.

Best Practice Guidelines for Embracing Motivation:

- Gamification strategies: Integrating interactivity in the form of challenges and rewards and tracking advancement will aid students in maintaining interest.
- Autonomous learning support: Furhat can shift based on individual student requirements so that learners can learn as quickly or slowly as possible.
- Providing personal feedback: Student-specific encouragement and accommodative descriptions can make students feel greater self-belief.

4.3.3. RQ3: What are the challenges and best Practices in Integrating Furhat Robots into Educational Environments?

Furhat Robot's integration into schools is an opportunity and challenge. The findings of Kulathunga (2024), Jessen (2022), and Calvo-Barajas et al. (2020) are that the success of Furhat depends on students' belief about it, its motivational impact, and first impressions' effect on trust. Taking these factors into consideration is necessary in a bid to integrate Furhat successfully into school settings.

4.3.3.1. Primary Integration Challenges**a) Being Regarded as a Companion Rather Than an Educational Tool (Kulathunga, 2024)**

- Challenge: Students regarded Furhat as a companion rather than a teacher, which had little pedagogical impact.
- Implication: When students think of Furhat as more of a social robot rather than an instrument of instruction, they will use it for enjoyment rather than educational benefit.
- Solution: Programmers and educators need to redefine Furhat's role by embedding structured pedagogical material so that it appears as a reliable teaching assistant.

b) Effectiveness Depends on Context and Implementation (Jessen, 2022)

- Challenge: Furhat fulfilled psychological and motivational needs but did not necessarily provoke interest in reading.
- Implication: The robot's effectiveness varies based on the subject and the students' requirements. Its motivational benefits are not always equal to improved academic performance.
- Solution: Educators must customize Furhat's role for different subjects so that it is particular to specific learning goals and not a generic fit.

4.3.3.2. Best Practices for Successful Integration

To respond to these challenges, the following best practices need to be employed:

a) Define Furhat's Educational Function Clearly

- Integrate subject-specific lesson plans into Furhat's dialogue and interaction model.
- Make Furhat AI-generated responses and learning objectives aligned to transform Furhat into an educational assistant and not a mere conversational companion.
- Include systematic assessment features by which Furhat can track students' progress and provide feedback.

b) Adapt Furhat's Function as a Function of Learning Context

- Use interactive stories and reading companion tools for literacy courses to elicit reading motivation.
- In learning STEM, implement problem-solving contexts where Furhat engages students with critical thinking.
- Use speech recognition and conversation AI to enhance speaking and listening skills in language study.

5. Conclusion

This study experimented with the effect of a robot learning platform on academic achievement and engagement levels among students based on the Furhat robot. The research worked with 10 students at Sohar University using a three-stage methodology, including a pre-test, a post-test, and a questionnaire. There was an improvement in student performance as it increased from 53% to 80% and had a p-value of 0.011, which indicated statistical significance. Further, student consistency improved, as reflected in a reduction of the standard deviation (from 1.075 to 0.843). Feedback in the survey supported the idea that students adopted the robot-based learning experience positively, with advantages enumerated as assistance in multiple languages and improved problem-solving. Some limitations were also identified: redundancy in Furhat's speech and lack of visual/audio context in the response. While Furhat has great potential, at present, it can best be utilized as a teaching assistant rather than being a substitute for human instructors. Overcoming such limitations with more significant development will make it more beneficial in classroom settings.

The research addressed core questions regarding Furhat's impact on student engagement, learning performance, and integration problems. Findings indicated that Furhat enhances student engagement through role perception, motivation, and trust, with enhanced academic performance being a consequence of model optimization. However, it is context-dependent and should be better designed. The limitations in integrating Furhat are its perceptions as a friend and not as an educator, indicating the need for clearly defined educational frameworks and interactive features. The research answered important research questions regarding the impact of Furhat on student engagement, academic performance, and integration challenges. The results showed that Furhat enhances engagement through role perception, motivation, and trust, and model optimization enhances academic performance. However, effectiveness diminishes according to context and requires improvements in design.

Issues in integration are issues of seeing Furhat as a companion rather than a teacher, so strong demand exists for formalized learning architecture and interactive augmentation.

In order to further develop the capabilities of Furhat and promote better learning for students, future work should target:

- Relieving Tedium – Employing human-like behaviours such as pauses, emphasis, coughs, and human-like variations in a speech to heighten interest in interactions.
- Improving Interactivity – Developing a vision recognition tool to detect opportunities where students raise their hands to allow live, spontaneous question-and-answer sessions.
- Improving Spontaneity of Conversation Flow – Enhancing Furhat's ability to determine the conclusion of a conversation to allow it to flow more fluidly and spontaneously with students.
- Long-Term Study – Extending the research to span an entire semester, with a more significant number of students, more extensive tests, and an enormous survey to measure Furhat's long-term performance in terms of student learning and engagement.

Through these updates, Furhat can become a more interactive, intelligent, and engaging learning companion, paving the way for upcoming robot-supported education models.

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