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Review

A Systematic Literature Review on the Applications of Robots and Natural Language Processing in Education

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Abstract: Natural language processing (NLP) is the art of investigating others' positive and cooperative communication and rapprochement with others as well as the art of communicating and speaking with others. Furthermore, NLP techniques may substantially enhance most phases of the information-system lifecycle, facilitate access to information for users, and allow for new paradigms in the usage of information-system services. NLP also has an important role in designing the study, presenting two fields converging on one side and overlapping on the other, namely the field of the NAO-robot world and the field of education, technology, and progress. The selected articles classified the study into four categories: special needs, kindergartens, schools, and universities. Our study looked at accurate keyword research. They are artificial intelligence, learning and teaching, education, NAO robot, undergraduate students, and university. In two fields of twelve journals and citations on reliable/high-reputation scientific sites, 82 scientific articles were extracted. From the Scientific Journal Rankings (SJR) website, the study samples included twelve reliable/high-reputation scientific journals for the period from 2014 to 2023 from well-known scientific journals with a high impact factor. This study evaluated the effect of a systematic literature review of NAO educational robots on language programming. It aimed to be a platform and guide for researchers, interested persons, trainees, supervisors, students, and those interested in the fields of NAO robots and education. All studies recognized the superiority and progress of NAO robots in the educational field. They concluded by urging students to publish in highly influential journals with a high scientific impact within the two fields of study by focusing on the study-sample journals.

Keywords: artificial intelligence; learning and teaching; education; NAO-robot; undergraduate

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1. Introduction

Humanoid robots known as NAOs have become significant and useful instruments in the robotics industry. The NAO robots were created by Aldebaran Robotics, which is currently owned by SoftBank Robotics. Due to their resemblance to human figures, they can interact with people in a way that feels instinctive and natural. These robots can detect their environment, comprehend human speech, recognize gestures, and even communicate emotions through their body language and facial expressions thanks to their powerful sensors, cameras, microphones, and speakers [1]. Artificial intelligence (AI) is a branch of computer science to make an intelligent machine or what we can say to make a computer system behave like a human being. In other words, artificial intelligence makes a computer or robot perform at a level or better than human computing capability in terms of accuracy, capacity, and speed. For example, NLP techniques, which involve AI, could play an important role in designing information systems by realizing user functional requirements. During the information system lifecycle, the NLP may be used for facilitating the user dialogue and automated understanding of the semantics of information for a conceptualization of the real world, which is essential in information-system design phases [2]. It is necessary to have access to the Oxford dictionary definitions of learning, teaching, and translation before starting the subject. Learning (education) is defined as "a process of teaching, training and learning, especially in schools, colleges or universities, to improve knowledge and develop skills", while teaching is defined as "the work of a teacher". The translation is defined as "the process of changing something that is written or spoken into another language". A dictionary is defined as "a book or electronic resource that lists the words of a language in an alphabetical order and explains what they mean or provides a word for them in a foreign language".

The robot connects learning with practical life because most of the projects presented in the competitions are real examples of how the learners live their daily lives, such as automatic teller machines and smart doors, which contribute to students' learning through understanding, application, and solutions to problems experienced by society, through the use of scientific research strategies [1]. Robot education facilitates creativity and problem-solving skills while enhancing the skills and capabilities needed for students to succeed in the core classroom [3–5]. In this study, we review the accomplishments of several studies on modern technology from 2014 to 2023. The NAO-robots' studies were systematized within 12 journals in the fields of education and robotics. The studies determined a consistent taxonomy from the literature, the multiple features that distinguish this development field, and are displayed with references. The distribution of these paper databases is sorted by country of production and publication year. The advantages of targeted targets were carried out. In addition, complaints, motivations, contributions, and recommendations for various directions are provided to support researchers, manufacturers, and end users concerning NAO robots [6,7]. NLP has many advantages in education as it enables personalized language-learning experiences. It automates language assessment, saving time for educators. NLP powers intelligent tutoring systems for personalized guidance. It facilitates communication and understanding across languages. NLP enhances text analysis and comprehension skills. It improves automated feedback and targeted instruction. NLP supports inclusive education for diverse populations. It enables adaptive content and interactive language exercises. NLP fosters language proficiency and fluency development. It empowers educators with powerful language-processing tools.

The fusion of robots and natural language processing (NLP) is reshaping the education landscape. Robots equipped with NLP algorithms offer personalized tutoring, adapting teaching approaches to individual students. They also promote collaborative learning, nurturing communication, and critical-thinking skills. NLP empowers robots to read and comprehend text, enabling automated grading and immediate feedback. Language learning is augmented through NLP-driven conversations and translation. Ethical considerations and privacy concerns must be addressed. However, responsibly integrating these technologies holds great potential for creating interactive, adaptive, and inclusive learning environments. The future of education is being transformed, empowering students and educators through the convergence of robots and NLP. From this, we have a set of questions that we discussed in our study.

Down to the best solution. The questions are:

1. Can the NAO robots be introduced in education? What is the comparison between the level of students before and after the introduction of robots in education?
2. What is the status of the NAO robots in education articles published in the selected journals from 2014 to 2023? Is the number of articles for each year divided into two seasons concerning this topic, increasing, or decreasing?
3. What research-sample groups are related to the selected articles from 2014 to 2023? What are the applications of Natural language programming? What are the advantages and disadvantages of NAO robots and NLP?

The rest of this paper is organized as follows: Section 2 presents the materials and methods, which consist of two parts: a first benchmark data set and a second set of study criteria. While Section 3 describes the results analysis and summary of studies, motivations, and contributions. Section 4 gives an overview of the discussion, which consists of the distribution of publications over the years of publication, and the distribution by the author's nationality. Then, advantages and disadvantages. Section 5 shows the conclusions.

1.1. Natural Language Processing

Natural language processing is a computational technique that can be used and applied to different levels of linguistic analysis (dare, deep analysis) to represent natural language in a useful representation or more. Artificial intelligence and language are closely related and they cannot be separated [8].

Artificial intelligence has entered many applications, such as speech excellence, image distinction, language recognition, image recognition, machine translation, general education, and machine education robots, analysis, extraction, and conformance. Artificial intelligence is the main umbrella and cover for other sciences and includes machine learning, deep learning, and natural language processing, which will be the focus of our study in the last part. It covers many fields, including educational, medical, health, business, commercial, telecommunications, and sports, as shown in Figure 1.

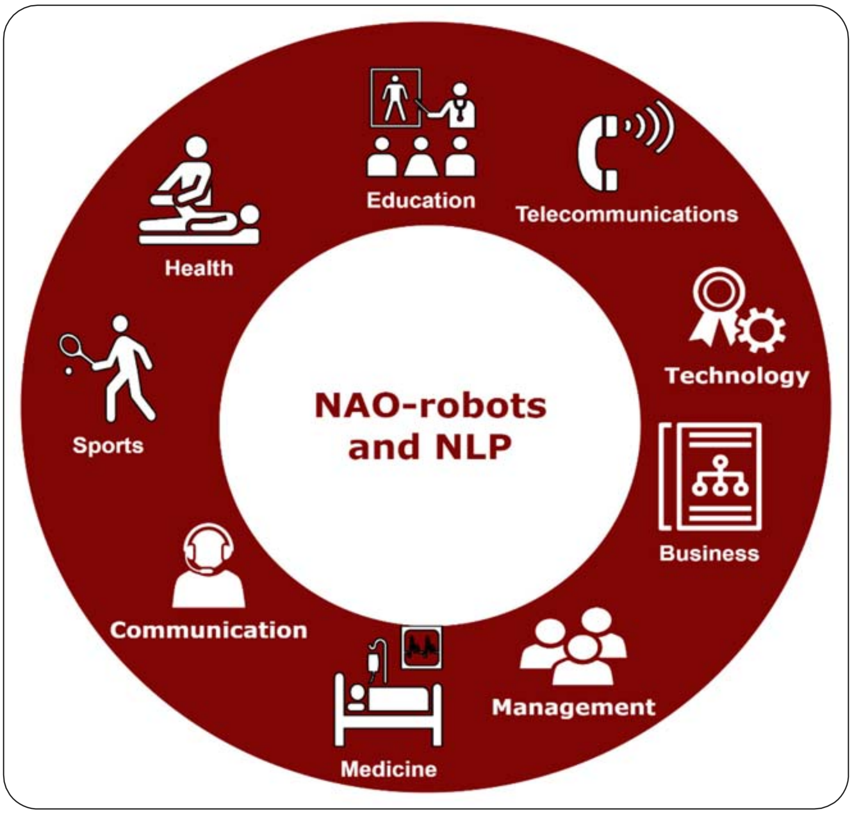

Figure 1. The area participating in the fields of use of NAO robots and NLP.

1.2. Natural Language Processing Applications

Since the year 1956, artificial intelligence has been known as an essential element in different fields of science, such as science, engineering, management, economics, and medical sciences, as well as some types of industries. However, today, artificial intelligence is becoming more prevalent. Thanks to the increase in the size of data and algorithms, in addition to the arrival of modern technology in the most important disciplines and fields of life. The natural linguistic programming applications can be limited to the domains.

2. Materials and Methods

2.1. Benchmark Dataset

The study was conducted on the highest classification of journals located only in the first quarter (Q1) and included two different fields; the first is in the field of robotics and the second is in the field of education to know the latest developments in information technology and the developments that accompany it. How do we introduce it in the field of Education? We were able to search for sober research sites in the Scimago Journal and Country Rank (SJR) Journals in two of the above areas within the sober scientific journals of the highest classification and the study covered the criteria of relevance: (1) input, (2) method of work, (3) technology used, (4) the extent of their use, and (5) mechanism of application.

The duration of the study was seven years (2014–2023). The most popular keywords have been entered on the topic, namely 'NAO-robots', 'educational robots', 'teaching', 'learning', 'artificial intelligence', 'academic', 'university', 'deep learning', 'modern technology', 'undergraduate student', and 'Natural-linguistic programming'. The domains, following a determination, are subject areas, subject categories, region/countries, type, and years; the entries were, respectively, computer sciences, artificial intelligence/miscellaneous (robotic and education), all regions, journal or conference, years (2014–2023). For the contents of this study, the selected journals were: *International Journal of Robotics Research, Soft Robotics, Journal of the ACM, Science Robotics, IEEE Robotics and Automation Letters, Science Robotics, Computers and Education, Internet and Higher Education, IEEE Transactions on Robotics, Computer Assisted Language Learning, Foundations and Trends in Machine Learning*, and *International Journal of Social Robotics*, as shown in Figure 2.

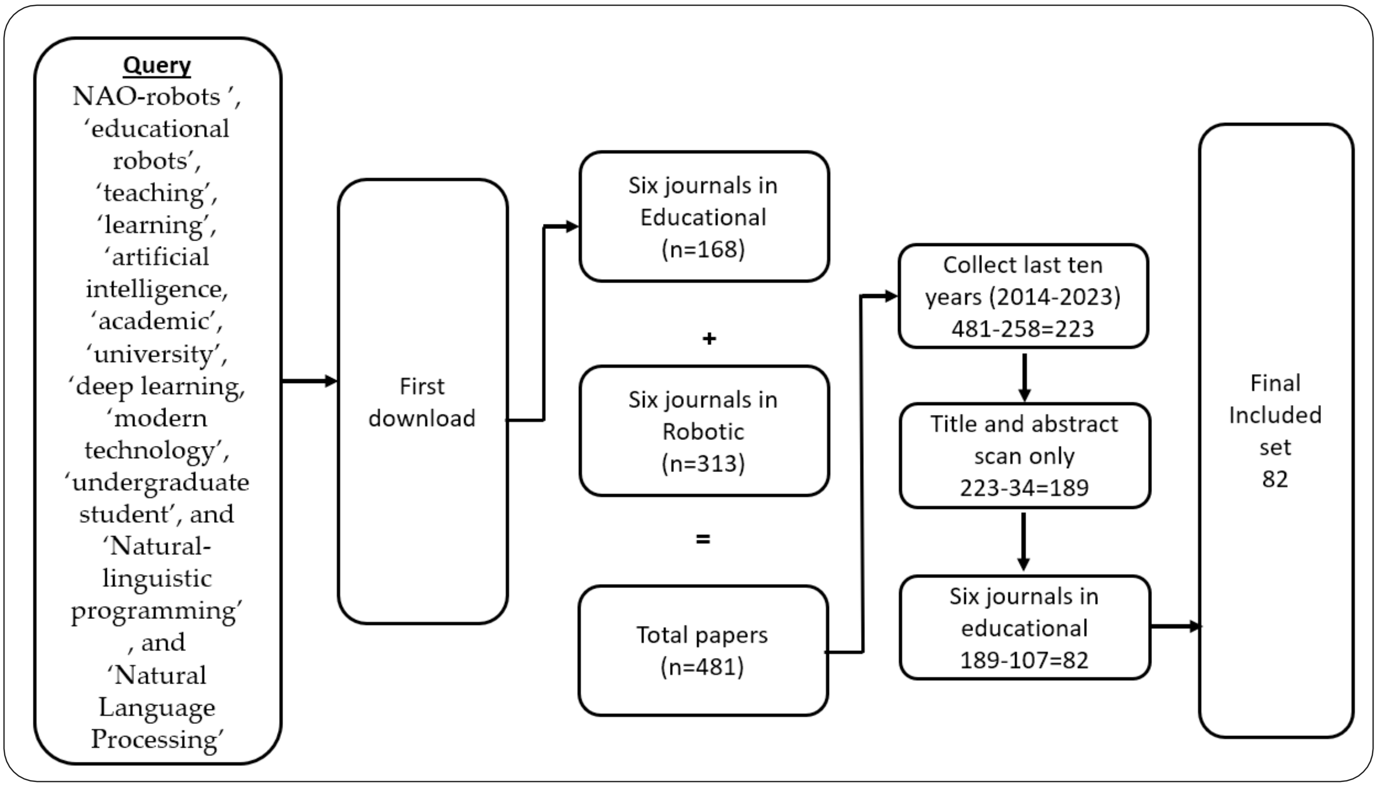

Figure 2. Flowchart diagram study query words use.

They were compiled using software from Mendeley (1.20.5). The content of the papers was filtered according to their second iteration. Titles and abstracts, as well as papers outside of our scope in this domain, were excluded. The papers were in the third version and filtered by reading the entire text and removing posts that were outside of the limits of our domain, and which do not fulfill our requirements. As such, we used the Max program to draw figures and Python to draw graphs.

2.2. Study Criteria Applied

The study criteria were as follows:

(a) Input paper, (b) method, (c) technology, (d) type of application, (e) outcome, (f) research sample, (g) research learning domains, (h) country and years, and (i) publisher3.

3. Results

The results extracted from the twelve scientific journals included in the study were in two fields: educational and robotic. From the educational field, 168 articles were extracted, and from the other field, which is the robotic, 313 articles according to the keywords closest to the study were extracted, of which the total was 481 articles. All journals were filtered. As many as 223 scientific articles were extracted outside the study period. After reading the articles, titles, and abstracts, 34 articles were excluded. The final phase included 82 articles in the study, which were read in full, and the required details were extracted according to the study criteria.

One of the studies divided the analysis of learning into two categories. The first included two articles that were known in the Latin American context for the adoption of learning analytics (LA). The second category included two articles on LA policy development. By introducing the LA applications in many Latin applications, this study met its primary objective. Brazil, Chile, Colombia, Ecuador, Mexico, and Uruguay are American countries that strengthen the advantages of international collaboration scientifically [2].

This research examined how educational robotics (ER) was applied in the classrooms to foster imagination among elementary school students and recognize the related challenges with its deployment. At separate elementary schools, twenty-six teachers were interviewed. Indepth interviews with teachers and grounded hypotheses were used to gather interviews and evaluate them. The results show the practical implications for educators and researchers interested in advancing pedagogical practices (PP) and integration (ER) to support students' creativity [3]. A study worked on the inclusion and introduction of social robots by higher education students in the social sciences major. It is a human social robot from SoftBank Robotics in a university course, in which 462 students participated. They used the unified theory of acceptance and the use of technology (UTAUT) that worked for structural equations modeling for data analysis. The characteristics were applied, such as trustworthiness, adaptability, social presence, and appearance. The students' desire to rely on robots in the learning field was reached by only 36.6%, theoretically [4].

Educators have several views and behaviors on the best ways to help students, such as critical thinking, imagination, and abilities to communicate and cooperate by linking the contemporary culture in the classroom [5]. The study discusses the challenges foreseen in the application and the use of building blocks that are important for understanding and teaching various topics related to the introduction of a smart systems case study of education in soft robotics using hot melt adhesives (HMA) to explore soft robotics ideas and technologies education. We have products and materials planned and we produced methods for tutorials involving higher education students. This paper discusses the conceptual context, strategies, and results we have achieved in their operations [6]. This paper presents a field study, in which we tested SPARC (supervised increasingly autonomous robot competencies), an innovative approach to address this challenge, in which a robot is progressively learning the appropriate autonomous approach actions from human demonstrations and suggestions in situ. Using machine-learning methods online, the study found the possibility of SPARC to learn robots from humans, and this ability is particularly useful [7]. The study of social robots was used in education among teachers, trainees, and learners with peers. The study concluded that they increased the cognitive, emotional, and educational results and achieved satisfactory results similar to that characteristic of human learning restricted to many tasks and proved the effectiveness of robots in education [9].

A field study addressed students' extra time at home by designing an accompanying learning robot to increase the activity of reading at home (focused reading) and examining the effect of the robot on the reading experience at home and comparing it without the use of robots. The study found positive experiences in building and developing students' skills in reading and preserving continuous participation as well as the example of robots in this study as an effective scientific tool [10]. Some studies have integrated educational robots into social robots [9,11]. In addition, advances in robotics have expanded the experience of human senses, intellect, and physical skills [12]. A study was applied to the care-receiving robot (CRR) in teaching verbs in the English language and the results reached a preference for the use of the care-receiving robot (CRR) [13,14].

A study shows that the robot enriches by integrating the sensory and cognitive processes as well as the learning processes modalities of kinaesthetics [15]. Another study presents a human–robot interaction (HRI), which aimed at investigating the function of the robot (peer vs. teacher) that would lead to further gains in learning. A teacher robot is seen much faster in making learning more effective. The students need to learn the basics of programming to walk through the maze via drag-and-drop tablet-screen instructions [16]. Educational robots are distinguished by many tasks. They have been used as a tool in teaching nontechnical subjects, such as drama, music, acting, and theatre. One study discusses the challenges of plays using an educational robot [17]. A study in Germany examined the effect of a robot gender when learning the sample that included 120 university students (60 Females and 60 males). The study referred to the checking of tampering, and the participants correctly identified the gender of the alleged robot. Most importantly, our results indicate prevailing gender stereotypes associated with learning do not apply to operating robots for gender-stereotyped tasks [18].

Some articles were presented on experimental studies on learning accompanied by artificial intelligence and designing learning algorithms based on artificial-intelligence techniques [19,20]. The study presented analytics and AI for learning: politics, pedagogy, and practice [21]. A study presents the results of papers that were in the third version based on interviews with eight language teachers to find out their opinions on how to efficiently use the robot adaptation to influence learning to reach the correct future directions [22].

One study implemented algorithms for object recognition used on the NAO robots for visual learning improvement for children. They found the use of digits and operators' handwritten identification. The precision of the algorithms for object recognition is within the range of when checked on images captured by the robot (82–91%) [23]. A study was conducted on 172 undergraduate students only. The data were collected and compared between Lego Mindstorms and an NAO robot. The data were collected and reviewed by an internal stimulus inventory and an analysis of the use of descriptive statistics. The data analysis produced the results using analysis of variance (ANOVA) and positive results were reached with an NAO robot [24]. Some studies have indicated the first side effects on computer science education [25] and the second is the effect of making a digital game [26].

In the United Arab Emirates, the research used one local primary school, of which an NAO robot was placed in a school and it was surveyed and inserted into one of the science subjects (mathematics); the machine reached positive results in teaching with an NAO robot. The sample included 44 male and female students. The results reached were: (i) get rid of reluctance, passivity, and nonparticipation; (ii) breaking the barrier of fear of student participation; (iii) great accuracy in the tests results, and (iv) students interact with the use of an NAO robot in the classroom more than they interact without it [27].

There were two studies reviewed on a social robot for education [28,29]. First in science, technology, engineering, and mathematics (STEM), and second, from teachers' perspectives. Many studies have offered to integrate and introduce modern technologies in presenting communication between students and university teachers to use communication [30,31] and present students' perceptions [32]. The study of some research papers used some types of robots that treated children with physical disabilities and special needs, such as the ZORA Robot [33] and the Kaspar Robot [34], in an educational manner and achieved their goals.

There were two studies conducted in Japan, the first of which was shown [13] and the second study indicates the support for trainers and teachers in teaching programming with a robot by introducing an education system that helps to detect and repair in programming classes that identify the student who raised his hand and responded to him [35].

A study introduced an arithmetic pattern that appeared in schools to learn arithmetic and the study reached positive results, showing that the intervention enhances mathematical concepts and arithmetic thinking and improves students' thinking skills [36]. In another study, a task was developed and worked to complete previous studies [37–39]. In the field of assistance and knowledge of the teacher. A total of 22 students from a Japanese university were silent in breaking the ice as one of the components of this content in educational content for students. The study concluded that it represents a problem in a great educational explanation for the teacher to explain and review [40]. In [41], another study, a teacher and the telepresence robot communicated, as shown in Figure 3. Positive results have been obtained by using NAO.

Figure 3. In an experimental simulation, the author is with a group of students.

A study created a cloud-based platform for educational purposes using an NAO robot. It implemented the Google Cloud Platform from the Google App Engine. This study aimed to create an idea that is supportive of the teacher in the educational environment, not to replace it [42], as shown in Figure 4.

Another study used robots as an educational tool by introducing mindtool in teaching and education. The study sample was 21 students in the second class who used LEGO Mindstorms NXT. The study found the effectiveness of robots as an educational tool for developing students' knowledge [43]. Some papers focus on applications and their introductions to the educational process are presented in Tables 1 and 2.

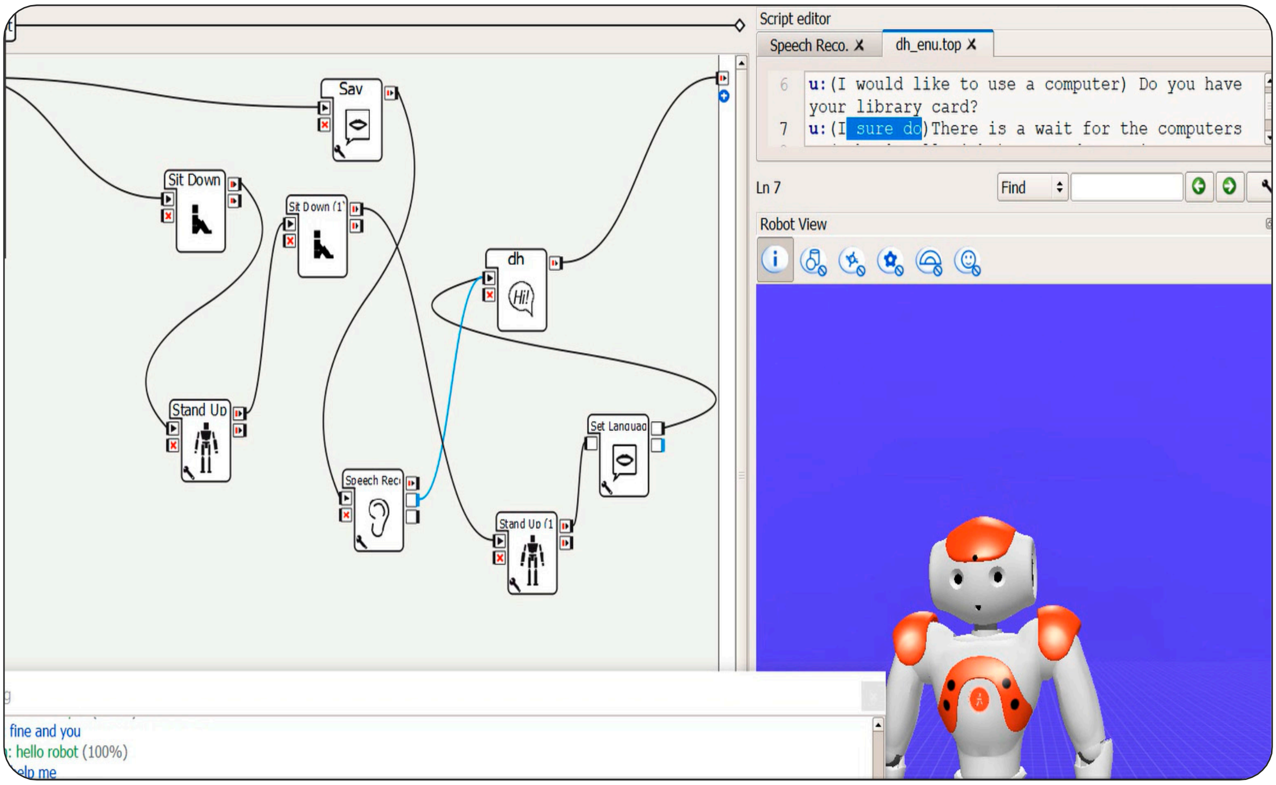

Figure 4. A platform for teachers with NAO.

Table 1. Summary of articles based on technologies, applications, target party, and motivation for NLP.

No.	Ref.	Technologies	Study Sample	Application	Target Party	Motivation
1	[44]	Artificial neural networks + inverse kinematics algorithms	Human instructor	Teaching	Human + Students	Intangible cultural heritage
2	[45]	Child–robot interaction	Children	Educational	Students + Children	Concentration + attention + Visualize performance
3	[41]	Telepresence	Children	Speak + Teaching	Children	Foreign language teaching
4	[46]	Project-Based learning constructivist approach.	Master students	Training	Master students	Program both virtual + real autonomous robots
5	[47]	___	Pupils	Teaching	Students	Timetables
6	[48]	Review	Children	Teaching + learning	Children	Improvement in student learning
7	[49]	Review	Hybrid	Speech	All	learning
8	[50]	Proposal + preliminary	Hybrid	Speech recognition	All	Learning + education
9	[51]	Robots in education	Hybrid	--	All	study
10	[52]	Bridging robotics education	High school + university	Speak + Teaching	Students	Education challenge

Table 2. Summary of articles based on the type of application, name technologies, variables (independent/dependent), method, outcome, and activity/purpose of the study.

No.	Ref.	Type of Application	Name Technologies	Variables (Independent/ Dependent)	Method	Outcome	Activity/ Purpose of the Study
1	[53]	Mobile applications	Mobile-assisted language learning Mobile-Assisted Language Learning (MALL)	58 teachers + WhatsApp + U-Dictionary + email	Evaluated by using a writing test and a critical thinking test	Capability on critical thinking for teachers	Improve English writing skills
2	[54]	-	Educational dictionary platform	Multimedia textbook + a multilingual dictionary + audio of conversational phrasebooks	Multilingual electronic dictionary	Electronic educational complex	Teaching students of the Uzbek language outside Uzbekistan
3	[55]	Tests	The project makes the most of a learning management system	600 students + 5 different tests + different languages,	Design and creation of tests to be carried out through the consultation of online dictionaries	Students who use dictionaries perform better	Teaching + translation
4	[56]	Experiments	OJAD (Online Japanese Accent Dictionary)	Visual + auditory + systematic + comprehensive	Dictionary	Generate its adequate word accent + phrase intonation	Aid teaching + learning
5	[57]	Training IT students	Q&A	Foreign languages + IT students	General language training of students.	Programs for machine translation	Technical translation+ search + read
6	[58]	--	Review	Digital libraries + databases+ online courses+ electronic textbooks+ dictionary + translators in Latin	review electronic resources in Latin	Opened access to vast resources of libraries+ using the scientific and educational potential and experience in teaching Latin	Development of e-learning tools + websites for the study of Latin in Ukraine
7	[59]	Combining advanced methods	Proposed a variant of Byte-Pair Encoding (BPE) algorithm	Methods in Japanese Vietnamese	Created the first NMT systems for Japanese to Vietnamese	Neural Machine translation	Translation

From Tables 1 and 2, we have observed that there is an overlap between NAO robots and NLP. Where NAO robots perform the tasks and activities of their approaches to the tasks of the NLP such as question answering, text similarity, text generation, sentiment analysis, and machine translation.

Table 3 is a summary of the results of associated works, including all aims of the studies, modes, datasets, study field/area, and limitations in the study sample.

3.1. Motivations

The focus of this study is the creation and training of personnel in education and learning: entrepreneurship curriculum, internship programmers, lifelong learning, and transfer of technology, training of educational staff, a collaboration between the university, industry, and students. The focus is on staff development and training in education and learning: entrepreneurship curricula, internship programmers, lifelong learning, and technology transfer, training educational staff, university-industry cooperation, and student cooperation [60].

Table 3. Summary of associated works includes all aim of study, model(s), dataset(s), study field/area, and limitation(s).

No.	References	Aim of Study	Model(s)	Dataset(s)	Study Field/Area	Limitation(s)
1	Dehghanzadeh et al. [61]	The goal to increase engagement, learning, and behavioral change; gamification aims to capitalize on people's inherent desire to play and compete	Meta-Analysis	(9) dataset	(PRISMA) guideline	• Excluded nonpeer-reviewed studies. • Focused only on formal K-12 classrooms. • Framework needs further empirical validation. • Limited to educational purposes, excluding noneducational contexts. • Future studies should have a broader focus.
2	Yang et al. [62]	Childhood education: Effects on computational thinking, sequencing ability, and self-regulation	Matatalab coding	101 kindergarteners	hypotheses	• Expand robot programming and computational thinking CT education in early childhood settings. • Integrate technology-enhanced curricula and train teachers in robot programming alongside traditional skills.
3	Zhang et al. [63]	Explore Chinese EFL learners' acceptance of mobile dictionaries (MDs) and identify factors influencing their perceptions	Technology acceptance mode, mobile technology evaluation framework	125 participants	NLP	• The study's focus is on Chinese EFL learners at Chinese universities. • Subjective data: questionnaire and group interviews. • Lack of discussion on sample limitations.
4	Veivo et al. [64]	Children's gaze behavior during dialogue breakdowns in robot-assisted language learning (RALL) is analyzed. Gaze patterns are identified through multimodal analysis of video recordings	IRE model	18 videos, 36 primary school	Robot (RALL)	• Limitations: Small sample size, limited generalizability. • Focus on specific age ranges and language learning, reliance on video recordings. • Potential omission of nonverbal cues.
5	Engwall et al. [65]	Analyze robot behavior in RALL with adult learners and interaction	NA	33 adults	Robot (RALL)	• Short-term duration; heterogeneous learner group. • Subject drop-out. • Semi-automated Wizard of Oz study.
6	Hwang et al. [66]	Smart UEnglish app improves English as a foreign language (EFL) conversation with authentic context effectiveness	Smart UEnglish	English textbook	Robot + NLP	• Short duration. • Limited number of participants impact study findings.
7	Cao et al. [67]	Compare ASD and TD children's joint attention responses with an adult and social robot (NAO)	Comparative study design	27 ASD + 40 TD children	Robot + Education	• Limited generalizability. • Short duration, small sample size, • Potential confounding factors.
8	Ko et al. [68]	Create human–human interaction dataset for teaching social behaviors to robot	NA	AIR-Act2Act	Robot	• Limited availability of human–human interaction datasets for learning social behaviors in various situations.
9	Belpaeme et al. [69]	Explore social robots as tutors for second language learning.	Simulation	40 adults	Robot + NLP	• Lacks empirical evidence, limited scope. • Ignores individual differences. • Lacks real-world examples, does not address challenges.

Table 3. *Cont.*

No.	References	Aim of Study	Model(s)	Dataset(s)	Study Field/Area	Limitation(s)
10	Engwall et al. [70]	Study Furhat robot's interaction styles for language practice, assess learner satisfaction	Four interaction styles	32 participants	Robot + NLP	• The study's limitations include a lack of generalizability due to a small sample size and limited diversity of participants. • It lacks comparison to other methods. • Focuses narrowly on postsession ratings. • Neglects individual learning needs.
11	Chew et al. [71]	Identify educational barriers to child rights in Malaysia, propose robot activists as an innovative solution.	Model design	Student	Robot + Education	• Limited discussion on challenges faced. • Absence of quantitative evaluation.
12	Le et al. [72]	Explore telepresence robot acceptance in education, analyze factors influencing use intention, and provide design recommendations for improved usability.	Platform Qualtrics	60 participants	Robot + Education	• The research on the acceptance of telepresence robots in educational contexts is underdeveloped. • The study focuses on analyzing factors influencing the use intention of telepresence robots in higher education.
13	Engwal et al. [73]	Assess the feasibility of autonomous robot-led conversations for second language practice and evaluate speech recognition and utterance selection methods	Language model	33 students	Robot	• Prior research used human wizards. • Hindering assessment of autonomous robot-led language practice with accuracy and adequacy challenges.
14	Esfandbd et al. [74]	Examine the effects of using RASA robot in speech therapy for children with language disorders.	CNN architectures	CK+ dataset	Robot + Education	• Focus on specific language disorders. • Lack of exploration of long-term effects and generalizability. • Small sample size limits generalizability, preliminary results. • Potential bias in video coding.
15	Zhou et al. [75]	Assess online course quality and identify factors influencing implementation effectiveness.	NA	100 courses	Education	• Study limitations include the rubric's limited ability to assess course content quality. • Sample generalizability to other institutions. • Empirical evidence linking course design features with student performance outcomes is needed in future research.
16	Peng et al. [76]	Enhance student engagement in online collaborative writing by integrating intergroup and intragroup awareness information	Technology acceptance model (TAM)	161 students	Education	• Potential effect of the system on collaborative learning. • Limited experimental settings. • Questionnaire survey limitations, contextual specificity.

Table 3. *Cont.*

No.	References	Aim of Study	Model(s)	Dataset(s)	Study Field/Area	Limitation(s)
17	Flanigan et al. [77]	Exploring online instructors' rapport-building strategies and factors for initiating and maintaining rapport with students	Community of inquiry (CoI)	Nineteen college instructors	Education	• Including multiple universities. • Compare instructional modalities. • Incorporate student perspectives and assess effectiveness of rapport strategies.
18	Selwyn et al. [78]	Critique discriminatory learning analytics and explore alternatives aligned with diverse learners and learning experiences	Learning analytics	students	NLP	• Addressing the limitations of learning analytics. • Advocating for diverse stakeholder perspectives. • Interdisciplinary approaches and accountability measures.
19	Belpaeme et al. [79]	Exploring social robots' impact on education outcomes and challenges	Review	Several studies	Robot + Education	• Limitations of social robots in education: technical, logistical, and ethical considerations.
20	Ramirez et al. [80]	Compare active and passive SDOH screening methods in clinical spaces.	Retrospective cohort analysis	1735 cases	NLP	• Limitations include ongoing debate over interpretability of machine-learning data. • Reliance on diverse data. • Small sample size for certain SDOH factors.
21	Chang, et al. [81]	To enhance professional trainers' effectiveness through a robot-based digital storytelling (DST) approach	BSFE model	40 trainers	Robot	• Effective professional trainers are crucial in cultivating expertise and identity recognition in various enterprises. • Traditional teaching methods for trainers focus on medical content, lacking plan design and content organization. • This study proposes a robot-based approach using the brainstorming, selection, forming, and evaluation (BSFE) model.
22	Velentza et al. [82]	To examine the performance of social robots as university professors in engineering education, measuring enjoyment, and knowledge acquisition, and to explore the correlation between enjoyment and knowledge acquisition through a series of experiments	Questionnaire	138 people, 7 Males + 131 Females	Robot	• Initial findings suggest that while human-tutor lectures led to higher knowledge acquisition robot-tutor lectures generated greater enjoyment. • Further research is needed to explore the correlation between enjoyment, surprise, and knowledge acquisition. • Generalizing results to all genders.
23	Smakman et al. [83]	The aim of this study is to identify and compare the moral considerations associated with the introduction of social robots in primary education, to develop guidelines for their responsible implementation	Questionnaire	118	Robot + Education	• Methodological limitations include a narrow focus on the Netherlands. • Small sample sizes and limited representativeness. • The limited number of participants per stakeholder group may not represent the entire population within each group.

Table 3. *Cont.*

No.	References	Aim of Study	Model(s)	Dataset(s)	Study Field/Area	Limitation(s)
24	Konijn et al. [47]	Investigate effects of robot behaviors on students' learning outcomes in multiplication	NA	86 students	Robot	• The study's sample size was large but had variations among the pupils, making statistical testing difficult. • Future research should include additional data collection and longer-term perspectives to validate the findings. • Testing with lower-grade students starting at a lower level could provide further insights into robot tutoring for arithmetic tasks.
25	Atapattu et al. [84]	Analyze and remove noise from lecture slides for structured data analysis.	Rating	7 University lecturers	NLP	• Current instructional methods focus on isolated information, hindering the identification of relationships. • Manual construction of concept maps from teaching materials is time consuming for academics. • Natural language processing (NLP) algorithms are developed to extract concept maps automatically. • Autogenerated concept maps show promising results and are rated positively by academics for pedagogical use. • Previous studies focused on extracting concept maps from different sources, while this research targets lecture slides. • The system generates comprehensive concept maps with elements like concepts, relations, hierarchy, and summarization.
26	Liu et al. [85]	Exploring artificial intelligence (AI) chatbot as a book talk companion to enhance reading experience and maintain students' interest and social connection	Artificial-intelligence techniques	68 students	NLP	• Limited generalizability to different dialog settings, and potential. • Challenges in multi-student interactions. • Nonanthropomorphic responses. • Need for machine-learning-based training.
27	Rodrigues et al. [86]	Formative assessment system for students and teachers, automating exam creation, monitoring progress, and providing feedback on free-text answers.	Assessment	History teachers	NLP	• Limited adaptability due to a service-oriented architecture. • Quantitative scores provided for training exams but only indications for evaluation exams. • Word matching and similarity scores may not capture all nuances of student responses. • Improved accuracy by expanding question and reference answer (RA) repository and using advanced pattern recognition methods.

Table 3. *Cont.*

No.	References	Aim of Study	Model(s)	Dataset(s)	Study Field/Area	Limitation(s)
28	Westera et al. [87]	Automated essay scoring methodology using NLP to reduce teacher workload. High precision achieves substantial workload reduction.	ReaderBench	173 reports	NLP	• Dataset bias. • Numerical instability. • Limited model selection guidance. • Potential complexity in automated essay scoring methods.
29	Kyu et al. [88]	Exploring automatic methods for constructing an expert model from textual explanations, focusing on key concepts, and evaluating different metrics.	Design/technology integration in learning	7 professors teaching and 6 major universities in the US	NLP	• Debate on whether an expert model can be built solely based on expert textual data without expert input
30	Rico-juan et al. [89]	Automated detection of inconsistencies in peer assessment using machine learning, aiming to reduce teachers' workload and ensure a fair evaluation process.	In this paper, we consider ML algorithms for NLP	354 students + 2 activities	NLP	• The study assumes a peer assessment scenario in overcrowded classrooms. • Aiming to detect inconsistencies between numerical scores and textual feedback provided by assessors. • Two approaches were presented, one using a regression algorithm with embedded textual data and the other using neural networks with direct text input. • Results showed good performance, but future work could focus on interactive learning to improve accuracy and reduce manual checking by teachers.
31	Gerard et al. [90]	Automated, adaptive guidance: moving students forward with personalized assistance.	Knowledge integration (KI) + c-raterML	798 6th and 7th-grade students	Education	• Limitations: despite automated, adaptive guidance, students struggle with integrated revisions. The annotator tool aids knowledge integration, but further investigation is needed.
32	Lee et al. [91]	Aim: Develop an AI-based chatbot to enhance preservice teachers' responsive questioning skills in mathematics education.	Chatbot	Private dataset	Education	• Small sample size, varying implementation settings. • Reduced complexity, and limited experience of participants. • Need for replication with in-service teachers, varying levels of student struggles. • Lack of expert feedback on questioning strategies.
33	Lu et al. [92]	Analyze social media impact on mental health and well-being.	analysis of randomly selecting	4 Course	Education	• Study based on Chinese MOOCs, unclear generalizability to English-speaking community. • Inaccuracy of data due to crawlers. • Need for improved text classification. • Limited investigation of social-background impact.

Table 3. *Cont.*

No.	References	Aim of Study	Model(s)	Dataset(s)	Study Field/Area	Limitation(s)
34	Wambsganss et al. [93]	Explore the impact of automated feedback and social comparison on students' logical argumentation writing abilities.	Feedback mechanisms and novel NLP approaches	71 students	NLP	• The argumentation mining algorithm's accuracy can be improved. • More diverse and extensive corpora can enhance model performance. • Future research should explore learner-centered design and intelligent educational systems for different learning scenarios and metacognition skills.
35	Hsu et al. [94]	Investigate differences in learning achievement, AI anxiety, computational thinking (CT), and learning behaviors in CT and AI concept learning.	Voice assistant application (VA app)	56 university first-year students	Education	• Limitations: novelty factor influencing reduction in AI-learning anxiety. • The potential influence of embedded videos. • Technical issues affect learning process. Future studies should address long-term AI knowledge management and compare video-embedded instruction.
36	Han et al. [95]	Investigate demographic factors influencing the unique experience of chatbot implementation for inclusive learning	FAQ chatbot	46 students	Education	• Small number of participants in the control group, varied attitudes towards the chatbot, need for further validation. • Future studies should explore visual design, usability, and privacy-related barriers to chatbot improvement.
37	Sikström et al. [96]	Develop pedagogical agents with adaptive, adequate, relational, and logical communication for effective and usable learning support	Systematic review	Papers published (2010 and 2020),	Education	• Limited scope due to multidisciplinary nature. • Potential exclusion of relevant articles from other domains and languages, strict inclusion criteria may have excluded relevant work.
38	Zhu et al. [97]	Investigate student reactions to automated feedback and the relationship between revisions and improvement in scientific-argument writing	NA	374 students	NLP	• The feedback statement may not change despite revisions if automated scores remain the same. • Personalized feedback based on automated scoring and user behavior analytics should be explored. • Comparative studies across different domains are needed.
39	Bywater et al. [98]	Investigate the impact of the teacher responding tool (TRT) on high school teachers' practice in effectively responding to students' mathematical ideas	NA	4 high school/teachers	Education	• The study did not observe teachers' responding practice in the classroom to assess the transfer of TRT usage. • Generalizability is limited as the study focused on four teachers in one school during one instructional context. • Differences in teachers' mathematics knowledge for teaching (MKT) could have influenced observed differences in responding, not just the TRT recommendations. • The TRT's focus on text-based explanations limits its applicability in contexts where students use other modes of expression or have linguistic diversity.

Table 3. *Cont.*

No.	References	Aim of Study	Model(s)	Dataset(s)	Study Field/Area	Limitation(s)
40	Greenhalgh et al. [99]	Analyze teacher-focused Twitter hashtags as distinct affinity spaces for learning	Descriptive and hierarchical analysis.	#michED1/9/2015 to 31/08/2016	Education	• Limited to exploring the #michED Twitter hashtag used by teachers in Michigan. • Focus on chat and nonchat spaces within the hashtag. • Reliance on Twitter's built-in features for communication. • Different literacy practices observed in chat and nonchat contexts. • Chat mode emphasizes social interaction, while nonchat mode focuses on content dissemination. • Informal learning through social media highlighted. • Implications for teacher educators, preservice teachers, and in-service teachers in understanding hashtag participation skills in different social situations
41	Wang et al. [100]	Analyze students' interactions with AI for English foreign language (EFL) learning and identify factors for success.	Cluster and epistemic network analysis	16 students	Education	• Limited number of participants from a specific EFL context. • Reliance on usage data and reflection essays as data sources. • Unequal sizes of student clusters generated by cluster analysis. • Limited generalizability to other types of AI agents. • Need for further exploration of different AI agent types. • Consideration of alternative theories for a comprehensive understanding of human–AI interactions in education. • Confinement to the combined frameworks of CoI and SAL. • Potential value in incorporating additional data-collection techniques.
42	Yang et al. [101]	Investigate massive open online courses (MOOC) learners' forum participation patterns and their impact on performance	Latent semantic analysis (LSA) model + decision tree model	69,867 learners	Education	• Single MOOC, topic, and platform may not represent all MOOCs. • Misclassification of posts containing words appearing in both topic-related and unrelated posts. • Model refinement is needed to identify triggers for misclassification. • Future research should consider learners' irrelevant posts for course design and facilitation. • Learners' topic-unrelated posts, complaints, and technical problems may impact grades and dropout rates. • Limited focus on grades as a measure of learner performance.

3.2. Contributions

- Provide a guide for researchers, trainers, teachers, orientalists, and students;
- Promote policies and initiatives by universities and institutes to improve the research capacity of academic staff and students to join the NAO robot in the classroom and the laboratory;
- Cultivate a culture of learning, training, and teaching with NAO robots and make it essential in the field of education;
- Develop the skills of students and enhance their scientific level, cooperating to achieve the correct answer for any question.

4. Discussion

The integration of robots and natural language processing (NLP) in education offers numerous benefits and challenges. Robots equipped with NLP algorithms provide personalized instruction, adapting teaching methods to individual student needs. They also foster collaborative learning, promote critical thinking, and enhance communication skills. NLP enables automated grading, immediate feedback, and language-learning support. Ethical considerations, such as data privacy and algorithmic fairness, must be addressed. Collaboration between educators and technology developers is crucial for successful implementation. By responsibly integrating these technologies, education can become more interactive, inclusive, and prepare students for the future.

Summary of the main points

1. Personalized instruction: robots provide tailored feedback, adaptive content delivery, and personalized tutoring;
2. Collaborative learning: robots facilitate group discussions, fostering communication and critical thinking skills;
3. Automated grading and feedback: NLP algorithms enable automated grading and timely feedback;
4. Language learning support: NLP-driven robots aid language learners through conversations and explanations;
5. Ethical considerations: privacy, fairness, and ethical implications must be addressed in implementation;
6. Teacher–technology collaboration: educators play a vital role in guiding and contextualizing technology use;
7. Preparation for future skills: robots and NLP prepare students for future workforce demands;
8. Inclusive education: robots promote inclusivity by supporting diverse learners;
9. Student engagement: robots increase student engagement and active participation in learning;
10. Advancements and challenges: ongoing advancements and challenges shape the future of these applications.

The study dealt with a review of twelve journals that received the highest ranking on the Scientific Journal Rankings (SJR) website and within the first quarter (Q1) in two different fields of meaning, merged with performance and converging with ideas, namely, the first field, robotics and the second field, education. The journals were extracted and prepared within the specified period of study and the journals came in succession. Figure 5. shows the number of articles in relation to the study journals. It came in the following form: *British Journal of Educational Technology* (10), *Computer Assisted Language Learning* (9), *Computers & Education* (3), *Foundations and Trends in Machine Learning* (1), *IEEE Robotics and Automation Letters* (7), *IEEE Transactions on Robotics* (7), *International Journal of Robotics Research* (6), *International Journal of Social Robotics* (3), *Internet and Higher Education* (16), *Journal of the ACM* (12), *Science Robotics* (7), and *Soft Robotics* (1). The *International Journal of Robotics Research* received the highest value of H-index (155,2020) and (180,2023) in the field of robotics and the *Computers & Education* Journal received the highest value of

H-index (164,2020) and (215,2023) in the field of robotics within the period of the study. We also realized that the *Internet and Higher Education* journal (16) articles, obtained the most publication and contributions from the current study, in comparison with other sober scientific journals. We also advise all researchers to accredit all study journals as having the highest classification in Scopus and SJR during the study period.

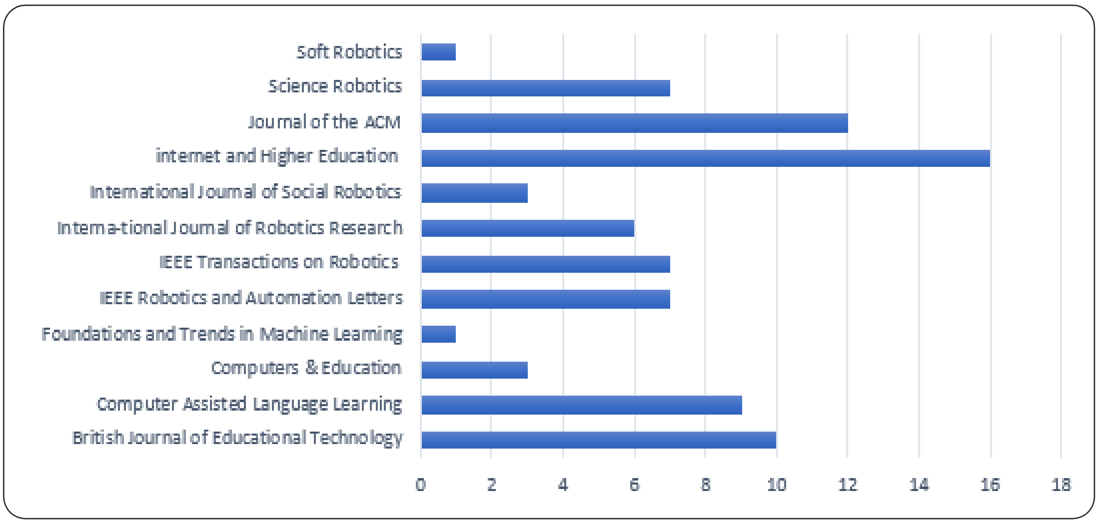

Figure 5. Number of articles in Journals.

After that, the categories of research articles were covered as it included four classes in the field of learning: special needs (12.5%), kindergartens (31.3%), schools (46.9%), and universities (9.3%); most of the research papers focus on the category of schools.

4.1. Distribution of Publications over the Years of Publication

The sample included a ten study. For the period from 2014 to June 2023. This study was distinguished by dividing each year into two first and second semesters (every six months) and appeared as follows: 5 papers have been published since 2014, 4 papers have been published since 2015, 7 papers have been published since 2016, 7 papers have been published since 2017, 5 papers have been published since 2018, 9 papers have been published since 2019, 3 papers have been published since 2020, 23 papers have been published since 2021, 12 papers have been published since 2022, and 7 papers have been published since 2023. We realized that the studies began to increase from the beginning of the period to the current year.

4.2. Distribution by the Author's Nationality

The articles covered 28 countries from 5 continents. The study articles were distributed among 82 countries. The UK came up with 12 studies, followed by the USA (9); next is Hong Kong (7), Japan (6), South Korea, Germany, and Switzerland (5 each), Italy, Taiwan, and Israel (3 each), China, Malaysia, Turkey, Denmark, Greece, and Australia (2 each), and Sweden, Slovakia, Ecuador, Portugal, Iceland, Singapore, Canada, Kazakhstan, India, Belgium, Chile, and South Africa (1 each).

Finally, we extracted the percentage of natural linguistic programming uses by age groups for the study sample.

The study articles are organized according to their use by age groups, respectively, (0, 77, 27, and 40) regarding the preparation of articles in the study, while (0, 71, 028, 25.233, and 3.738) consecutively in percentage.

4.3. Advantages

Students can benefit from robots in education in a number of ways. First of all, they give students a hands-on learning opportunity, enabling them to engage with and experiment with complicated ideas. Second, robots engage students' interest and drive, enhancing the educational experience. Robots may also be designed to adjust to the needs of each learner, providing individualized learning opportunities with tailored feedback and assistance. By promoting collaboration and communication among students, they also support group learning. Finally, introducing kids to coding and programming ideas through the use of robots in the classroom helps them develop their problem-solving and computational thinking abilities.

Natural language processing (NLP) offers several advantages in education. It enables the development of intelligent tutoring systems that provide personalized guidance and assistance based on students' natural language input. NLP technologies aid in language learning by analyzing language patterns and providing targeted suggestions and corrections. NLP algorithms can also organize educational content and offer personalized recommendations based on students' needs and interests. Furthermore, NLP allows for automated assessment and feedback, saving time for educators and providing timely feedback to students to track their progress and identify areas for improvement.

4.4. Disadvantages

The use of robots in education comes with several disadvantages. First, the cost of acquiring and maintaining robots, as well as providing the necessary infrastructure and training, can be financially challenging for schools and educational institutions. Secondly, operating and maintaining robots can be technically complex, requiring additional training and expertise for educators and IT staff. Moreover, robots are often designed for specific tasks and lack adaptability, limiting their usefulness across various subjects and grade levels. Additionally, relying heavily on robots creates a dependency on technology, which can disrupt the learning process if technical issues arise. Lastly, robots cannot replace the social and emotional aspects of human interaction that teachers provide, as they lack empathy, understanding, and nuanced support.

The use of natural language processing (NLP) in education has its disadvantages. First, NLP systems may struggle with understanding various accents, dialects, or language variations, leading to potential misinterpretation of student input and inaccurate feedback. Secondly, privacy and data security concerns arise as NLP systems collect and analyze student data, requiring proper safeguarding to protect sensitive information. Additionally, while NLP-based assessment tools offer efficiency, they may not fully capture complex skills like creativity and critical thinking, relying too heavily on automated assessments. Bias and cultural sensitivity can also be problematic, as NLP algorithms can be influenced by biases in the training data, reinforcing inequalities or stereotypes. Finally, technological limitations in NLP systems may result in a limited understanding of context, idiomatic expressions, or nuanced language use, impacting the accuracy of responses and the comprehension of human communication.

5. Conclusions

A systematic literature review was carried out as part of this investigation utilizing the PRISMA approach. First, significant keywords and pertinent databases were found, and a PRISMA flow chart was used to meticulously document the search procedure for 12 journals. The outcomes were screened using inclusion and exclusion standards, and the included reports are detailed. A table containing the evaluation findings is also included (technologies, applications, target party, motivation, the aim of the study, model, dataset, study field/area, and limitation) was presented, summarizing the results. We observed that all presented used NLP and NAO robots in education for several reasons, for they were utilized in education to personalize language learning, create interactive experiences, support special needs students, streamline assessment, and develop future skills. These technologies enhance engagement, adapt instruction, and foster a dynamic learning environment for students in diverse educational settings.

Based on the previous studies, the following conclusions have been drawn:

1. Transformational impact: robots and NLP have the potential to transform education;
2. Personalized learning: individualized instruction enhances engagement and knowledge retention;
3. Collaborative environment: robots foster communication, critical thinking, and teamwork skills;
4. Efficiency and feedback: automated grading saves time and provides immediate feedback;
5. Language learning enhancement: NLP-driven robots support language acquisition and accessibility;
6. Ethical considerations: privacy, fairness, and transparency must be prioritized;
7. Teacher empowerment: collaboration between educators and technology developers is crucial;
8. Future readiness: integrating robots and NLP equips students with essential skills;
9. Inclusivity and engagement: robots promote inclusive education and active student participation;
10. Constant evolution: advancements and challenges continue to shape these applications.

Through the literary studies reviewed in our paper, conclusions were made, many important points were reached, and the contributions are represented by two axes: the first axis is students or learners (recipient) and the second axis is teachers, trainers, or supervisors (the sender). The first axis represents the positive outcomes of the introduction of robots into learning, theoretical materials, and the study process, implanting the spirit of cooperation among students, competition, and rapid access to the outcome and solving educational problems, the number of repetitions of reaching the goal and positive results, and the great interaction between students, the involvement of all students in the educational process, eliminating the lethargy of some students by making an interactive environment (participation of all), avoiding exclusivity, lack of friction, and talking with some students. As for the second axis, an observer of a no-show assistant teacher or teacher taking the absence record and the positive and negative behaviors of a student, knowing the distinguished student by recording the number of his participation in discussions and answering questions, carrying out a mechanism for correcting electronic books, and showing the results or sending them to higher administrations. The innovative ideas in this article are not limited to education but can be extended to many other fields, such as speech and translation between languages, etc.

To answer the three questions of the study: (Q1) The sample of the study proved that learning with NAO robots is more desirable for several reasons, including the acceptance of students for this modern science, as it included mathematics, science, engineering, medicine, sports, and others. (Q2) The number of studies exceeded in the first half of the years (2016, 2018, 2019, and 2020), where it reached 68 studies compared to the second text of the sample study, which indicates a trend in this field in recent studies. (Q3) The study sample obtained the following percentages: special needs (12.5%), kindergartens (31.3%), schools (46.9%), and universities (9.3%), It showed the superiority of schools in the application and used several countries; for example, the USA, Hong Kong, Japan, South Korea, Germany, Switzerland, Italy, Taiwan, Israel, Qatar, and the United Arab Emirates. See Appendices A and B.

NAO robots are significant because of their adaptability and variety of uses. They have applications in a variety of fields, including science, healthcare, entertainment, and education. NAO robots are useful teaching tools for teaching programming, robotics, and STEM subjects to students of all ages in educational settings. Their user-friendly programming interface enables students to obtain practical experience and advance crucial coding and robotics abilities.

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N.I.R.R. and M.N.; project administration W.G. and N.A.G.; funding acquisition N.I.R.R., W.G. and N.A.G. All authors have read and agreed to the published version of the manuscript.

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Abbreviations

The following abbreviations are used in this manuscript.

NLP	Natural Language Processing
SJR	Scientific Journal Rankings
AI	Artificial Intelligence
Q1	First Quarter
ACM	Association For Computing Machinery
IEEE	Institute of Electrical and Electronics Engineers
LA	Learning Analytics
ER	Educational Robotics
PP	Pedagogical Practices
UTAUT	A Unified Theory of Acceptance and The Use of Technology
HMA	Hot Melt Adhesives
SPARC	Supervised Increasingly Autonomous Robot Competencies
CRR	Care-Receiving Robot
HRI	Human–Robot Interaction
ANOVA	Analysis of Variance
MALL	Mobile Assisted Language Learning
BPE	Byte-Pair Encoding
KI	Knowledge Integration
CT	Computational Thinking
STEM	Technology, Engineering, And Mathematics
OJAD	Online Japanese Accent Dictionary
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
MDs	Mobile Dictionaries
RALL	Robot-Assisted Language Learning
EFL	English Foreign Language
DST	Digital Storytelling
RA	Reference Answer
KI	Knowledge Integration
ML	Machine Learning
TRT	Teacher Responding Tool
LSA	Latent Semantic Analysis
MOOC	Massive Open Online Courses

Appendix A

Table A1. Summary number of articles and details of journals.

No.	Name of Journal	Web Journal	H-Index	
			Accessed on 18 June 2020	Accessed on 18 June 2023
1	British Journal of Educational Technology	https://www.scimagojr.com/journalsearch.php?q=23988&tip=sid&clean=0	87	110
2	Computer-Assisted Language Learning	https://www.scimagojr.com/journalsearch.php?q=144747&tip=sid&clean=0	45	63
3	Computers & Education	https://www.scimagojr.com/journalsearch.php?q=17645&tip=sid&clean=0	164	215
4	Foundations and Trends in Machine Learning	https://www.scimagojr.com/journalsearch.php?q=19300156903&tip=sid&clean=0	30	36
5	IEEE Robotics and Automation Letters	https://www.scimagojr.com/journalsearch.php?q=21100900379&tip=sid&clean=0	34	82
6	IEEE Transactions on Robotics	https://www.scimagojr.com/journalsearch.php?q=95101&tip=sid&clean=	146	177
7	International Journal of Robotics Research	https://www.scimagojr.com/journalsearch.php?q=18050&tip=sid&clean=0	155	180
8	International Journal of Social Robotics	https://www.scimagojr.com/journalsearch.php?q=19500157063&tip=sid&clean=0	44	68
9	Internet and Higher Education	https://www.scimagojr.com/journalsearch.php?q=16965&tip=sid&clean=0	81	109
10	Journal of the ACM	https://www.scimagojr.com/journalsearch.php?q=23127&tip=sid&clean=0	123	133
11	Science Robotics	https://www.scimagojr.com/journalsearch.php?q=21100886132&tip=sid&clean=0	30	79
12	Soft Robotics	https://www.scimagojr.com/journalsearch.php?q=21100779064&tip=sid&clean=0	32	63

Appendix B

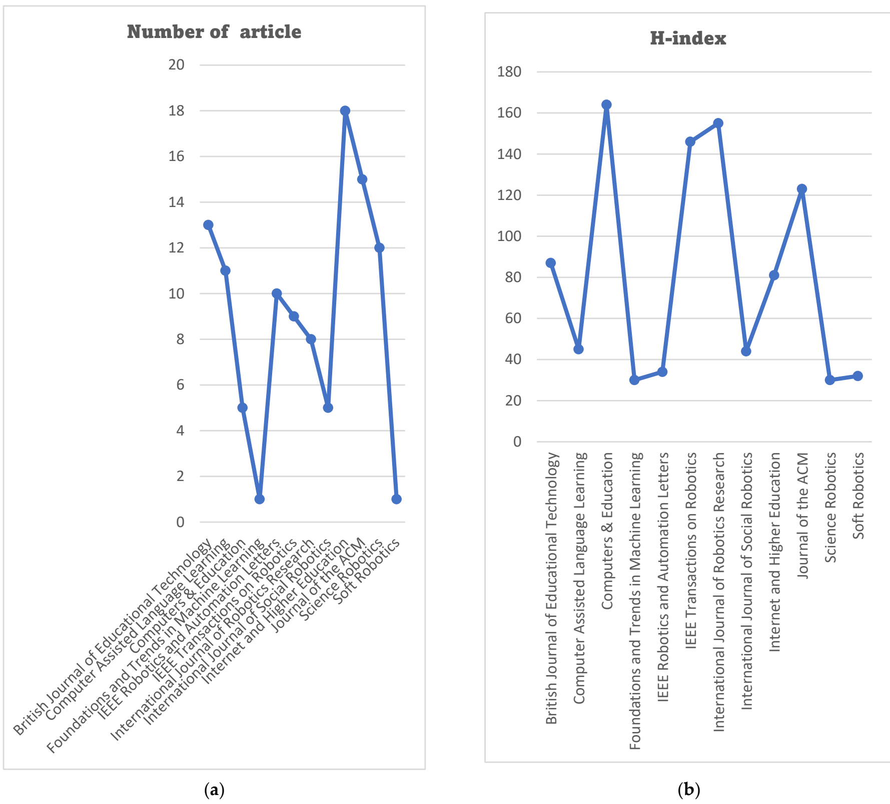

Figure A1. (**a**) Number of study articles and (**b**) H-index value for Journal.

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