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ENHANCING TECHNOLOGICAL AWARENESS AMONG SPECIAL NEEDS LEARNERS THROUGH ROBOTICS EDUCATION: PRELIMINARY OVERVIEW

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Abstract:

This research investigates the efficacy of integrating educational robotics and block-based coding as pedagogical tools to enhance the understanding of computational complexity among special need students (deaf, autism, dyslexia, slow learners). Combining a mixed-methods approach, the study engaged students in hands-on activities involving programmable robots (mBot) and visual coding environments (mBlock Blockly). Qualitative observations and quantitative assessments measured students' ability to grasp core programming concepts such as sequencing, loops, conditionals, and debugging through tactile, visual, and interactive modalities. Findings indicate that robotics and block coding had significantly making abstract computational concepts easier to understand by providing concrete, multisensory learning experiences. Students demonstrated improved engagement, problem-solving persistence,

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and conceptual comprehension. The study concludes that robotics and block coding offer a promising, inclusive pathway to making complex technology accessible for diverse learners, advocating for broader integration in student curricula alongside teacher training in kinaesthetic teaching approach.

Keywords:

Special Need Students, Robots, Coding, Kinaesthetic Teaching

Introduction

The rapid advancement of technology is important for all parties, making digital literacy and technological competence essential skills for full participation in the 21st century even for special needs students. It is widely acknowledged that engagement with science, technology, engineering, and mathematics as a critical pathway to future academic and career opportunities. (Bakala et al., 2021) However, students with special needs (deaf, autism, dyslexia and slow learners) often face significant barriers to accessing and benefiting from mainstream science and technology education. These barriers can range from a lack of tailored instructional strategies and assistive technologies to persistent societal attitudes that underestimate their capabilities, leading to their underrepresentation in technological fields.(Fälth & Selenius, 2024). In response to this challenge, innovative educational interventions are required to bridge the accessibility gap and empower these students. This research paper presents and evaluates a project designed to address this need for the implementation of a robotics and coding program specifically tailored for special needs students.(Chalmers, 2018) The project focused on experiential learning with robots can serve as a powerful catalyst for engagement. In this study, the students were provided with tangible and interactive medium, robotics that can interpret abstract technological concepts, making them more accessible and comprehensible. The primary objective of this project is to enhance students' awareness of and interest in technology. At the same time, the program aims to foster foundational computational thinking, problem-solving skills, and creativity. Through structured activities where students build, program, and interact with robots, the project seeks to create an inclusive learning environment that celebrates different abilities and learning styles.(Papadakis, 2020) It is hypothesized that this direct interaction with technology will not only build technical confidence but also positively influence the students' perceptions of their own potential to be creators and innovators in a digital world. (Bowen & Probst, 2023) This paper will detail the methodology of the project, present findings on its impact on student engagement and technological awareness and discuss the implications for creating more inclusive and effective science and technology education pathways for learners with diverse needs.

Literature Review

In recent years, robotics has garnered significant attention within the educational domain due to its potential to enhance student motivation and classroom engagement attributes closely linked to curiosity, interest, optimism, and passion (Magallanes, 2022.). Educational robots have demonstrated efficacy in developing a range of cognitive and social skills among learners, including those with special educational needs.

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These robots are designed to be contextually adaptive, allowing for flexible integration across diverse learning environments. (Fung et al., 2025) reported that robot-assisted instruction notably increased engagement, motivation, and participation among students with dyslexia, surpassing the outcomes observed in their typically developing peers. This finding aligns with (Coşkunserçe, 2021), who examined teacher-centered robotics activities and concluded that such interventions significantly improved students' motivation, satisfaction, and scientific competencies, particularly in populations where sustaining engagement poses considerable challenges.

The application of robotics in special education continues to evolve. Hendrik et al. (2022) introduced a novel robotics-based learning activity aimed at fostering creativity, critical thinking, and problem-solving abilities. Similarly, (Coufal, 2022) emphasised that project-based STEM learning involving robotics can cultivate essential collaborative skills such as teamwork, communication, and critical thinking among students with special needs.

Student with special needs face significant challenges in educational settings that extend far beyond academic requirements. These students often struggle with their feelings and with other people, finding it particularly difficult to understand and control their emotions. As example students with autism spectrum disorder, frequently experience heightened anxiety, especially in loud or unpredictable situations that are common in school environments.

Unfortunately, their differences make them targets for bullying or social exclusion, creating additional barriers to their educational experience. In order to overcome these challenges, the schools and communities need to do more to help. Teachers need better training to understand the unique needs of these students and implement effective strategies. (Zainal & Zainodin, 2025)

A study involving 21 hearing-impaired students special education schools found that using Scratch block coding and mBot robots is an engaging and effective teaching method that helps students learn programming concepts while improving their group work, communication, and problem-solving skills. Teachers reported that the technology acted like a "magnet" for student attention, though challenges included communication difficulties without established sign language for technical terms, the high cost of equipment, and additional preparation time.

The researchers concluded that this visual and hands-on approach is promising for teaching technology skills to hearing-impaired students, but successful implementation requires proper funding for resources and teachers skilled in both the technology and communicating with hearing-impaired students. (Yusuf , 2024)

A review of instructional technologies for individuals with intellectual disabilities and autism reveals significant positive impacts, particularly for developing communication, social, and learning skills. The study involved systematic study, ethical application, and iterative refinement of technological tools and methodologies to design, implement, and assess learning environments. Its purpose is to optimize instructional effectiveness, efficiency, and accessibility while promoting inclusive, engaging educational experiences across diverse learner populations. Studies on intellectual disabilities (2019-2021) focused on ages 10-15 and 20-25 using tech-assisted learning and augmented reality with qualitative methods, while

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autism research (2022) targeted younger children (5-10) using tech-assisted learning, virtual reality, and robots with quantitative approaches.

Overall, technology-assisted learning, augmented reality, and virtual reality were most common, with over 80% of studies reporting positive effects, especially in supporting student learning (17.87%), social skills (9.89%), and communication (7.98%). Research increased during COVID-19 due to remote learning needs but remains primarily Western-focused with limited parent/teacher involvement and gaps in studying newer technologies like AI. Recommendations include teacher training, family support, more diverse cultural research, and exploring emerging technologies, concluding that these tools are generally effective for skill development when appropriately implemented. (Kalemkuş, 2025)

Methodology

147 participants were involved in this study. They were given a pre and post survey questionnaire to be evaluated before and after the short robotic introduction session. The students were guided by the teachers to understand the questionnaire as some of the participants has shown lacked vocabulary knowledge due to unfamiliar language as their main communication medium is *sign language*.

The questionnaire survey was developed from (Glynn et al., 2011) that identified five key motivation components for college science learning which are intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation. These are used in validating the questionnaire's construct through exploratory and confirmatory factor analyses; these components, particularly self-efficacy, correlated with students' science GPAs, while science majors scored higher than non-science majors on all components, and gender differences emerged with men reporting higher self-efficacy and women demonstrating greater self-determination across both majors, indicating the questionnaire is a valid, efficient tool for assessing science motivation and that these components significantly contribute to student achievement.

Analysis of both quantitative and qualitative data will be used to the experimental group to see the outcome on perceptions of integrated STEM education, enhanced knowledge in robotic, increased or depletion in interest for robotics, and stronger career orientation toward related fields. These findings consequently offer valuable insights and practical suggestions to inform future science and technology curriculum development. (Chen & Chang, 2018)

Table 1: Items for Demographic Section

ITEMS	
Gender	Female Male
Age	7 8 9 10 11 12 13

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Type of Disabilities	Autism Dyslexia Hearing Learning Vision

Table 2: Items for Exposure to Technology

ITEMS	
I use a smartphone every day.	Yes No
I often play video games.	Yes No
There is a robot vacuum cleaner in my house.	Yes No
I have a robotic toy (like a moving robot dog or talking toy) at home.	Yes No
I enjoy watching sci-fi movies. (e.g., robots, AI, futuristic movies)	Yes No

Table 3: Items for Exposure Interest in Robots

ITEMS	
I am interested in learning about robots and how they work.	Strongly Disagree Disagree Neutral Agree Strongly Agree
I think robots are important in today's world.	Strongly Disagree Disagree Neutral Agree Strongly Agree
I enjoy solving problems related to technology.	Strongly Disagree Disagree Neutral Agree Strongly Agree
I would like to build or program a robot.	Strongly Disagree Disagree Neutral Agree Strongly Agree
I would recommend robotics activities to my friends.	Strongly Disagree Disagree Neutral Agree Strongly Agree

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I know how robot works.	Strongly Disagree Disagree Neutral Agree Strongly Agree
I like to learn Science subjects.	Strongly Disagree Disagree Neutral Agree Strongly Agree

Procedure

This project followed a structured procedure consisting of three phases. There are pre-test, intervention, and post-test. In the pre-test phase, students completed the questionnaire prior to the activity to establish baseline data. The intervention phase involved hands-on practice, where students identified the components of the robot and connected them as part of the robotics activity. Finally, in the post-test phase, the same questionnaire was given after the activity to measure changes in students' responses and evaluate the effectiveness of the intervention. (Çakır et al., 2021)

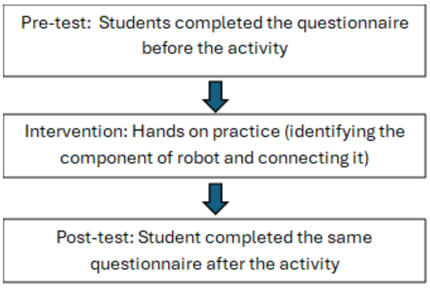

Figure 1: Research Procedure Flowchart

Data Analysis

All the data were collected from pre-test and post-test. We analysed using paired-sample t-tests to examine differences between pre-test and post-test scores, as this statistical method is appropriate for comparing the means of two related groups. In addition, descriptive statistics, including mean, standard deviation, and percentages, were employed to summarize participants' responses and provide an overall understanding of the data distribution. The result from the data finding will be discussed in the next section.

Result & Discussion

Demographic Analysis

This research surveyed a total of 147 students from various schools. The distribution of participants across schools in Figure 1 shows that the highest contribution came from SKPK Negeri Sembilan (22 students, 15%), making it the most represented school in the study. Other schools with relatively high participation included SKPK Padang Kemunting (18 students, 12.2%), SKPK Persekutuan Penang (17 students, 11.6%), and SKPK Kuala Terengganu (15 students, 10.2%), each contributing around 10–12% of the total sample.

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In comparison, schools such as SKPK Melaka (14 students, 9.5%), SKPK Sungai Petani (13 students, 8.8%), and SKPK Besut (12 students, 8.2%) contributed at a moderate level, while SK Taman Ria (6 students, 4.1%), SK Tanjung Gelam (7 students, 4.8%), SKPK Kelantan (7 students, 4.8%), and SKPK Padang Hiliran (8 students, 5.4%) had smaller representation, each making up less than 6% of the total participants.

Overall, the number of participants from each school varied considerably. Schools such as SKPK Negeri Sembilan, SKPK Padang Kemunting, SKPK Persekutuan Penang, and SKPK Kuala Terengganu recorded higher participation, while schools like SK Taman Ria, SK Tanjung Gelam, SKPK Kelantan, and SKPK Padang Hiliran had smaller representation. This variation is not due to the level of program promotion or engagement. Still, it is influenced by the number of students enrolled in each school, which depends on the type of disabilities catered to. Therefore, the differences in participant numbers reflect the diversity of special needs student populations across schools and their varying capacities to take part in the RoboCode program.

Based on the Table 4, it is consisting of 101 males (68.7%) and 46 females (31.3%). This shows that the majority of participants are male students. Students' ages range from 7 to 13 years old, with the largest group being 12 years old (36.1%), followed by 11 years old (18.4%). This indicates that most participants are upper primary. The largest category of disabilities is hearing disabilities (55.1%), followed by learning disabilities (36.7%). Autism (2.7%), dyslexia (2.0%), and vision disabilities (3.4%) make up a much smaller proportion. This distribution suggests that the study mainly reflects the perspectives of hearing- and learning-disabled students. The demographics show a diverse group of students with disabilities, although the findings are mainly influenced by those with hearing and learning disabilities due to their larger representation.

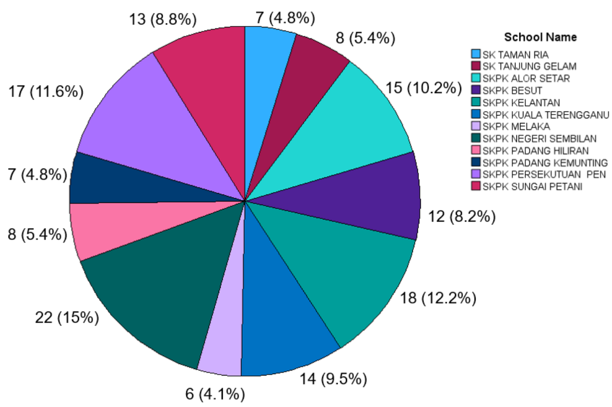

Figure 2: Distribution of Participants Across School

Table 4: Demographic Analysis

Variables	Sample, (%)
Gender	
Female	46 (31.3)
Male	101 (68.7)
Age	
7	2 (1.4)

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8	7 (4.8)
9	15 (10.2)
10	23 (15.6)
11	27 (18.4)
12	53 (36.1)
13	20 (13.6)
Type of Disabilities	
Autism	4 (2.7)
Dyslexia	3 (2.0)
Hearing	81 (55.1)
Learning	54 (36.7)
Vision	5 (3.4)

Crosstab Analysis

The crosstab analysis in Table 5 revealed distinct patterns of responses across disability groups, with varying levels of agreement toward their perception of robots. The highest levels of agreement were recorded among students with vision disabilities, where 80% strongly agreed that they enjoyed solving technology-related problems and 60% strongly agreed that robots are important in today's world. Students with hearing disabilities also demonstrated consistently high agreement, with over 70% agreeing or strongly agreeing that they were interested in learning about robots and 48.1% strongly agreeing that they would like to build or program robots.

Similarly, students with learning disabilities showed strong engagement, with 55.6% strongly agreeing to building or programming robots and 63% strongly agreeing that they like learning science. In contrast, the responses of students with autism and dyslexia were more moderate. For instance, among the autism group, 50% agreed to having an interest in learning about robots, while in the dyslexia group, only 33.3% strongly agreed that robots are important, and 100% disagreed with wanting to build or program robots. Despite these differences, most groups still indicated a willingness to recommend robotics activities to friends, with particularly strong endorsement from the vision group (80% strongly agreed). These findings suggest that RoboCode was most impactful for students with hearing, learning, and vision disabilities, while students with autism and dyslexia demonstrated more mixed levels of engagement.

Generally, most participants agreed or strongly agreed that they were interested in learning about robots, recognized the importance of robots in today's world, enjoyed problem-solving that related to technology, and were keen to build or program robots. In addition, students indicated their willingness to recommend robotics activities to their peers and reported interest in science subjects. Nevertheless, some variation was evident between groups. For example, students with hearing and learning disabilities tended to demonstrate stronger levels of agreement across several items, whereas smaller groups such as those with autism and dyslexia provided more mixed responses.

The chi-square tests in Table 6 offered further insights into these patterns by identifying statistically significant differences across disability categories. Two items demonstrated significant associations: "I am interested in learning about robots" ($p = 0.007$) and "I think

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robots are important in today's world" (p = 0.028). These results indicate that students' level of interest and perception of the importance of robots were influenced by their type of disability. In particular, hearing- and learning-disabled students reported higher levels of agreement in these areas, while students with autism and dyslexia showed greater variation.

By contrast, no significant associations were found for the other items. Enjoyment of problem-solving (p = 0.650), desire to build or program robots (p = 0.101), willingness to recommend robotics activities to friends (p = 0.866), knowledge of how robots work (p = 0.099), and interest in science subjects (p = 0.821) were broadly consistent across disability types.

In conclusion, this study shows that RoboCode was successful in promoting technological awareness, fostering interest in robotics, and motivating science learning among students with disabilities. The significant findings highlight that some groups, particularly those with hearing and learning disabilities, benefitted more strongly in terms of interest and awareness, while other outcomes were shared more evenly across all groups. These results suggest that RoboCode is both effective and inclusive, offering equitable learning opportunities across a wide range of disabilities.

Table 5: Crosstabulation Analysis

Type of Disabilities	Autism (4)	Dyslexia (3)	Hearing (81)	Learning (54)	Vision (5)
I am interested in learning about robots and how they work.					
Strongly Disagree	1 (25)	0 (0)	1 (1.2)	2 (3.7)	0 (0)
Disagree	0 (0)	0 (0)	1 (1.2)	1 (1.9)	0 (0)
Neutral	0 (0)	0 (0)	5 (6.2)	18 (33.3)	0 (0)
Agree	**2 (50)**	1 (33.3)	31 (38.3)	10 (18.5)	**3 (60)**
Strongly Agree	1 (25)	**2 (66.7)**	**43 (53.1)**	**23 (42.6)**	2 (40)
I think robots are important in today's world.					
Strongly Disagree	0 (0)	**2 (66.7)**	2 (2.5)	9 (16.7)	0 (0)
Disagree	1 (25)	0 (0)	6 (7.4)	3 (5.6)	0 (0)
Neutral	1 (25)	0 (0)	15 (18.5)	5 (9.3)	0 (0)
Agree	0 (0)	0 (0)	22 (27.2)	13 (24.1)	2 (40)
Strongly Agree	**2 (50)**	1 (33.3)	36 (44.4)	24 (44.4)	3 (60)
I enjoy solving problems related to technology.					
Strongly Disagree	1 (25)	0 (0)	3 (3.7)	1 (1.9)	0 (0)
Disagree	0 (0)	0 (0)	6 (7.4)	5 (9.3)	0 (0)
Neutral	1 (25)	0 (0)	19 (23.5)	12 (22.2)	0 (0)
Agree	1 (25)	2 (66.7)	(23.5)	15 (27.8)	1 (20)

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Strongly Agree	1 (25)	1 (33.3)	21 (25.9) 32 (39.5)	21 (38.9)	4 (80)
I would like to build or program a robot.					
Strongly Disagree	0 (0)	0 (0)	1 (1.2)	2 (3.7)	0 (0)
Disagree	0 (0)	0 (0)	6 (7.4)	3 (5.6)	2 (40)
Neutral	2 (50)	0 (0)	6 (7.4)	7 (13)	0 (0)
Agree	1 (25)	0 (0)	29 (35.8)	12 (22.2)	2 (40)
Strongly Agree	1 (25)	3 (100)	39 (48.1)	30 (55.6)	1 (20)
I would recommend robotics activities to my friends.					
Strongly Disagree	0 (0)	0 (0)	3 (3.7)	2 (3.7)	0 (0)
Disagree	0 (0)	0 (0)	3 (3.7)	5 (9.3)	0 (0)
Neutral	1 (25)	1 (33.3)	8 (9.9)	5 (9.3)	0 (0)
Agree	1 (25)	0 (0)	28 (34.6)	12 (22.2)	1 (20)
Strongly Agree	2 (50)	2 (66.7)	39 (48.1)	30 (55.6)	4 (80)
I know how robot works.					
Strongly Disagree	0 (0)	1 (33.3)	4 (4.9)	4 (7.4)	1 (20)
Disagree	0 (0)	1 (33.3)	12 (14.8)	5 (9.3)	3 (60)
Neutral	0 (0)	0 (0)	20 (24.7)	17 (31.5)	1 (20)
Agree	3 (75)	1 (33.3)	17 (21)	9 (16.7)	0 (0)
Strongly Agree	1 (25)	0 (0)	27 (33.3)	19 (35.2)	0 (0)
I like to learn Science subject.					
Strongly Disagree	0 (0)	0 (0)	3 (3.7)	2 (3.7)	0 (0)
Disagree	0 (0)	0 (0)	2 (2.5)	2 (3.7)	1 (20)
Neutral	1 (25)	0 (0)	14 (17.3)	6 (11.1)	1 (20)
Agree	0 (0)	1 (33.3)	19 (23.5)	10 (18.5)	2 (40)
Strongly Agree	3 (75)	2 (66.7)	43 (53.1)	34 (63)	1 (20)

Table 6: Chi-Square Tests (Pearson Chi-Square)

Items	**Asymptotic Significance (2-sided)**
I am interested in learning about robots and how they work.	**0.007**
I think robots are important in today's world.	**0.028**
I enjoy solving problems related to technology.	0.650

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I would like to build or program a robot.	0.101
I would recommend robotics activities to my friends.	0.866
I know how robot works.	0.099
I like to learn Science subject.	0.821

Conclusion

This preliminary overview suggests that robotics education holds considerable promise in enhancing technological awareness among special needs learners. The multisensory, interactive, and problem-based characteristics of robotics activities provide meaningful opportunities for learners to engage with technological concepts in accessible and authentic ways. Beyond enhancing cognitive understanding, such activities have been shown to foster confidence, creativity, and collaboration. These outcomes highlight robotics as more than a technical tool; it is also a medium for inclusion, empowerment, and lifelong learning.

From an academic perspective, the findings contribute to the growing discourse on inclusive education and the integration of emerging technologies into special needs pedagogy. They align with global calls for equipping all learners with digital literacy and 21st-century skills, ensuring that no group is excluded from the rapid pace of technological development. Moreover, preliminary evidence indicates that robotics-based learning can significantly enhance student’s motivation and interest in the sciences. It is believed that it has the potential to serve as a catalyst for sustained engagement in STEM education. Importantly, this study underscores the value of robotics not only for cognitive and technical development but also for building essential soft skills, thereby bridging the gap between abstract learning and real-world application. Nevertheless, as this is a preliminary exploration, several limitations must be acknowledged. The discussion is largely conceptual and exploratory, without comprehensive empirical validation across diverse contexts of special needs education. Factors such as accessibility of resources, teacher preparedness, curriculum integration, and the heterogeneity of learner needs remain significant challenges that warrant systematic investigation.

Future research should therefore adopt empirical and longitudinal approaches to evaluate the long-term impact of robotics education on technological awareness and overall learning outcomes among special needs learners. Comparative studies across different disability categories, age groups, and cultural contexts could provide richer insights into best practices for implementation. Additionally, professional development for teachers and collaborative design with stakeholders are essential to maximize the potential of robotics as a sustainable and inclusive educational tool.

In conclusion, robotics education represents a promising yet underexplored avenue for advancing technological inclusivity. With careful planning, adequate support, and rigorous research, it has the potential to transform special education into a more engaging, empowering, and future-ready learning environment.

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