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Original Article

Exploring the Impact of Robotics-Based Learning on Students' Emotional Intelligence and Academic Achievement: A Semi-Experimental Study

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ABSTRACT

Background: Nowadays, the advancement and integration of new technologies in educational settings have emerged as significant and complex challenges. Among these innovations, Robotic-based Learning (RBL) has garnered considerable interest from researchers and educators alike. This study aimed to explore the impact of RBL on students' Emotional Intelligence (EI) and Academic Achievement.

Methods: This semi-experimental study employed a pre-test-post-test design featuring two groups: an intervention group that underwent training using the RBL method and a control group that received traditional training. The research was carried out at a secondary school in Behbahan City, Iran, from September 2022 to May 2023. A total of 30 eligible students were selected through a convenience sampling method, with 15 randomly assigned to the intervention group and 15 to the control group. A learning achievement test comprising 20 open-ended questions covering various mathematical domains was administered as a pre-test in September 2022 and again as a post-test immediately after the intervention in May 2023. Additionally, the Brief Emotional Intelligence Scale (BEIS-10) was employed to evaluate the emotional intelligence (EI) of the students. Data analysis was performed using analysis of covariance and independent samples t-tests, utilizing SPSS version 24, with a significance threshold set at a P-value of less than 0.05.

Results: The results indicated that RBL has a significant effect on students' EI and sub-dimensions of self-motivation (P=0.081), self-awareness (P<0.001), self-control (P=0.061), social awareness (P<0.001), and social skills (P=0.003). Also, the results of the ANCOVA test comparing the pre-test and post-test of both intervention and control groups revealed a significant effect of RBL on the students' learning achievements (P<0.001).

Conclusion: The findings of this study indicate that RBL is an effective instructional approach for enhancing both student achievement and EI among first-year secondary students.

Keywords: Robotics, Learning, Students, Emotional Intelligence, Learning Achievement

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Introduction

The incorporation of technology into education has profoundly changed conventional learning approaches (1). It has created an environment where students can engage with complex concepts through interactive and hands-on experiences (2). This transition significantly improves learning opportunities by increasing access to information through the Internet, online databases, and educational platforms. Consequently, it democratizes education for students from various backgrounds and promotes autonomous exploration (3). Interactive tools such as whiteboards, educational apps, and virtual simulations further enrich the educational experience by catering to various learning styles and fostering collaboration among peers. Among the advancements in educational technology, Robotics-Based Learning (RBL) stands out as a particularly impactful approach that not only deepens students' understanding of Science, Technology, Engineering, and Mathematics (STEM) subjects but also contributes to the development of Emotional Intelligence (EI)—an essential component of holistic student development (4). RBL engages students in hands-on activities to build, program, and operate robots to solve problems and explore scientific concepts. This interactive learning environment captivates students' attention and fosters critical thinking, decision-making, and problem-solving skills as they encounter challenges in robot design and programming (5). As educators increasingly integrate these digital tools into curricula, they are tasked with leveraging innovations like RBL to enhance student learning outcomes while equipping them with critical skills such as collaboration and creativity. (4) Robotics projects often involve teamwork, encouraging students to communicate effectively and appreciate diverse perspectives, thereby preparing them for the interconnected nature of the modern workplace. Furthermore, adaptive learning technologies within RBL allow for personalized education tailored to individual strengths and weaknesses, fostering an inclusive environment that accommodates various learning paces (5). Ultimately, this comprehensive approach underscores the importance of technology in promoting both academic success and personal growth among students. By bridging theoretical knowledge with practical application, RBL enhances engagement and cultivates essential 21st-century skills that are crucial for navigating the complexities of the digital age workforce. As educational robotics continues to evolve, its influence in preparing learners for the future will become increasingly important (6).

RBL not only enhances students' understanding of STEM subjects but also plays a pivotal role in developing EI, which is essential for holistic student development. Since RBL engages students in hands-on activities where they build, program, and operate robots, it can create an interactive learning environment that captivates their attention. This approach fosters critical thinking, decision-making, and problem-solving skills as students navigate challenges in robot design and programming (7). Furthermore, the collaborative nature of robotics projects not only encourages effective communication but also fosters an appreciation for diverse perspectives. These are essential components of EI, which play a vital role in successful teamwork and innovation. Research supports the idea that incorporating EI into educational robotics can significantly enhance social interaction among students (8). For instance, emotionally responsive robots can improve communication and engagement by simulating empathy, thereby fostering a supportive learning climate. This is consistent with the objectives of social and emotional learning (SEL), which seeks to enhance self-awareness, social awareness, relationship skills, and responsible decision-making. Through collaboration on robotics projects, students not only tackle technical challenges but also cultivate vital interpersonal skills, including teamwork and conflict resolution (9). As educators increasingly integrate RBL into curricula, they are tasked with leveraging this innovative approach to enhance student learning outcomes while equipping them with critical skills necessary for the modern workforce. The adaptive learning technologies within RBL allow for personalized education tailored to individual strengths and weaknesses, promoting an inclusive environment that accommodates various learning paces. This comprehensive approach underscores the importance of technology in fostering both academic success and personal growth among students (10).

Research indicates that students with high EI are better equipped to manage stress, maintain motivation, and engage in effective problem-solving. For instance, a study by Akintunde and Olujide (2018) demonstrated that both EI and locus of control significantly predict academic achievement among high-ability students. Their findings suggest that students who understand their emotions and strengths tend to perform better academically, emphasizing the importance of cultivating EI in educational settings (11). Simultaneously, an RBL interactive environment not only improves students' comprehension of STEM disciplines but also develops critical thinking and problem-solving abilities. A meta-analysis has demonstrated that educational robotics has a beneficial impact on students' academic performance and their attitudes towards STEM education. By offering practical applications for theoretical concepts, RBL encourages greater engagement and enhances knowledge retention (12).

In another study, analyzing the effects of educational robotics activities on students' attitudes toward STEM and Information and Communication Technologies (ICT) courses, the researcher highlighted how robotics activities positively affect students' willingness to study technology and engineering, further supporting the notion that RBL is a valuable tool for motivating students in scientific education (13). In addition, Alkhalaf and colleagues, investigating the effect of the integration of robotics and EI in e-learning on motivating interaction during training, revealed that the robot and EI affect convincing students with better learning choices and their abilities (10). In Iran, research was conducted to evaluate the impact of teaching robotic structures on the critical thinking, creativity, and mathematical learning of junior high school students. The findings indicated that instruction involving robotic structures positively influenced students' creativity and critical thinking, as well as their mathematical learning outcomes (14).

While there is an increasing amount of research investigating the effects of RBL on students' academic performance and emotional intelligence, the current studies do not provide a comprehensive understanding of the complexities inherent in this relationship. Given the identified knowledge gap, there is a pressing need for semi-experimental studies that investigate the impact of RBL on both emotional intelligence and academic achievement. Such research will offer a deeper insight into how interaction with robotics can enhance cognitive abilities while also fostering emotional skills. Furthermore, exploring this relationship is crucial for educators seeking to implement RBL effectively within their curricula. Insights into how RBL affects emotional intelligence can guide instructional approaches that support both academic achievement and the social-emotional growth of students. Consequently, this study aimed to examine the influence of RBL on the emotional intelligence and academic achievement of first-year secondary students in Behbahan City, Iran.

Methods

Study Design and Setting

This semi-experimental study employed a pre-test-post-test design featuring two groups: an intervention group that underwent training using the RBL method and a control group that received traditional training. The research was carried out at a secondary school in Behbahan City, Iran, from September 2022 to May 2023.

Intervention

***Educational Intervention*:** The RBL teaching intervention comprised a sequence of organized sessions aimed at employing RBL to improve students' emotional intelligence and academic achievement. Each session featured hands-on learning, problem-solving activities, collaboration, interdisciplinary approaches, and adaptability to ensure an inclusive educational environment. The following section provides a comprehensive outline of the implementation of RBL across several critical dimensions.

A total of 12 sessions, once a week, each lasting 60 minutes, were organized. The study involved thirty seventh-grade students who were divided into two groups: one intervention group and one control group, with each group comprising 15 students. The groups were matched in terms of age, gender, and educational level. Both groups were taught by the same instructor. The academic content was delivered through the use of robotics kits (LEGO Mindstorms), computers equipped with programming software, projectors, and collaborative workspaces. Details regarding the robotics training sessions are presented in Table 1.

Implementation Aspects: The subsequent factors were considered during the implementation of the RBL steps.

1. Hands-on Learning: During each session, students participated in interactive activities involving the construction and programming of robots. This experiential learning method enabled students to implement theoretical principles acquired in class, including physics and mathematics, in practical contexts. For instance, students designed a robot capable of navigating a maze, which necessitated a comprehension of concepts such as motion, force, and angles.

2. Problem-solving and Critical Thinking: During the sessions, students encountered specific challenges, including designing a robot capable of performing designated functions, such as object retrieval. They were required to define the problem, generate potential solutions, develop their robot designs accordingly, and conduct tests on these designs. This iterative approach promoted critical thinking, as students assessed the effectiveness of their solutions and made adjustments based on empirical testing and refinement.

3. Collaboration and Communication: Each session prioritized collaboration by organizing students into pairs or small groups. Effective communication was essential for students to exchange ideas, assign tasks, and offer constructive feedback on one another's contributions (for instance, one student might concentrate on programming while another manages the robot's physical assembly). This cooperative setting fostered the development of interpersonal skills and enhanced emotional intelligence through shared experiences.

4. Interdisciplinary Learning: RBL sessions incorporated knowledge from multiple disciplines, particularly in STEM. For instance, while constructing robots, students utilized mathematical principles for measurements and calculations, while also taking into account aesthetic design aspects. This interdisciplinary strategy enabled students to recognize the interrelationships among various fields of study, thereby enriching their overall comprehension.

5. Integration of Knowledge through Robotic-Based Training: Throughout the intervention, students were encouraged to consider how the knowledge gained from various subjects informed their robotics projects. They engaged in discussions about the application of physics principles in programming robot movements and the use of mathematical algorithms in coding. This integrative approach enhances their learning experience and fosters connections between theoretical concepts and practical applications.

6. Adaptability and Inclusivity: The RBL intervention was developed to be flexible and address the varied needs of all students. Differentiated instructional strategies were implemented to cater to different skill levels; for instance, advanced students assumed leadership positions within groups or engaged in more challenging programming assignments. Furthermore, inclusive practices were adopted to ensure that every student felt appreciated and supported throughout their learning experience.

Table 1: Details regarding the robotics training sessions

Session	Description
1	1. Overview of *Poya Ebtekar* and *Robo Robo* company featuring visual media 2. Organizing participants into groups of 15 with custom names 3. Engaging children in group discussions on robot definitions and validation 4. Exploring the etymology and concept of "robot" • Literal interpretation • Broader implications • Asimov's robotics principles 5. Discussing various robot categories through questions and answers • Presenting home videos and images • Types: medical, military, sports, humanoid, entertainment 6. Participants create robot designs as researchers—group discussion on each design and its purpose 7. Demonstrating the animal bot kit and detailing the functionality of each component
2	• Understanding movement concepts and wheel utilization • Constructing the frog robot through stage six • Group collaboration exercise
3	• Exploring power dynamics and engine functionality • Finalizing the frog robot assembly • Preparing the robot for racing events
4	• Class group competitions • Selecting and rewarding the top group • Disassembling the frog robot
5	• Exploring energy concepts and various energy sources • Constructing the dog robot through stage six • Applying the acquired knowledge in robot construction
6	• Completing the dog robot assembly • Student-led troubleshooting of the robot • Ready-making robots for competition
7	• Class group competitions • Selecting and rewarding the top group • Disassembling the dog robot
8	• Constructing the crab robot through stage seven • Reviewing engine and power concepts • Teaching reptilian movement systems
9	• Completing the crab robot assembly • Troubleshooting the crab robot's motion system • Preparing the robot for competition
10	• Class group competitions • Selecting and rewarding the top group • Disassembling the crab robot
11	• Constructing the deer robot through stage six • Reviewing energy concepts and sources
12	• Completing the deer robot assembly • Troubleshooting issues with deer legs • Preparing the robot for competition

1. From the fifth session onward, pertinent explanations were provided for each component of the assembled robot. For instance, when the engine was installed, its specifications and power requirements were reiterated. Similarly, when the legs were positioned, the details regarding the wheels and movement were also emphasized. 2. Following each competition, the winning group received educational tools, such as colored cubes and similar items. 3. The class operated harmoniously, indicating that all groups were nearly equal in capability. In instances where a group was notably stronger or faster, or conversely, weaker or slower, the instructor utilized the explanations as a pause point to allow slower participants to catch up and to help faster participants align with the overall pace of the class.

Participants and Sampling

The study's statistical population consisted of 30 seventh-grade students from a single classroom at secondary schools in Behbahan City, Iran, using convenience sampling.

To investigate the impact of RBL on students' emotional intelligence and academic achievement, simple random sampling was employed to assign participants to either the intervention or control group by chance using a table of random digits. This approach guaranteed that each student had an equal opportunity for selection into either group, thereby reducing the potential for selection bias. The study's pre-test and post-test design is illustrated in Figure 1.

Random Allocation Process

Following the identification of participants, a simple random sampling technique was employed to allocate them to either the intervention group or the control group. The procedure for this allocation is outlined below:

1. A complete list of all participating students was created to establish the sampling frame.

2. Using a random sampling table or a computer-generated random number generator, students were randomly assigned to one of the two groups.

This approach guaranteed that each student had an equal opportunity to be selected for either group, effectively eliminating bias and minimizing the risk of selection bias. The students were categorized into two distinct groups: The Intervention Group and the Control Group. The study focused on all male seventh-grade students, typically aged 12 to 13, who were enrolled at a secondary school in Behbahan City, Iran, for the academic year spanning September 2022 to June 2023. Furthermore, participants were required to express their willingness to participate and obtain parental or guardian consent to ensure adherence to ethical standards.

Students with documented special educational needs or disabilities that significantly impede their ability to participate in standard classroom activities were excluded to ensure a homogeneous sample regarding learning capabilities. Students who have previously participated in robotics programs or courses may also have been excluded to minimize bias related to prior knowledge and experience that could affect study outcomes (Figure 2).

Tools/Instruments

The study employed two separate instruments: a mathematics exam to assess students' learning achievement and a standard questionnaire to measure emotional intelligence. Both tools were evaluated for validity and reliability.

Learning achievement test

To assess the learning outcomes of the students, a mathematics examination comprising 20 open-ended questions encompassing all areas of mathematics was administered as a pre-test on September 26, 2022.

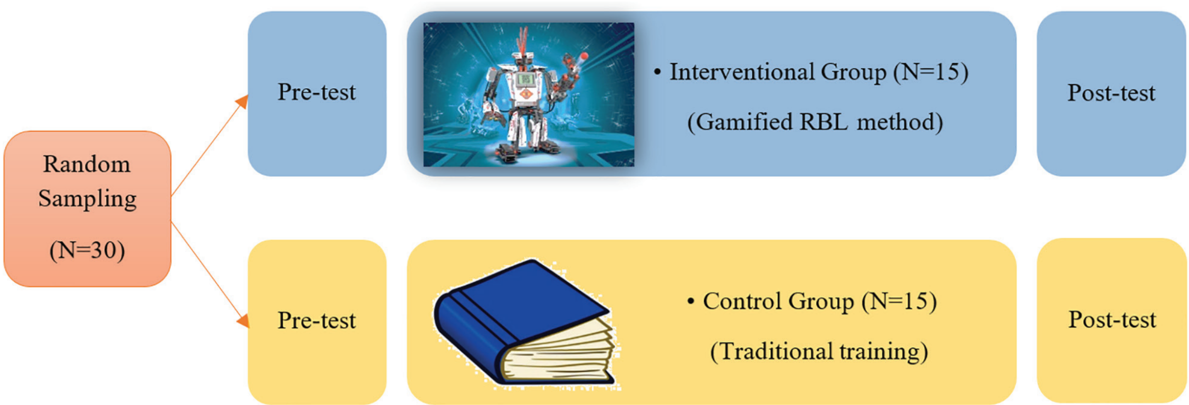

Figure 1: Pre-test and Post-test design of the study

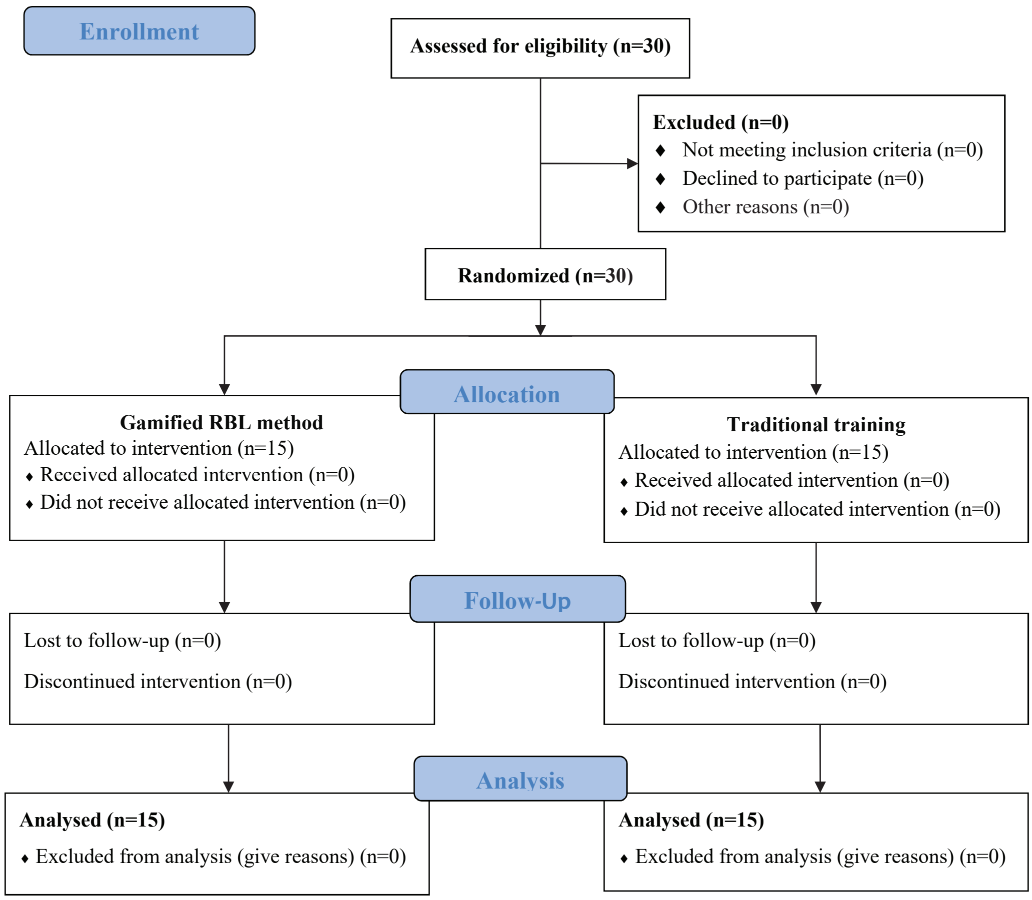

Figure 2: Consort diagram of research process and sampling

Post-tests were conducted immediately following the intervention on June 20, 2023. Participants were allotted one hour to complete the questions. Both the pre-test and post-test items were developed by the educational office of the schools and were designed to maintain an equivalent level of difficulty.

The pre-test and post-test were structured similarly in terms of content and format to ensure that any observed changes in participants' responses could be reliably linked to the intervention. This consistency was essential for accurately evaluating the effectiveness of the educational strategy employed.

Validity and Reliability - To determine validity, the Content Validity Index (CVI) and Content Validity Ratio (CVR) methods were employed, using the opinions of 10 experts: four math teachers, four educational administrators, and two robotics experts. The total CVI value was 0.80, and the CVR value was 0.85. Reliability was also confirmed using internal consistency, with a Cronbach's alpha coefficient of 0.83.

The Brief Emotional Intelligence Scale (BEIS-10): The BEIS-10 is a concise tool for measuring emotional intelligence developed by Davies and colleagues (2010), consisting of 10 items that assess five dimensions of emotional intelligence (15). The five dimensions assessed by BEIS-10 are Self-Awareness, Self-Control, Self-Motivation, Social Awareness, and Social Skills. Each dimension is represented by two items, allowing for a quick evaluation of emotional competencies. Scoring The BEIS-10 employs a 5-point Likert scale for responses, ranging from 1 (strongly disagree) to 5 (strongly agree). The total score can range from 10 to 50, with higher scores indicating higher EI.

Validity and reliability - The BEIS-10 has demonstrated good construct validity, confirmed through Confirmatory Factor Analysis (CFA), which supported its multidimensional structure. Its internal consistency and test-retest reliability evidences the reliability of the BEIS-10. The reported CVI value of 0.89 indicates that most items on the scale are relevant and appropriate for measuring emotional intelligence (15). The Persian version of the BEIS-10 used in the study has been adapted and validated to assess emotional intelligence in the Iranian population. A CVR value of 1 for the BEIS-10 indicates unanimous agreement among experts that each item is essential for measuring emotional intelligence. This acceptable score suggests that every item in the BEIS-10 is critical for capturing the nuances of emotional intelligence, further validating its use as a measurement tool (16).

Data Collection

The questionnaires were distributed to both groups in-person before the course commencement on 26 September 2022. Post-tests were conducted immediately following the completion of the intervention on May 9, 2023. The test duration was established at one hour to provide participants with adequate time to showcase their knowledge and skills, while also maintaining their engagement during the assessment.

Data Analysis

Data collection involved both descriptive statistics (mean, standard deviation, minimum, and maximum) and inferential statistics (ANCOVA and independent t-tests), which were analyzed comparatively. The Kolmogorov-Smirnov test was employed to assess the normality of the data distribution. Statistical analyses were conducted using SPSS software version 24, with significance established at a P value of less than 0.05.

Ethics - Data analysis and reporting of findings were conducted anonymously. All participants were required to exhibit both the willingness and capability to engage in the study, along with obtaining consent from a parent or guardian to ensure adherence to ethical standards. This study was conducted

Table 2: Mean and standard deviation of research variables in the intervention and control groups

Variables	Groups	N	Pre-Test	Post-Test	P value
			Mean±SD	Mean±SD	Within-Group
Learning Achievement (GPA Scores)	Intervention	15	18.22±0.87	19.14±0.52	P<0.001
	Control	15	17.49±1.057	17.23±1.47	
	Between-group	30	---	P<0.001	---
Emotional Intelligence	Intervention	15	108.20±11.47	119.47±9.49	P<0.001
	Control	15	96.60±9.36	104.73±5.49	
	Between-group	30	P=0.63	P<0.001	---
Emotional Intelligence Components					
Self-motivation	Intervention	15	22.00±5.21	26.33±1.83	P<0.001
	Control	15	19.27±4.54	22.53±2.46	
	Between-group	30	P=0.52	P=0.081	---
Self-awareness	Intervention	15	27.33±5.21	30.67±3.55	P<0.001
	Control	15	26.80±4.53	26.73±3.34	
	Between-group	30	P=0.56	P<0.001	---
Self-control	Intervention	15	22.20±5.361	26.93±2.963	P<0.001
	Control	15	19.00±2.752	21.27±3.150	
	Between-group	30	P=0.64	P=0.061	---
Social Consciousness	Intervention	15	16.40±2.995	22.07±2.219	P<0.001
	Control	15	14.93±3.751	18.67±3.347	
	Between-group	30	P=0.51	P<0.001	---
Social skills	Intervention	15	19.20±4.039	20.40±1.352	P<0.001
	Control	15	16.73±2.549	15.40±1.724	
	Between-group	30	P=0.62	P=0.003	---

*GPA: Grade Point Scores; SD: Standard Deviation in accordance with the guidelines established by the Research and Technology Office of the Islamic Azad University, Behbahan Branch, Iran.

Results

All participants in both the intervention and control groups were randomly selected from boys' schools, resulting in a total of 30 male participants. Among these, 17 were aged 12, while 13 were aged 13. Table 2 presents the mean and standard deviation of the research variables for both the intervention and control groups during the pre-test and post-test phases.

Initially, Levine's test was used to check the homogeneity of variances as one of the assumptions of covariance analysis. The results indicated that Levine's F statistic for evaluating the homogeneity of variances among the dependent variables was not statistically significant across all components ($P<0.05$). Consequently, the assumption of homogeneity of variances was confirmed. Subsequently, a Multivariate Analysis of Covariance (ANCOVA) test was used to investigate the effectiveness of RBL training on EI and learning achievements of first-secondary school students. The within-group comparison of the intervention and control groups is provided in Table 3. The ANCOVA results demonstrated that there were significant differences in the dependent variables between the test and control groups.

Following the adjustment of post-test average scores by removing the pre-test effect, the intervention in the post-test phase had a significant impact ($P<0.001$, $F=11.238$) on the learning scores. Similarly, after adjusting the average post-test scores by removing the pre-test effect, the intervention in the post-test phase had a significant impact ($P<0.001$, $F=19.656$) on EI scores. In general, these results showed that there is a significant difference in the dependent variables (learning achievement and EI) between the averages of the intervention and control groups. This shows the positive effect of the intervention on learning and EI. An independent group's t-test was used to compare the impact of robotics education on learning in the intervention group based on the students' post-test scores.

Finally, results of the ANCOVA test revealed that there is a significant difference between the results of all first-secondary school participants of this study in the pre-test and post-test and Self-Awareness, Self-Control, Self-Motivation, Social Awareness, and Social Skills dimensions of EI.

Discussion

The study aimed to investigate the impact of RBL on students' EI and academic achievement using a semi-experimental design. The results showed significant differences in pre-test and post-test scores among first-secondary school participants, in the areas of Self-Awareness, Self-Control, Self-Motivation, Social Awareness, and Social Skills. These findings suggest that RBL has the potential to be an effective teaching method for improving both EI and academic performance. The significant improvement in Self-Awareness suggests that RBL may provide students with opportunities to reflect on their emotions and behaviors in a structured environment. Engaging with robotics likely encourages students to recognize their strengths and weaknesses, fostering greater

Table 3: Results of the ANCOVA test for the intervention and control groups

Variable		df	SS*	MS*	F	P value
Group	Learning Achievement (GPA* Scores)	1	11.988	11.988	11.238	P<0.001
	Emotional Intelligence	1	1273.389	1273.389	19.656	P<0.001
Error	Learning Achievement (GPA Scores)	26	26.911	1.035	---	---
	Emotional Intelligence	26	1653.762	63.606		
Total	Learning Achievement (GPA Scores)	30	9984.382	---		
	Emotional Intelligence	30	380305			

GPA: Grade Point Average; SS: Sum of Squares; MS: Mean of Squares self-understanding. This dimension is crucial as it lays the foundation for other EI skills, enabling students to navigate their emotional landscapes more effectively. These findings are similar to the Sutton's study, in which the researcher explored dispositional self-awareness and its outcomes, emphasizing the role of self-reflection and insight in predicting beneficial outcomes (17). The study highlighted how self-awareness can alleviate psychological distress and enhance self-development, which aligns with the idea that structured environments, like those provided by RBL, foster greater self-understanding and emotional navigation.

The enhancement in self-control indicates that engaging in robotics activities can help students develop better emotional regulation strategies. The hands-on nature of RBL requires patience, concentration, and resilience, which are essential qualities for regulating impulses and sustaining composure in high-pressure situations. This finding aligns with the current literature emphasizing the importance of experiential learning in the development of self-regulatory skills. A study examined the impact of experiential learning on students' self-regulation skills and found that hands-on activities promote patience, focus, and perseverance—qualities crucial for self-control. The results indicate that experiential learning environments can significantly enhance students' ability to manage their emotions and behaviors effectively (18).

The current study also explored how self-control affects learning achievement among students. The results revealed a significant positive correlation between self-control and learning achievement, indicating that higher levels of self-control lead to greater achievement in academic activities. In a recent study carried out by Zanoubi (19), analyzing the effectiveness of life skills training on students' academic achievement, the researcher discussed how self-control allows students to align their thoughts, feelings, and actions with long-term academic objectives, even when faced with the allure of immediate rewards. The review highlights longitudinal evidence linking self-control to various academic outcomes, including course grades and standardized test performance (19).

Consistent with the findings of the current study, Jones and colleagues examined the impact of robotic learning on self-control, explicitly exploring how robotic tutors can improve self-regulated learning abilities in primary school students (20). The research demonstrated that when a robotic tutor personalized and adaptively supported self-regulated behaviors using an Open Learner Model (OLM), students exhibited more remarkable self-regulated behavior compared to a control group that received only domain support. This longer-term interaction indicated that the effects were not short-lived and highlighted the robot's effectiveness in scaffolding self-regulated learning skills in a real-world school environment (20)

The increase in self-motivation observed in the post-test scores suggests that RBL can spark intrinsic motivation among students. Engaging with robotics can give students a sense of accomplishment and autonomy, which in turn can enhance their drive to learn and succeed academically. This intrinsic motivation is crucial for sustained engagement and success in both educational settings and future endeavors. In another study, with different results, the relationship between intrinsic and extrinsic motivation types and student engagement in an elementary school setting was examined (21). The study found that while many students exhibit intrinsic motivation, a significant portion also relies on extrinsic factors for engagement. Students who preferred extrinsic motivation displayed varying forms of engagement, including ritualistic and retreat behaviors, rather than the authentic engagement typically associated with intrinsic motivation (21).

Some studies highlight the significant role of intrinsic motivation in achieving long-term academic success, and their findings align closely with the present study's (22, 23). They underscore the critical role that intrinsic motivation plays in fostering long-term academic success, highlighting several key reasons for this connection.

Moreover, the notable improvements in Social Awareness and Social Skills emphasize the collaborative aspect of RBL. Engaging in teamwork to address challenges or complete projects fosters essential components of social competence, such as communication, empathy, and collaboration. These abilities are increasingly vital in our interconnected society, where successful outcomes often hinge on effective cooperation. Yu and colleagues explored the detrimental impact of group dynamics on the development of social skills within collaborative environments. Their findings indicated that interpersonal conflicts within teams can impede communication and obstruct the enhancement of social awareness. This research highlights that not all group interactions yield beneficial social results, emphasizing the importance of collaboration quality in nurturing effective social skills (24).

Another study analyzing the Influence of social consciousness on achievement in social science among secondary school students found a significant relationship between social consciousness and achievement in social science subjects, which is similar to the findings of the present study. This research highlighted that students with higher social consciousness tend to perform better academically, suggesting that awareness of social issues can enhance engagement and motivation in the learning environment (25).

The study revealed that, alongside enhancements in EI dimensions, RBL had a positive effect on academic achievement. This association can be attributed to various factors, including the interactive and dynamic characteristics of robotics, which can boost student engagement and facilitate more profound learning experiences. Furthermore, RBL fosters problem-solving and critical-thinking skills that are closely connected to academic success. As previously mentioned, heightened self-motivation can contribute to better academic performance as students become more engaged in their educational pursuits. Supporting these findings, Mahardini and colleagues explored the effects of collaborative robotics projects on student motivation and academic performance. Their research indicated that while collaboration can enhance teamwork, it does not always result in improved academic outcomes. Some students reported feeling overwhelmed by group dynamics, which negatively impacted their motivation and engagement with the material (26).

Limitations and Suggestions

This study provides valuable insights into the impact of RBL on EI and academic achievement. However, it is important to acknowledge its limitations. The sample size was limited to first-secondary school participants, which may affect the generalizability of the findings. Future research should explore diverse educational settings and age groups to further validate these results. Additionally, longitudinal studies could provide insights into the long-term effects of RBL on EI development and academic success. It would also be beneficial to investigate how these skills transfer to real-world contexts.

Conclusion

This study emphasized the significant impact of RBL on enhancing EI dimensions and academic achievement among first-secondary school students. By fostering skills such as self-awareness, self-control, social awareness, self-motivation, and social skills, RBL presents a promising avenue for educators aiming to cultivate well-rounded learners prepared for the challenges of the future.

The findings have several implications for educators who want to incorporate RBL into their curricula. Integrating robotics into educational programs can offer a comprehensive approach to learning that enhances both EI and academic performance. It is essential to provide teachers with training on effective RBL strategies to fully leverage their advantages in the classroom. Additionally, educators should assess not only academic outcomes but also EI dimensions when evaluating student progress.

Abbreviations

EI: Emotional Intelligence
OLM: Open Learner Model
RBL: Robotic Based Learning
SEL: Social and Emotional Learning
STEM: Science, Technology, Engineering, and Mathematics

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Authors' Contribution

KDM and LA designed the study. LA collected the data. KDM analyzed the data. KDM drafted the manuscript. LA finalized the manuscript. All authors reviewed the manuscript and approved the final version. They take full responsibility for the content and writing of this article.

Conflicts of Interest

The authors declare that they have no conflicts of interest to disclose.

Ethical considerations

This study was conducted in accordance with the guidelines established by the Research and Technology Office of the Islamic Azad University, Behbahan Branch, Iran, under the reference code 1403/7168. All participants were required to demonstrate their willingness and ability to participate in the study, along with obtaining consent from a parent or guardian to ensure compliance with ethical standards.

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There is nothing to declare.

Availability of Data and Materials

The data supporting this study's results are available upon request from the corresponding author. In accordance with privacy and ethical guidelines, these data are not accessible to the public.

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