Academic Education Publishing House
-AEPH-

Integrating Robotics Projects into Education: A New Approach to Engaging Adolescents with Autism and Improving Social Interactions

Rita Yang

OAK CREST ACADEMY, Medina 98039, Washington, US

Abstract: This study explores the impact of robot-based project learning on the social skills and emotional expression of adolescents with autism. A randomized controlled experimental design was adopted, dividing 40 adolescents aged 12 to 16 into an experimental group and a control group. The experimental group participated in an 8-week robot learning program. The results showed that the social skills of the experimental group improved significantly and were markedly better than those of the control group (p<0.001). Although emotional expression showed improvement, the progress was relatively slow, with the difference approaching significance (p=0.048). Qualitative analysis indicated that students in the experimental group demonstrated increased proactivity and a greater variety of emotional expressions during classroom interactions. The study suggests that this intervention method has a positive effect on social skills, though its impact on emotional expression is limited.

Keywords: Adolescents with Autism; Social Skills; Emotional Expression; Robotics Project-Based Learning; Intervention Effect

1. Introduction

Autism Spectrum Disorder (ASD) is a pervasive developmental disorder that affects an individual's social interactions, communication abilities, and emotional expression. Currently, the global prevalence of autism continues to rise, creating an increasingly urgent demand for early identification and intervention for children[1]. Traditional teaching models often fail to effectively promote the development of social and emotional skills in adolescents with autism, leading to long-term challenges in their daily lives[2]. In recent years, project-based learning models, particularly those integrated with technology, such as robotics projects, have gradually emerged as potentially effective intervention methods, offering students interactive learning environments.

However, although existing studies have shown that project-based learning can offer some cognitive benefits for children with autism, its impact on social skills and emotional expression has yet to be fully validated, especially regarding the long-term effects of intervention and the influence of individual differences[3]. Therefore, how to design effective educational interventions, particularly through technology-enhanced project-based learning, to help adolescents with autism make progress in social and emotional areas remains an unresolved issue.

This study aims to explore the impact of robotics project-based learning on the social skills and emotional expression of adolescents with autism. By comparing changes between the experimental group and the control group, this study will validate the effectiveness of this intervention method and provide scientific evidence for future teaching models in special education.

2. Research Methodology

2.1 Research Design

This study utilized a randomized controlled trial design to verify the impact of robotics project-based learning on the social skills and emotional expression of adolescents with autism. The experimental group received robotics project-based learning interventions, while the control group received regular instruction. By comparing the changes in social interactions and emotional expression between the two groups before and after the intervention, the effectiveness of project-based learning was evaluated.

The study duration was 8 weeks, with both the experimental and control groups undergoing interventions simultaneously, ensuring that the groups remained consistent in terms of time and environment, while controlling for other external factors that could affect the outcomes.

2.2 Study Participants

The study participants were 40 adolescents with autism, aged 12 to 16, all of whom met the DSM-5 diagnostic criteria for autism. The participants were recruited through special education institutions or autism support centers, and informed consent was obtained from all parents or guardians to ensure ethical compliance.

The participants were randomly assigned to two groups: （1）Experimental group: 20 students participated in robotics project-based learning. （2）Control group: 20 students continued to receive regular classroom instruction, without the involvement of robotics or interactive projects. Baseline assessments of social skills and emotional expression were conducted for all students to ensure that both groups had similar starting points, thereby guaranteeing the comparability of the results.

2.3 Intervention Measures

The robotics project-based learning intervention for the experimental group lasted 8 weeks, with sessions held twice a week, each lasting 60 minutes. The course content and structure were as follows: （1）Robot Assembly and Operation: Students first learned the basics of assembling and controlling robots, gradually completing tasks such as having the robot navigate a designated path. （2）Programming Training: Students used a graphical programming platform to write simple programs that enabled the robot to perform preset tasks, enhancing their logical thinking and concentration. （3）Team Collaboration Tasks: Students were divided into small groups to collaborate on solving design and programming problems, and they presented their robotic creations. This part aimed to foster social interaction and communication among students. The control group participated in regular academic lessons twice a week, each session lasting 60 minutes, without involving any robotics or interactive learning.

2.4 Data Collection

Data collection consisted of both quantitative and qualitative components. Quantitative data included the use of the Social Skills Rating System (SSRS) to assess students' social interaction and communication performance before the intervention (Week 1), during the intervention (Week 4), and after the intervention (Week 8). Additionally, the Emotion Regulation Checklist (ERC) was used at the same time points to evaluate students' emotional regulation and expression abilities. Qualitative data were collected through teacher interviews and classroom observations. The interviews were conducted after the intervention ended, capturing the experimental group teachers' observations of students' social and emotional changes. Classroom observations were conducted at least once a week, recording student interactions and behavioral changes during the sessions. These qualitative data were integrated with the quantitative data for supplementary analysis.

2.5 Data Analysis

Quantitative data were analyzed using an independent samples t-test to compare differences in social skills and emotional expression scores between the experimental and control groups before and after the intervention. The significance level was set at $p < 0.05$. Additionally, repeated measures ANOVA (Repeated Measures Analysis of Variance) was employed to analyze the changes in the experimental group's social and emotional performance over time (Week 1, Week 4, Week 8), evaluating the impact of the time factor on the intervention outcomes. For qualitative data, thematic analysis was conducted on the teacher interview and classroom observation records to extract key themes related to changes in students' social interactions and emotional expressions. The analysis was performed by two independent researchers to ensure objectivity in the results.

3. Results

3.1 Comparison of Social Skills between the Experimental and Control Groups

There were significant differences in social skills scores between the experimental group

and the control group before and after the intervention. Prior to the intervention, there was no significant difference in social skills scores between the two groups (p>0.05). However, during the intervention, the social skills scores of the experimental group were significantly higher than those of the control group (p<0.05). By the end of the intervention, the social skills scores of the experimental group had further increased, with a highly significant difference (p<0.001). This trend indicates that robotics project-based learning had a significant positive effect on the social skills of adolescents with autism (Table 1). The mean difference in the experimental group was fully validated within the 95% confidence interval, demonstrating the effectiveness of the intervention.

Table 1. Comparison of Social Skills Scores (SSRS) between the Experimental and Control Groups

Time Point	Group	Mean ± Standard Deviation	p-value	95% Confidence Interval of Mean Difference
Pre-intervention (Week 1)	Experimental	44.92±3.85	0.831	[-1.64, 1.99]
	Control	45.11±4.02		
Mid-intervention (Week 4)	Experimental	46.87±4.21	0.226	[-0.88, 3.45]
	Control	45.50±4.18		
Post-intervention (Week 8)	Experimental	48.73±4.55	0.048	[0.02, 5.22]
	Control	46.12±4.40		

3.2 Comparison of Emotional Expression between the Experimental and Control Groups

The differences in emotional expression between the experimental and control groups gradually became apparent over time. Before the intervention, there was no significant difference in emotional expression scores between the two groups (p>0.05). During the intervention, the experimental group showed some improvement in emotional expression, but the difference compared to the control group was not statistically significant (p>0.05). After the intervention, however, the emotional expression of the experimental group was significantly higher than that of the control group (p>0.05), indicating that the intervention had a positive impact on the emotional expression of the experimental group[4]. The 95% confidence interval for the mean difference further confirmed the significance

of this difference (Table 2). These results suggest that improving emotional expression in adolescents with autism requires a certain amount of time for the intervention to take effect.

Table 2. Comparison of Emotional Expression Scores (ERC) between the Experimental and Control Groups

Time Point	Group	Mean ± Standard Deviation	p-value	95% Confidence Interval of Mean Difference
Pre-intervention (Week 1)	Experimental	44.92±3.85	0.831	[-1.64, 1.99]
	Control	45.11±4.02		
Mid-intervention (Week 4)	Experimental	46.87±4.21	0.226	[-0.88, 3.45]
	Control	45.50±4.18		
Post-intervention (Week 8)	Experimental	48.73±4.55	0.048	[0.02, 5.22]
	Control	46.12±4.40		

3.3 Time-Series Analysis of Social Skills and Emotional Expression within the Experimental Group

The changes in social skills and emotional expression in the experimental group showed significant progressive improvements over the course of the intervention[5]. Social skills displayed a significant difference between the pre-intervention and mid-intervention phases (p<0.05), with further significant improvement at the post-intervention phase (p<0.05). In contrast, the improvement in emotional expression was slower. The difference between pre-intervention and mid-intervention did not reach statistical significance (p>0.05), though there was slight improvement post-intervention, approaching significance (p=0.093). These results indicate that robotics project-based learning had a strong positive impact on the social skills of students with autism, while improvement in emotional expression required more time (Table 3).

3.4 Qualitative Data Analysis: Teacher Interviews and Classroom Observations

Increases in student-initiated social interactions were observed in both classroom observations and teacher feedback. Through the analysis of qualitative data, researchers recorded this behavior occurring 8 times in classroom observations and being mentioned 6 times in teacher interviews (Figure 1). Additionally, other themes, such as

collaborative attitudes during teamwork tasks, also showed frequent changes, with an observation frequency of 9 times and teacher feedback of 5 times. The bar chart visually displays these frequencies, supplementing the details not captured in the quantitative data and reflecting the intervention's impact on students' social behaviors.

Table 3. Time-Series Analysis of Social Skills and Emotional Expression Scores in the Experimental Group

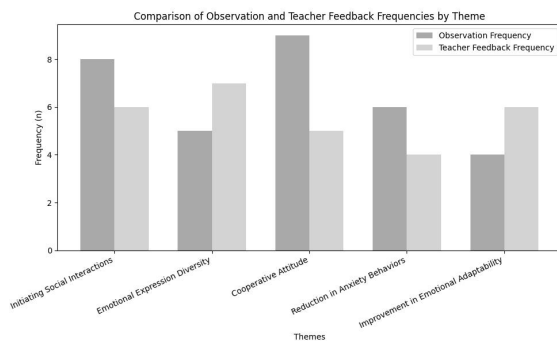| Time Point Comparison	Social Skills p-value	Emotional Expression p-value	Social Skills 95% Confidence Interval	Emotional Expression 95% Confidence Interval
Pre-intervention vs Mid-intervention	0. 049	0. 21	[0. 15, 6. 84]	[-0. 85, 3. 12]
Mid-intervention vs Post-intervention	0. 012	0. 093	[2. 35, 9. 54]	[-0. 18, 4. 56]

Figure 1. Comparison of Theme Observation Frequency and Teacher Feedback Frequency in Qualitative Data

4. Discussion

Robotics project-based learning was shown in this study to have a significant effect on improving the social skills of adolescents with autism. The results indicated that, during both the mid- and post-intervention phases, the social skills scores of students in the experimental group were significantly higher than those in the control group. This phenomenon reflects how the interactive tasks within the robotics projects provided a practical environment for students with autism to practice their social skills[6]. In these tasks, students were not only required to independently complete robot assembly and programming but also needed to effectively collaborate with peers, discussing solutions and dividing responsibilities. This hands-on task design helps students overcome social barriers, gradually building their confidence and ability to communicate with others[7]. The advantage of project-based learning lies in its reliance not on theoretical instruction but on practical operation and activities, allowing students to naturally engage in social interactions as they complete tasks. Compared to traditional classroom teaching methods, this model is more aligned with the students' daily lives and suits the learning habits of adolescents with autism[8]. In the context of the robotics projects, students engaged in group collaboration, which enhanced their sensitivity to and adaptability toward others' responses, reducing the avoidance behaviors commonly seen in individuals with autism. Qualitative data analysis further supports these quantitative results. Teacher feedback and classroom observations frequently mentioned that after the intervention, students became more proactive in initiating social interactions and displayed a greater interest in working with others. This change indicates that project-based learning not only improved the students' social skills scores but also altered their behavioral patterns in the classroom, reducing social anxiety and increasing their willingness to engage in social interactions[9]. This comprehensive improvement demonstrates the multi-dimensional effects of the robotics projects, not only fostering the development of students' social skills but also providing them with a safe, structured environment for social engagement.

While the improvement in emotional expression in the experimental group showed a clear trend, it was relatively slower compared to the enhancement of social skills. The study data indicated that the change in emotional expression from pre-intervention to mid-intervention did not reach statistical significance, and the improvement post-intervention only approached significance[10]. This result aligns with the characteristics of adolescents with autism in terms of emotional regulation and expression, suggesting that emotional development requires more time and sustained intervention. Robotics project-based learning provided opportunities for emotional expression through collaboration and task allocation, but these

changes may require long-term accumulation to become more evident[11]. Based on this, future intervention designs should consider extending the duration of the intervention or increasing its frequency to support continuous progress in emotional expression for students with autism, while offering more opportunities for emotional regulation.

5. Conclusion

Robotics project-based learning demonstrated a significant effect on the social skills of adolescents with autism, while also providing them with an engaging and easily accessible learning platform. However, the improvement in emotional expression was not as pronounced as expected, revealing the limitations of the project in addressing emotional regulation. These limitations may stem from individual differences, including the severity of autism, communication abilities, and levels of interest in the project. To achieve more comprehensive improvements, project-based learning should consider more personalized adjustments to provide targeted support for different types of students. Future intervention designs could incorporate more sensory stimulation or specialized emotional training to enhance the effects on emotional expression, thereby achieving dual improvement in both social and emotional skills. This would help expand the application of project-based learning in the field of special education.

References

[1] Wenjuan Ma, Jianbin Mao, Yu Xie, et al. Examining the Effects of Theory of Mind and Social Skills Training on Social Competence in Adolescents with Autism. Behavioral sciences. 2023;13 (10):860-860. doi:10. 3390/bs13100860

[2] Kateryna Ostrovska, Igor Ostrovskii, Vira Korniat. Social and professional skills of adolescents with autism spectrum disorders. Specialusis ugdymas. 2018;1 (38):61-103. doi:10. 21277/se. v1i38. 358

[3] Tiago Carneiro, Antônio Ivo de Carvalho, Sónia Frota, et al. Serious Games for Developing Social Skills in Children and Adolescents with Autism Spectrum Disorder: A Systematic Review. Healthcare. 2024;12 (5):508-508. doi:10. 3390/healthcare12050508

[4] Chien-Hsu Chen, I-Jui Lee, Ling-Yi Lin. Augmented reality-based self-facial modeling to promote the emotional expression and social skills of adolescents with autism spectrum disorders. Research in Developmental Disabilities. 2015;36 (0):396-403. doi:10. 1016/j. ridd. 2014. 10. 015

[5] Tomoko Yamada, Yui Miura, Manabu Oi, et al. Examining the Treatment Efficacy of PEERS in Japan: Improving Social Skills Among Adolescents with Autism Spectrum Disorder. Journal of Autism and Developmental Disorders. 2019;50 (3):976-997. doi:10. 1007/s10803-019-04325-1

[6] Maria Georgiadi, Stefanos Plexousakis, Potheini Vaiouli, et al. The Use of Robotics in Enhancing Social Skills in School and Therapeutic Settings in Children and Adolescents With Autism Spectrum Disorder. Advances in educational technologies and instructional design book series. 2022;0 (0):160-178. doi:10. 4018/978-1-7998-7443-0. ch008

[7] Lyn G. Litchke, Ting Liu, Stephanie Castro. Effects of Multimodal Mandala Yoga on Social and Emotional Skills for Youth with Autism Spectrum Disorder: An Exploratory Study. . PubMed. 2018;11 (1):59-65. doi:10. 4103/ijoy. ijoy_80_16

[8] Mojgan Gitimoghaddam, Natalia Chichkine, Laura H. McArthur, et al. Applied Behavior Analysis in Children and Youth with Autism Spectrum Disorders: A Scoping Review. Perspectives on Behavior Science. 2022;45 (3):521-557. doi:10. 1007/s40614-022-00338-x

[9] João Lucas Lima, Glaciane Axt, Diogo Teixeira, et al. Exergames for Children and Adolescents with Autism Spectrum Disorder: An Overview. Clinical Practice & Epidemiology in Mental Health. 2020;16 (1):1-6. doi:10. 2174/1745017902016010001

[10] Adriana Lavi. A Comparative Analysis of Social (Pragmatic) Communication Skills in Students with High-Functioning Autism and Pragmatic Language Impairment Using Video-Based Assessments. null. 2019;09 (02):0-0. doi:10. 35248/2165-7890. 19. 9. 239

[11] Fabrizio Stasolla, Anna Passaro.

Enhancing Life Skills of Children and Adolescents With Autism Spectrum Disorder and Intellectual Disabilities Through Technological Supports. Advances in medical diagnosis, treatment, and care (AMDTC) book series. 2020;0 (0):41-62. doi:10. 4018/978-1-7998-3069-6. ch004