Exploring Primary School Students' Perceptions of Educational Robotics for Motivation and Learning

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Abstract: Educational robotics can improve student engagement and learning, especially in STEM subjects, by combining hands-on tasks with real-world applications that promote intrinsic motivation and 21st century skills such as problem solving, collaboration and critical thinking. This study examines how primary school students perceive a robotics activity in which mBot robots are programmed to perform real-world tasks in a collaborative environment. To promote motivation, engagement and computational thinking, students' attitudes were examined using three theoretical models: the Motivation Model (MM), the Technology Acceptance Model (TAM) and the Value-based Adoption Model (VAM). Primary school students (N=45) aged 10 to 12 years participated in the study, including 19 girls and 25 boys, about half of whom had already had one year of experience in robotics. The results show high intrinsic motivation and satisfaction. Students found the activity fun, engaging and educationally valuable, although some noted that it was time and effort intensive. Nevertheless, most found the experience worthwhile and would recommend it to others. The results highlight the potential of well-designed robotics activities to promote motivation and support meaningful learning in primary education.

Keywords: Educational robotics, technology-enhanced learning, problem-based learning, K-12, STEM, education

1. Introduction

Educational robotics is an interdisciplinary field in which robots are integrated into the educational settings to enrich learning experiences by integrating different areas of knowledge and developing skills. It combines science, technology, engineering and math (STEM) with computer science, art and pedagogy to support the development of comprehensive and engaging curricula (Harter & Caulkett, 2022). In recent years, it has gained great popularity as a pedagogical approach to promote student motivation, collaboration, and computational thinking, especially in STEM education (Ribeiro, et al., 2023). Robotics activities also provide opportunities for teamwork, communication, and interdisciplinary learning, making robotics a powerful medium for developing 21st century skills (Darmawansah, et al., 2023).

Embedded in problem-based learning (PBL) scenarios, robotics activities immerse students in hands-on tasks that promote critical thinking, teamwork, and creative problem solving, while making abstract concepts more tangible (Yildirim & Sahin-Izmirli, 2024). Integrating storytelling into such activities has been shown to further increase motivation, deepen learning, and promote computational thinking (Kalogiannakis, et al., 2021; Tengler, et al., 2021). The increasing accessibility of user-friendly robotics kits such as mBot, Maqueen and LEGO Mindstorms has facilitated their use in formal and informal learning environments and at all levels of education, from early childhood to higher education (Orhani & Babuna, 2024; Samara, et al., 2021).

Building on this potential, this study examines how primary school students perceive and engage with a robot-based learning activity. Using a structured survey, it investigates motivation, perceived usefulness and ease of use, and cost–benefit perceptions. The activity involved team-based programming of mBot robots to solve real-world tasks designed to promote computational thinking and support STEM learning objectives. Conducted within the MetaRoboLearn project, which explores how educational robots can be integrated into physical and virtual environments to enable seamless K–12 learning. While earlier studies have highlighted the benefits of educational robotics in primary education, this study examines how younger students perceive such activities in terms of motivation, usability, and value, particularly when designed as real-world, team-based problem scenarios.

2. Related Work

Educational robotics is widely recognized as a promising approach to improve learning outcomes, student engagement, and technical and social skills such as teamwork, communication and problem solving (Eguchi, 2014; Benitti, 2012). By providing a playful yet structured environment, students can explore cause-and-effect relationships, develop programming logic, and become both creators and informed users of technology. Through active participation and experimentation, learners engage with complex STEM concepts while benefiting from improved classroom dynamics, sustained focus, and cross-curricular integration. Increasingly, robotics is also enriching learning in non-STEM subjects, including language, arts, and social sciences (Wang, et al., 2023).

A key strength of educational robotics is its emphasis on active learning approaches that place students at the center of the process. Rather than passively receiving information, learners build their knowledge through hands-on tasks, collaborative challenges and creative exploration. Robot-assisted instruction based on active learning has been shown to increase motivation, deepen understanding, and improve retention of complex content (Zhang, et al., 2024), especially when students are encouraged to experiment, learn from mistakes, and iterate solutions in a supportive environment. Beyond cognitive gains, educational robotics promotes creativity and self-expression, especially when students can customize their robots, develop unique solutions to open-ended problems, or tell stories through robotic movements. As Nagy and Holik (2023) note, educational robots can act as a means of expression, allowing students to communicate their ideas in novel ways, combining artistic and technical domains. This highlights the value of integrating open-ended tasks and design thinking into robotics activities to encourage creativity alongside computational thinking.

The benefits are particularly evident in early education, where the tactile and visual nature of learning experiences helps younger learners to accept abstract concepts more easily (Bers, et al., 2014; Mubin, et al., 2013). Early exposure to this technology can provide a solid foundation for later engagement in science and technology, while improving classroom dynamics and student inclusion by accommodating different learning styles. In elementary school, integrating stories, real-world challenges, and collaborative group work into robotics activities can further increase motivation and engagement, even among students who may not initially be interested in STEM (Tengler, et al., 2021).

3. Methodology

The aim of this study is to investigate how primary school students perceive robotics activities, focusing on motivation, perceived usefulness, perceived ease of use and the relationship between effort and benefit. By examining these factors, the study helps to understand how early experiences with educational robotics shape students' attitudes and intentions towards future engagement with similar technologies.

Research questions were:

- RQ1: How do students perceive their intrinsic and extrinsic motivation to learn computer science after participating in robotics activities?
- RQ2: How do perceived ease of use and usefulness of robotics activities influence students' attitudes and intentions to engage with similar technologies in the future?
- RQ3: How do students rate the cost-benefit ratio (in terms of time and effort) of robotics activities and how does this affect their willingness to participate again?

3.1 Participants

A total of 45 primary school students between the ages of 10 and 12 participated in the activity, accompanied by their teachers and with parental consent. The sample included 10 fourth-graders (22.2%), 16 fifth-graders (35.6%) and 18 sixth-graders (40%), while one participant did not specify his grade level (2.2%). In terms of gender distribution, there were 19 girls (42.2%) and 25 boys (55.6%), with one student (2.2%) not specifying their gender. It is worth noting that 21 students (46.7%) reported previous experience with extracurricular robotics activities, with an average duration of about one year.

3.1.1 Study Procedure and Instrument

The survey was conducted during the Open Day at the Faculty of Informatics and Digital Technology. Printed questionnaires were used, which were distributed to the students immediately after the robotics activity was completed. In this activity, students worked in teams to program and control mBot robots using a block-based programming environment, where the wheeled robots could only move forward or turn left and right. The students controlled the wheeled robots across a coordinate-labeled grid, overcoming obstacles and delivering objects from a virtual post office to various destinations. The tasks required problem solving, collaboration and computational thinking through logical sequencing, route planning and iterative debugging (Zunic, et al., 2025). The questionnaire contained 16 statements with a Likert scale that targeted specific theoretical dimensions to analyze students' motivation, perceived learning value, and future behavioral intentions. The statements were derived from the Motivation Model (MM), the Technology Acceptance Model (TAM) and the Value-based Adoption Model (VAM), covering dimensions such as Intrinsic Motivation (IM), Extrinsic Motivation–External Regulation (EM-ER), Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Perceived Value (PV). This approach was chosen to focus the study on motivation, technology use and perceived value as key factors in understanding students' attitudes towards educational robotics. All statements are listed in Table 1. At the end, participants could give open-ended comments on the activity's most enjoyable and challenging aspects, as well as suggestions for improvement.

4. Results

Table 1 shows that students responded very positively to the robotics activity, with 14 of 16 statements scoring above 4.0. They rated the activity as interesting (M = 4.80, SD = 0.457), enjoyable (M = 4.80, SD = 0.457), and emotionally rewarding ("I felt good participating," M = 4.78, SD = 0.471). They also recognized its real-world relevance (M = 4.51, SD = 0.695). Instruction clarity received high score (M = 4.82, SD = 0.442), while controlling the mBot was rated somewhat lower (M = 4.33, SD = 0.798), pointing to minor usability issues. Teamwork was considered highly beneficial (M = 4.60, SD = 0.618), and many agreed that such activities motivate them to learn computer science (M = 4.44, SD = 0.918). Intention to participate again was positive but slightly lower (M = 4.27, SD = 0.845). Students found the problems challenging but solvable (M = 4.60, SD = 0.618) and felt proud when solving them (M = 4.40, SD = 0.809). They valued the learning experience (M = 4.69, SD = 0.514) and were highly willing to recommend it to peers (M = 4.80, SD = 0.462). Although many noted the activity required effort (M = 3.70, SD = 1.212) and time (M = 3.42, SD = 1.270), most felt the benefits outweighed the costs (M = 4.07, SD = 1.214). The overall evaluation was extremely positive (Figure 1). Of 40 respondents, 37 rated the activity "5 - excellent," two "4 - very good," and one "3 - good."

In their open responses, the participants most frequently emphasized the robot control, programming and teamwork as enjoyable aspects, while they also appreciated the problem solving and the stimulating atmosphere. Suggestions for improvement mainly concerned technical issues (e.g., robot responsiveness, tire functionality) as well as requests for more challenging tasks, longer sessions and additional activities.

Table 1. *Participant feedback for the activity*

Statement	Used model	Dimension	Mean	St. dev.
RQ1: Intrinsic and extrinsic motivation				
I found the activity interesting.	MM	IM	4.80	0.457
I felt good participating in the activity.	MM	IM	4.78	0.471
I had fun.	VAM	PV-HV	4.80	0.457
This activity helped me understand how computer science can be useful in real life.	VAM	PV-UV	4,51	0,695
RQ2: Ease of use, usefulness, attitudes, intentions				
It was clearly explained to me what was expected.	TAM	PEOU	4,82	0,442
It was easy for me to control the mBot.	TAM	PEOU	4,33	0,798
Teamwork and sharing ideas helped me solve problems more effectively.	VAM	PV-UV	4,60	0,618
Activities like this motivate me to learn computer science.	MM	EM-ER	4.44	0.918
I plan to participate in similar activities in the future.	TAM	BI	4.27	0.845
RQ3: Cost-benefit ratio of time and effort				
The problems we had to solve were challenging but solvable.	VAM	PV-UV	4.60	0.618
I felt proud when I solved the given problems.	MM	IM	4.40	0.809
I believe I can learn something new through these activities (e.g.. controlling robots by programming).	TAM	PU	4.69	0.514
I would recommend these robotics activities to other students.	TAM	ATU	4.80	0.462
Solving the problems required a lot of effort.	VAM	PS-EC	3.70	1.212
Solving the problems required a lot of time.	VAM	PS-TC	3.42	1.270
I gained more from this activity than the time and effort I invested.	VAM	PS-PVOC	4.07	1.214

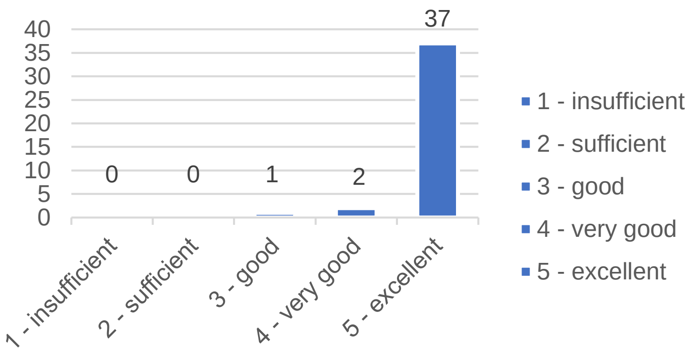

Figure 1. Overall rating of the activity by respondents

5. Discussion

The results address all three research questions and provide insights into students' engagement, motivation and learning experiences with robotics activities. RQ1 is answered with the help of statements on intrinsic and extrinsic motivation. The activity promoted both intrinsic and extrinsic motivation. Students found it enjoyable, satisfying and useful, indicating strong intrinsic motivation. Many expressed pride in completing the tasks, while the experience also promoted extrinsic motivation by stimulating interest in learning computer science and emphasizing the practical relevance of the skills they were developing. The robotics activity was successful in promoting both forms of motivation, supporting the idea that hands-on, problem-based tasks are effective in engaging elementary school students in STEM subjects.

These findings are consistent with Zhang et al. (2024), who emphasize that robotics can motivate learners through experimentation and tangible feedback.

Regarding RQ2, which explored how perceived ease of use and perceived usefulness influence students' attitudes and intentions for future engagement, the results were generally positive. Clear instructions enhanced students' confidence, although some had difficulty operating the robot, reflecting the accessibility and usability concerns mentioned by Bers et al. (2014) and Mubin et al. (2013). Future versions could address these issues by using advanced robots with artificial intelligence or providing additional support for less experienced users. Overall, students found the activity very valuable and an important learning experience. Many expressed a willingness to participate again and recommend the activity to their peers. Although personal re-engagement was slightly lower, it showed great interest and openness to further participation. For some, re-participation may depend on factors such as time availability, perceived difficulties or access to similar opportunities outside the classroom. These findings are consistent with previous research emphasizing that students' continued interest in such learning activities depends on continued access, targeted support and integration into the curriculum (Eguchi, 2014; Samara, et al., 2021).

The answers to RQ3, which examined the students' cost-benefit assessment in terms of time and effort, varied. Students agreed that the activity was cognitively demanding and time consuming, which is consistent with research that emphasizes a balance between challenge and accessibility (Bers, et al., 2014; Mubin, et al., 2013). Nevertheless, most felt that the benefits outweighed the challenges. They valued real-world problem solving, collaboration, and developing skills that extend beyond the classroom. This supports value-based acceptance theory (Samara, et al., 2021), which states that meaningful outcomes promote engagement despite the challenges. Students also highlighted the fun and social aspects, with teamwork improving both engagement and effectiveness. The high overall satisfaction suggests that the activity achieved a successful balance between challenge and reward, highlighting the need to design robotics activities that are educational, engaging and developmentally appropriate.

The open-ended responses confirmed these results, with students most often finding programming, teamwork and problem solving enjoyable, and remembering tasks such as obstacle navigation and object delivery as especially memorable. These observations are consistent with those of Zhang et al. (2024) and Eguchi (2014), who emphasize the cognitive and emotional benefits of hands-on robotics activities for young learners. Suggestions for improvement included better robot responsiveness, longer sessions, and more complex challenges, reflecting a desire for smoother performance and deeper engagement, consistent with Darmawansah et al. (2023). However, almost half of the participants (46.7%) had previous experience with robots, which may have influenced motivation and usability ratings. Future studies should include larger, more diverse samples and analyze results by participant background to improve generalizability.

6. Conclusions

This study highlights the great potential of educational robotics as an effective pedagogical tool to increase the engagement, motivation and learning experience of primary school students. By integrating hands-on robotics activities into a problem-based learning framework, students were encouraged to think critically, collaborate with peers, and apply computational thinking skills to real-world challenges. The positive feedback shows that such activities are perceived as enjoyable and rewarding by students. Building on the strong motivation and interest of students, future work will focus on refining and extending this approach through well-designed robotics activities that are aligned with learner interests, technological advancement and learning outcomes. Particular attention will be given to the integration of robots with artificial intelligence to further enhance motivation and enrich the learning experience.

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