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The Impact of Robotics on Learning Mathematics and Physics: Results from the Mentes Robóticas Project

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Abstract: The **Mentes Robóticas** project, implemented at João Batista de Carvalho State School in Bambuí-MG, aimed to integrate robotics and programming into the high school curriculum, focusing on developing computational thinking and the practical application of interdisciplinary concepts. This preprint presents the project's final results, highlighting the impact of robotics on learning mathematics and physics. Through theoretical and practical lessons, students were introduced to concepts in electronics, programming, and robotics, using Arduino kits and digital tools such as TinkerCAD. Feedback from teachers indicates that robotics sparked students' interest in technology, potentially extending to related fields such as mathematics, physics, and chemistry. This contributes to an interdisciplinary and contextualized learning approach, making education more engaging and meaningful. The project also demonstrated the potential of robotics as an inclusive educational tool, with students with Autism Spectrum Disorder (ASD) actively participating and showing interest in the activities. Initial findings suggest that robotics can be an effective way to enhance mathematics and physics education by connecting theoretical concepts to practical applications and fostering a deeper understanding of STEM disciplines.

Keywords: robotics in education; mathematics learning; stem education; arduino in schools; interdisciplinary learning; physics; inclusive education; computational thinking; practical applications of mathematics and physics; high school curriculum; educational technology

1. Introduction

The integration of robotics into education has gained significant attention as a powerful tool for teaching science, technology, engineering, and mathematics (STEM). However, its implementation in high school, especially in public schools, still faces challenges due to a lack of resources and teacher training. The **Mentes Robóticas** project emerged from a demand at João Batista de Carvalho State School, located in Bambuí-MG, where robotics kits were available but remained unused because no teacher knew how to utilize them. The project's main objective was to teach robotics classes to students using the available robotics kits while simultaneously training teachers so that they could continue using these resources in their lessons in the future. This study analyzes the impact of robotics on learning mathematics and physics, investigating how the practical application of mathematical and physical concepts in robotics projects can enhance students' understanding and engagement.

2. Methodology

The project was implemented in three first-year high school classes, with weekly lessons combining theory and practice. During the lessons, students used Arduino kits, sensors, motors, and other electronic components to assemble circuits and develop projects. Digital tools such as TinkerCAD were also used to simulate circuits and projects. Additionally, teachers attended the classes, learning the

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fundamentals of robotics and how to apply the kits in their teaching practices, ensuring the continued use of these technologies in the school.

3. Results

Feedback from students and teachers who participated in the Mentes Robóticas project revealed that robotics had a positive impact on learning mathematics and physics. According to their reports, students showed greater interest and engagement in lessons, particularly when concepts from these subjects were applied in practical projects. Moreover, many teachers observed an improvement in academic performance, with students who traditionally struggled in these subjects showing progress after participating in the project.

Among the most highlighted aspects were interdisciplinary projects, such as developing a line-following robot and an automatic lighting system, which required the direct application of mathematical and physical concepts. According to students, these activities not only facilitated the understanding of content but also contributed to the development of essential skills such as teamwork and problem-solving.

Another key observation from teachers was a significant behavioral change in certain students. Those who typically exhibited behavioral difficulties showed greater dedication during robotics lessons, resulting in increased focus and engagement. This suggests that the practical and interactive approach of robotics can serve as a motivational factor, providing a constructive alternative for active student participation in class.

4. Discussion

Robotics proved to be an effective tool for connecting theoretical knowledge with practical applications, promoting an interdisciplinary learning approach. Integrating mathematical and physical concepts into robotics projects allowed students to visualize their practical applications, enhancing their understanding and interest. Furthermore, the project demonstrated that robotics could be an inclusive tool, with students with Autism Spectrum Disorder (ASD) actively participating in activities and showing enthusiasm for the content. Collaboration with support teachers was essential to ensure accessibility and inclusion for all students.

5. Conclusions

The **Mentes Robóticas** project highlighted the potential of robotics as an educational tool, particularly in teaching mathematics and physics. The practical application of mathematical and physical concepts in robotics projects sparked students' interest in technology and made learning more dynamic. Continuing the project, with an expansion to second- and third-year high school classes, could strengthen this approach and prepare students for new challenges.

6. Future Perspectives

This preprint provides an overview of the preliminary results of the **Mentes Robóticas** project. However, the project team plans to publish a full paper that will provide a more in-depth analysis of the students' results throughout the project, including quantitative and qualitative analyses, comparisons between classes, and a more extensive evaluation of the impact of robotics on learning mathematics, physics, and other related subjects. This paper aims to provide additional insights into how robotics can be integrated into the school curriculum to enhance STEM education, particularly in mathematics and physics. The study will include recommendations for future implementations and expansions of the project.

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References

1. ABUSHAWAR, B.; ATWELL, E. **Alice Chatbot: Trials and Outputs**. Computación y Sistemas, México, v. 19, n. 4, p. 625-632, 2015. Available at: https://www.researchgate.net/publication/289684788_ALICE_chatbot_Trials_and_outputs. Accessed on: May 20, 2023.
2. BANZI, Massimo; SHILOH, Michael. **Primeiros passos com o Arduino**. São Paulo: Novatec, 2011.
3. BNCC. **Base Nacional Comum Curricular**. 2018. Available at: http://portal.mec.gov.br/docman/fevereiro-2022-pdf/236791-anexo-ao-parecer-cne-ceb-n-2-2022-bncc-computacao/file. Accessed on: May 15, 2023.
4. BOSTON CONSULTING GROUP. **Robotics Outlook 2030: How Intelligence and Mobility Shape the Future**. 2021. Available at: https://www.bcg.com/publications/2021/how-intelligence-and-mobility-will-shape-the-future-of-the-robotics-industry. Accessed on: May 15, 2023.
5. Brasscom. **Demanda de Talentos em TIC e Estratégia TCEM**. 2021. Available at: https://brasscom.org.br/pdfs/demanda-de-talentos-em-tic-e-estrategia-tcem/. Accessed on: May 17, 2023.
6. DIRIK, M. **Al-Jazari's Legacy: How medieval robotics inspire modern AI systems**. J. Comput. Sci. Eng., 2020.