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Incorporation of Robotics in AI Education: Barriers and Enablers as Perceived by K-12 Teachers

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Abstract: Adopting robotics as a pedagogical tool is commonly observed in school-based programs related to AI education; however, scant research has been conducted on teachers' perceived challenges therein. This study, through interviewing K-12 teachers (n = 11), aimed to probe into their perceived barriers and enablers (as well as the corresponding impacts) in the situation of harnessing robotics in AI education. This study revealed that, apart from the presence of some common external and internal barriers/ enablers, a new factor, namely "technology" concerning the quality and functions of technology emerged. This work provides the field with insights into designing and implementing teacher professional development training on AI education in K-12 contexts.

Keywords: AI Education, Robotics, K-12 Teachers, Barriers, Enablers

1. Introduction

Since the beginning of this decade, artificial intelligence (AI) education has been regarded as a globally important initiative across elementary to higher education (e.g., Chiu et al., 2022; Dai et al., 2023; Li et al., 2022). On top of that, the significant societal impact of AI calls for the incorporation of AI-related knowledge in earlier educational stages. Recently, there has been a notable push to develop AI curricula in K-12 education worldwide, with robotics emerging as a pivotal tool for enhancing learning and teaching (Yue et al., 2022). However, scant attention has been given to the challenges teachers face amid the surge of AI education in the K-12 domain, particularly regarding the use of robotics. While previous research has investigated the barriers related to integrating Information and Communications Technology (ICT) into K-12 education (Brun & Hinostroza, 2014), limited research has focused on the integration of robotics, especially within AI courses. The aim of the present study is to explore the barriers and potential enablers pertaining to robotics-supported AI lessons perceived by K-12 teachers, as well as how these factors might influence teachers' opportunities for teaching with robotics.

AI-powered educational robotics can be an effective tool in teaching K-12 students AI knowledge. Devices such as ClicBot, RoboMaster and LEGO offer various pre-designed modules that support different AI functions, including facial recognition, emotions, sounds, objects, colors, and gesture detection. Teachers can use robotics to increase students' engagement and motivation (Shang et al., 2023; Yang et al., 2023), foster computational thinking (Ching & Hsu, 2023; Shang et al., 2023), and enhance the understanding of programming concepts (Nayak et al., 2023), Despite the above benefits, teachers may encounter various challenges in integrating robotics into teaching practices due to diverse reasons (Ching & Hsu, 2023).

Factors affecting technology integration can be categorized into external and internal. External factors include access to computers or devices, internet connectivity, district policies, teacher training, technical support, peer support, and time. Internal factors encompass personal beliefs, self-efficacy, previous experiences, visions of technology integration, and confidence (Tondeur et al., 2017). Common barriers mentioned include insufficient hardware or software, inadequate technical support, and resistance to technology use. Enablers can include comprehensive professional training, resources, and financial support. There is limited literature that explores the barriers and enablers of integrating robotics into AI lessons.

2. Methodology

Eleven Chinese K-12 teachers (labeled A through K), who are pioneers in school AI education, participated in semi-structured interviews to explore the barriers and enablers of integrating robotics into AI lessons. The interviews were analyzed using a two-step coding approach (Saldaña, 2021). The first phase condensed data into descriptive and inferential codes. The second phase employed pattern and focused coding to generate themes. Constant comparison methods were used to highlight the common barriers and enablers.

3. Preliminary Findings

Two primary external barriers were identified: limited robotics availability and insufficient professional training. As stated by the teacher, “It’s too expensive to provide every student with robotics (B),” the cost of procuring robotics for each student is prohibitively high, impacting their learning experience. Teachers also expressed concerns about the insufficient training to use robotics in their teaching. One remarked, “Without expert guidance, I resort to online resources, which makes me uncertain about the accuracy (M).” A possible reason could be the minor status and positioning of AI as a discipline. AI courses are often embedded within the information and technology (IT) subject, which is viewed as a minor subject. They described IT teachers as, “We are the marginalized teachers who teach the marginalized subject, so school investment in our discipline is severely limited (J).” Eight teachers reported that a lack of confidence in integrating robotics is the primary internal barrier. One remarked, “My academic background is not in AI, and I am not familiar with robotics. Integration of robotics feels risky to me (K).” In fact, it is common for teachers who teach IT, or even AI in K-12, to not have majored in computer science. The lack of AI content knowledge and robotics proficiency contributes to this barrier.

We identified a new category of barrier: the technology factor, which was mentioned by all participants. Different from typical external barriers, such as a lack of hardware (robotics), the technology factor concerns the quality and functions of the robotics. One teacher reported, “Students need one robotic that can carry all AI concepts. I mean, students can learn various aspects of AI through interaction with a single device (D).” However, teachers often need to utilize different kinds of robotics to teach corresponding AI knowledge. Apart from the demand of connecting to different AI content knowledge, teachers expect robotics to create a context for students to solve authentic problems as well. As one commented, “If robotics cannot help me to contextualize a problem to be solved, I will be less inclined to use it in my classrooms (E).” Teachers also emphasized the ability of robotics to capture students’ interests, “The primary aim of AI education for K-12 students is to foster their interests in the AI-powered world. Integrating dull and unintelligent robotics in my classes is challenging because they fail to engage students’ attention on AI technology (F).”

Correspondingly, we also identified enablers under external, internal, and technology factors. Nine teachers acknowledged the effectiveness of robotic competitions as external enablers. One said, “Robotic competitions play a vital role in motivating schools and me to incorporate robotics into the AI learning environment. Students need a platform to examine their learning outcomes, and competitions provide an excellent opportunity to evaluate students’ learning

performance (C).” Regarding internal enablers, teachers valued positive attitudes towards technology (10 mentions) and constructivist beliefs (9 mentions). One commented, “I firmly believe that students construct their understanding of AI through learning hands-on tasks. By using robotics, students can get an in-depth understanding of the AI problem and deal with these tasks effectively (A).” Finally, all teachers agreed that user-friendly robotics is a critical enabler under the technology factor. They expected robotics to be easy-to-use devices that minimize complications for both teachers and students.

4. Discussion and Conclusion

The preliminary findings highlight key barriers and potential enablers perceived by K-12 teachers when integrating robotics into AI courses, which generally are aligned with previous research on studying external and internal factors of technology integration. Besides, a unique factor, the “technology factors,” emerged from the results of the current study in the context of AI education. Teachers are concerned with the functions and quality of technology (i.e., robotics in this context) itself. The technology factor intersects with both external and internal factors. For instance, teachers believed that if robotics did not possess the expected functions, regardless of the availability of sufficient resources and support (an external factor) or their wiliness to use them (an internal factor), it would still present a barrier to teaching AI knowledge. In addition, teachers identified more internal enablers compared to external enablers that facilitate the integration of robotics in AI lessons. The data reveal a strong interest and motivation among teachers towards incorporating robotics in AI curricula, despite any constraints they might experience due to a lack of external support. Future research should aim at designing and implementing teacher professional training programs to address these barriers effectively. Additionally, the impact of the technological factor on teachers' decisions regarding the integration of robotics warrants further exploration.

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