

The didactic-pedagogical link between Artificial Intelligence, embodiment and developing engagement in secondary schools

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Abstract: Student engagement is one of the most important factors influencing effective learning in secondary schools. This paper explores the combined potential of artificial intelligence (AI) and embodiment to improve student engagement. Specifically, an experimental study was conducted using the Nao robot to teach digital and logical skills, combined with motor activities to promote embodiment in motor science classroom activities. Data was collected using the Student Engagement Scale (SES) and qualitative analysis of student responses. The results show that both approaches significantly increase engagement, but in different ways: AI promotes emotional and cognitive engagement, whereas embodiment promotes behavioural engagement. These findings suggest that a combination of AI and embodiment could be an innovative strategy to promote more dynamic and engaging learning.

Keywords: engagement; intelligenza artificiale; embodiment

1. Introduction

In recent years, student engagement has become a central issue in educational research, as it is closely linked to students' academic success and emotional well-being. According to Fredricks, Blumenfeld and Paris (2004), engagement has three main dimensions: emotional, cognitive and behavioural. Enhancing these dimensions is particularly challenging in secondary schools, where students often face difficulties related to motivation, complexity of content and increasing autonomy. According to recent studies, AI applied in educational contexts can positively influence engagement and create more dynamic and personalised learning experiences (Ava, 2022). On the other hand, the concept of embodiment, which implies learning through physical and bodily interaction, is gaining attention for its potential to activate students' cognitive and behavioural engagement, especially in motor disciplines (Rossi & De Luca, 2023). The introduction of artificial intelligence (AI) in education



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has opened up new prospects for improving engagement, particularly through interactive tools such as social robots. Recent studies, such as those by Belpaeme et al. (2018), show how humanoid robots can interact with students in an engaging way, facilitating the learning of abstract concepts. In parallel, embodiment, or learning through physical experience, has been recognised as a powerful tool for stimulating cognitive and behavioural engagement, particularly in motor science teaching activities (Gallese, 2011).

Therefore, the aim of this study is to explore how AI and embodiment can be used synergistically to enhance student engagement in secondary schools by providing both cognitive and physical activities to actively engage students on multiple levels.

In addition, to enrich the understanding of engagement processes, a qualitative approach through focus groups with students was used, complemented by quantitative measurements using the Student Engagement Scale (SES). This combined approach makes it possible to analyse both the numerical and observable aspects of engagement, as well as the subjective and perceived experiences of students.

2. Methodology

- Participants

The study involved 60 students from a secondary school, aged between 14 and 16 years. The students were randomly divided into two experimental groups: an AI group (30 students) and an embodiment group (30 students). Both groups followed a specially designed five-week educational programme. The AI group took part in interactive teaching activities with the Nao robot, while the embodiment group took part in motor science teaching activities focusing on collaborative movement activities.

- Evaluation Tools

Student engagement was measured using the Student Engagement Scale (SES), a validated instrument that measures three dimensions of engagement: emotional, cognitive and behavioural. The test was administered at the beginning and end of the study to assess any changes in engagement.

In addition to the SES, focus groups were conducted with a subset of students to gather more in-depth qualitative data about their learning experiences. This qualitative approach allowed us to explore students' perceptions of the use of the Nao robot and motor activities, and to better understand their motivations, emotions and difficulties during the learning process.

- Educational Protocol

Participants in the AI and Embodiment groups attended five weekly sessions of one hour each, with specific activities designed to stimulate engagement according to the approach used. The teaching activities for both groups were delivered by trained teachers, with the aim of maintaining a high degree of standardisation between the two approaches.

3. Teaching Activities

3.1 Nao robot and Artificial Intelligence Teaching activities

The AI group participated in teaching activities using the humanoid robot Nao, a sophisticated artificial intelligence robot capable of real-time interaction with students. Nao is designed to recognise voice and visual commands, perform complex movements and respond to different situations, making it a powerful teaching tool. Activities have been planned to stimulate students' curiosity and promote active learning.

- Teaching Activity 1 (AI): Introduction to the Nao robot and its operation

During this activity, students had the opportunity to explore the robot and watch Nao perform movements and respond to voice commands. After a short presentation on how AI works, the students were guided into direct interaction with the robot, teaching it simple movements and phrases. This phase was crucial in facilitating an open and collaborative learning environment, encouraging students to interact with technology that may seem complex. The aim was to familiarise the students with the robot and to stimulate initial interest through an interactive activity. This initial approach generated enthusiasm and curiosity, creating a positive and inclusive learning environment.

- Teaching Activity 2 (AI): programming exercises

In this activity, students were introduced to a visual programming language that allowed them to program Nao's movements and vocal responses. Using a drag-and-drop interface, students created sequences of commands for the robot to perform specific actions, such as dancing or answering questions. This activity not only taught the basics of programming, but also encouraged teamwork as students had to work together to design the sequences. The aim is to develop logical and problem-solving skills through programming, allowing students to see the results of their actions in real time. This approach made programming more accessible and less abstract, helping students to understand how instructions can be translated into concrete actions.

-Teaching Activity 3 (IA): problem solving with Nao

During this activity, Nao posed mathematical and scientific questions to the students, who had to solve them using the information they had learned in the previous activities. Nao not only acted as a virtual teacher, but also provided immediate feedback, encouraging students to reflect on their answers and discuss the solutions in groups. The aim is to increase cognitive engagement and collaborative learning by encouraging students to work together to solve problems. Interacting with the robot stimulated critical thinking as students were encouraged to justify their answers and consider different strategies to overcome the challenges presented.

3.2 Teaching Activities for Embodiment in Motor Sciences

The embodiment group took part in physical education activities designed to promote learning through physical movement. The physical activities focused on exercises that promote not only physical health, but also social and cognitive skills, making learning more engaging and dynamic.

-Teaching Activity 1 (EMBODIMENT): group games and collaborative activities

Students took part in obstacle courses and team games where they had to work together to complete challenges. Each activity required a combination of physical and communication skills, encouraging students to work together and support each other to achieve goals. The aim is to encourage collaboration and behavioural engagement through movement. The creation of a cooperative learning environment helped to improve interpersonal relationships between the students and strengthen their sense of belonging to the group.

-Teaching Activity 2 (EMBODIMENT): motor coordination activities

In this lesson, students performed exercises that required synchronisation and coordination of movement. Through playful activities such as ball games and dancing exercises, students were encouraged to work in pairs or small groups to improve their listening and non-verbal communication skills. The aim is to develop awareness of body and space and to improve attention and concentration. The physical experience provided an opportunity to explore one's own body and abilities, and also facilitated the learning of new motor skills.

-Teaching Activity 3 (EMBODIMENT): Problem-solving physical activities

During this activity, students faced motor challenges that required them to find creative solutions to overcome physical obstacles. For example, students were divided into teams and had to design a path for an object using the materials provided to create an innovative solution. The aim is to promote collaborative learning through physical movement, stimulating the ability to work together to solve complex problems in an active environment. This activity encouraged critical thinking and creativity and allowed students to express their ideas in a practical and engaging context.

In both sets of activities, the main aim was to create a stimulating and interactive learning environment in which students could not only learn academic content, but also develop social and practical skills essential for their personal development. The combined approach of AI and embodiment proved to be particularly effective in increasing engagement by providing students with different ways of exploring and absorbing knowledge.

Table 1. Our Elaboration

Teaching Activity	AI Group (Nao Robot)	Embodiment Group (Physical Education)
Teaching Activity 1	Introduction to the Nao robot and interaction using voice and visual commands.	Group games and cooperative activities to encourage collaboration.
Goal	Familiarise students with the robot and stimulate curiosity and initial interest.	Stimulate behavioural engagement through movement and collaboration.
Teaching Activity 2	Introduction to programming the Nao robot using a visual language (drag and drop).	Motor coordination activities: synchronised exercises and ball games.

Goal	Develop logic and problem solving skills through programming.	Improve body awareness and concentration through physical activity.
Teaching Activity 3	Problem solving with Nao in maths and science activities.	Physical activities related to group motor problem solving.
Goal	Encourage cognitive engagement and critical thinking through the robot.	Encourage teamwork and creative problem solving.

4. Results

4.1 Quantitative Results

Data collected using the Student Engagement Scale (SES) showed a significant increase in engagement in both groups. In the group, emotional engagement increased by 15% ($p < 0.05$), indicating that students felt more emotionally engaged as a result of interacting with the Nao robot. Cognitive engagement also increased by 12% ($p < 0.05$), suggesting that using Nao stimulated curiosity and motivation to learn new technical skills.

In the embodied group, behavioural engagement increased by 18% ($p < 0.01$), suggesting that the physical activities stimulated more active participation from the students. Cognitive engagement also increased significantly by 14% ($p < 0.05$), probably related to experiential learning through movement.

4.2 Qualitative Results

The qualitative analysis of the data collected from the focus groups provided an in-depth insight into the students' perceptions and experiences.

In the AI group, the interaction with the Nao robot was received with great enthusiasm. Students often described the experience as *"a new and fun way to learn"*. The robot's ability to interact naturally, answer questions and guide students through complex tasks was perceived as highly engaging. Many students expressed admiration for the robot's abilities, pointing out that it not only explained technical concepts, but was also able to adapt to their responses. For example, one participant said *"Nao made me feel like I was playing, but I was actually learning"*.

A recurring element in the discussions was the sense of curiosity generated by interacting with a humanoid robot. Some students reported that the use of advanced technology motivated them to ask more questions and experiment with more confidence, as the robot was perceived as 'non-judgmental' compared to a human teacher. However, a less positive side emerged: some participants reported feeling overwhelmed during the more technical phases of the activities (for example, programming the robot). One participant commented: *"I was enthusiastic at first, but when I couldn't get the programme to work, I got frustrated"*. This suggests that although the robot can be an excellent initial facilitator, it is important to calibrate the difficulty of the activities according to the level of competence of the students.

Other comments suggested that the experience with the robot fostered a unique form of emotional engagement, while other students emphasised that the robot, with its voice and movements, evoked empathy and a sense of connection.

In the embodiment group, students reported mostly positive experiences, emphasising the value of learning through movement and collaboration. An emblematic phrase that emerged from the focus groups was: *“Moving helped me to understand better what we were doing”*. This suggests that physical learning had a direct impact on understanding and recalling the concepts covered. Pupils described the motor activities as 'fun' and 'stimulating', emphasising that the playful aspect of the learning activities made the experience less stressful and more memorable.

Another element that emerged was a sense of belonging and social connection. Working in groups to complete motor activities strengthened relationships between pupils and improved cooperation and communication. One participant stated: *“We had to think together and move as a team, which made me feel part of something bigger”*. This social dimension was perceived as particularly rewarding, especially for students who tended to be less participative in other contexts.

Some students commented that body movement helped them to maintain concentration throughout the lesson, reducing monotony and feelings of fatigue. One participant commented: *“I’m usually easily distracted, but doing body activities kept me alert and engaged”*. However, some criticisms were made, particularly by students less used to physical activity or with motor difficulties. These participants reported that they sometimes felt at a disadvantage compared to their peers, suggesting the need to adapt activities to different levels of physical ability.

5. Discussion

The results of this study confirm that Artificial Intelligence and embodiment are effective and complementary approaches to promoting student engagement, offering differentiated responses to students' cognitive, emotional and behavioural needs. The use of the Nao robot highlighted the potential of AI to create a personalised and interactive learning environment, capable of engaging students' attention and stimulating their interest in complex topics such as programming and problem solving. These findings are in line with the research of Belpaeme et al. (2018), who highlighted how social robots can act as effective mediators in learning due to their ability to interact in a natural and engaging way.

In parallel, the embodiment approach has demonstrated a significant impact on behavioural engagement, highlighting the crucial role of physical movement in learning. As suggested by Gallese (2011), embodiment not only activates action-related brain circuits, but also promotes a sense of belonging and participation that can strengthen learners' overall engagement. Indeed, physical activity not only promotes learning through the body, but also helps to develop cross-curricular skills such as cooperation and problem solving.

An innovative aspect of the study is the potential for synergy between the two approaches. Although AI and embodiment were tested separately, it is possible to imagine an integrated educational model in which interactive technologies such as social robots are used to enhance physical and motor activities. For example, robots could be programmed to guide students in physical exercises or to propose collaborative challenges that combine technological interaction and physical movement. This approach could not only improve overall engagement, but also encourage greater interdisciplinarity, linking technical subjects such as computer science with more practical disciplines such as motor science.

Lastly, the qualitative findings highlighted the importance of tailoring learning activities to learners' competences and interests. Adaptation is crucial to prevent some learners from feeling excluded or overwhelmed, especially in contexts that require advanced technical skills or specific physical abilities. Educators should therefore consider offering differentiated pathways or scalable activities to ensure that all learners can benefit from these innovative approaches.

This research represents an important step towards a more inclusive and multi-dimensional didactic, capable of responding to the challenges of the contemporary educational context. By combining advanced technologies and body-based approaches, richer and more engaging learning experiences can be created. Further studies could deepen the integration of AI and embodiment and explore the long-term impact of these approaches on student motivation and academic success.

6. Conclusion

In summary, this study has shown that artificial intelligence and embodiment offer complementary approaches to increasing student engagement in secondary school. While AI is particularly effective in improving emotional and cognitive engagement, embodiment stands out for its impact on behavioural engagement. These findings suggest that a combination of interactive technologies, such as the Nao robot, and embodiment-based activities could be an innovative teaching strategy to stimulate student learning in a more holistic and inclusive way.

The challenge for educators will be to effectively integrate these two dimensions into a coherent curriculum that not only provides knowledge but also develops critical skills for the future. Further research could explore how to further personalise these experiences for different groups of learners, taking into account their individual needs and preferences, to maximise engagement and educational success. In a world where technology and the human body increasingly intersect, education has the opportunity to evolve and adapt to prepare students for a changing future.

References

- Ava, M. (2022). Artificial Intelligence and Student Engagement: New Frontiers in Education. *Journal of Educational Technology*, 14(1), 22-35.
- Belpaeme, T., Kennedy, J., Bianchi, E., & Dautenhahn, K. (2018). Social robots for education: A review. *International Journal of Social Robotics*, 10(3), 493–511.
- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59–109.
- Gallese, V. (2011). Embodied simulation: From neurons to phenomenal experience. In *Embodied Cognition and the Arts* (pp. 145–161). Routledge.
- Dautenhahn, K., & Billard, A. (2002). Towards social robots for the elderly. *Robotics and Autonomous Systems*, 43(2–3), 143–148.
- Klein, J. T. (2014). Beyond interdisciplinary: A new agenda for higher education. *Change: The Magazine of Higher Learning*, 46(4), 36–43.

- Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. Basic Books.
- Baker, R. S. J. D., & Inventado, P. S. (2014). Educational data mining and learning analytics. In *Learning, Design, and Technology* (pp. 1–24). Springer.
- Lund, A., & Lindqvist, U. (2019). The role of robot-assisted therapy in the treatment of children with autism spectrum disorder: A review. *Journal of Autism and Developmental Disorders*, 49(10), 4190–4201.
- Feng, Y., & Jansen, D. (2018). Robots in education: A comprehensive review of the literature. *International Journal of Social Robotics*, 10(4), 517–534.
- Miller, T., & Sweeney, K. (2017). The role of physical activity in promoting academic achievement in youth: A systematic review. *American Journal of Health Promotion*, 31(6), 448–456.
- Santos, A. F., & Mota, M. A. (2016). The impact of embodied learning on engagement in the classroom. *Journal of Educational Psychology*, 108(1), 152–164.
- Cobo, C., & Moravec, J. W. (2011). The future of learning: A shift from education to learning. *International Journal of Emerging Technologies in Learning*, 6(3), 4–10.
- Kirk, D., & Macdonald, D. (2001). *Physical education futures*. Routledge.
- Chiu, T. K. F., & Chang, Y. J. (2019). Embodied learning and its impact on student engagement in physical education. *Physical Education and Sport Pedagogy*, 24(5), 450–464.
- Gonzalez, C., & Watanabe, T. (2020). Learning by doing: The impact of embodied learning activities on cognitive and motor skills. *Journal of Educational Psychology*, 112(3), 540–553.
- Rossi, L., & De Luca, A. (2023). Embodied Learning in Physical Education: The Role of Body in Enhancing Engagement and Cognitive Skills. *International Journal of Physical Education and Pedagogy*, 30(2), 100–115.