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PEER LEARNING IN EDUCATION 5.0: STRENGTHENING THE TEACHING-LEARNING RELATIONSHIP IN TEACHING PROGRAMMING

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ABSTRACT

Education 5.0 emerges as a trend that integrates current technologies, aiming to promote the integral development of students and prepare them to face social, cultural, and professional challenges. This work presents a proposal that aligns theory and practice in the context of Education 5.0, using the Peer Learning methodology applied to computing disciplines. The initiative seeks to provide students with real project experiences in the classroom, encouraging learning through the practical application of their knowledge in interdisciplinary projects. This approach allows students to experience aspects of the professional routine, resulting in an improvement in learning, greater engagement with science, human development, and strengthening of critical thinking.

Keywords: Education 5.0. Peer Learning. Teaching of computing. Active methodologies.

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INTRODUCTION

Society 5.0 emerges as a paradigm in which technologies are integrated into everyday life to solve social problems and improve quality of life (VIEIRA et al., 2023). The reforms proposed by this new society aim to promote social harmony and create an inclusive and inclusive environment, allowing the active participation of citizens and meeting the diverse individual needs (VILLIERS, 2024).

The paradigm of Society 5.0 drives a continuous project of social transformation, from which the concept of Education 5.0 emerges. This new approach reflects the evolution of previous educational practices (1.0, 2.0, 3.0, and 4.0), shaped by significant historical events such as industrial revolutions, the advancement of technologies, the popularization of the Internet, and technological integration into teaching environments (FELCHER et al., 2022). Education 5.0 promotes the construction of a digital society that integrates social inclusion and sustainable practices as pillars of educational development (VIEIRA et al., 2023; PINE; SANTOS, 2023). However, according to Felcher (2022), Education 1.0 still predominates in many schools in Brazil, characterized by traditional methods, such as lectures and tests.

To adapt to this new reality, educational institutions need to adopt a mindset focused on solving social problems, promoting human well-being, and balancing economic growth and sustainability (VIEIRA et al., 2023; PINE; SANTOS, 2023). An example of this approach is the *International School of Asia* (ISAK), founded in 2014 in Karuizawa, Japan, which aims to use education to unite people and cultures, promoting inclusion and a sustainable future[5].

Society is constantly changing, which requires education to adapt to the needs of modern human beings (VIEIRA et al., 2023; LEAL et al., 2017). In this context, Education 5.0 questions the effectiveness of traditional teaching methods, such as the expository class, which is still widely used (PEREIRA, 2018). In this scenario, active methodologies, essential in Education 4.0, remain extremely relevant in Education 5.0. These methodologies promote the active participation of students, replacing the traditional teacher-centered model with a collaborative, student-focused format (FELCHER et al., 2022). To this end, some universities have implemented new teaching-learning methods, such as *Digital Storytelling*, Dialogued Class, Problem-Based Learning, *Role Play*, Verbalization Groups, and Technical Visits (LEAL et al., 2017; KOBRINSKII, 2022). These

[5] Accessed on 11/13/2024, https://uwcisak.jp/

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methods aim to help students contextualize the content learned more quickly, with a humanized and critical view, and using approaches that integrate appropriate technologies.

BACKGROUND

In the era of digital transformation, training in technological areas, such as Computer Engineering and Data Science, requires more than mastery of technical content. Currently, it is essential for students to develop skills such as management, critical thinking, teamwork, and the practical application of knowledge. However, the transition to modern pedagogical practices, capable of overcoming learning difficulties, still represents a challenge for institutions that continue to adopt traditional methods (PEREIRA, 2018; HEW; BRUSH, 2007). The expository approach, centered on the passive role of the student, limits the development of critical thinking and hinders the construction of inclusive and sustainable learning. To mitigate this problem, new teaching methods, such as Peer Learning and Collaborative Learning, have shown that students achieve better use when inserted in more dynamic and participatory learning environments.

To achieve this goal, it is essential that students feel comfortable building their own knowledge from what is taught, reflecting and applying the content in their social contexts. Thus, the classroom environment should be designed to be welcoming, interactive, and student-centered, promoting aspects such as creativity, collaboration, and reflection. This perspective is corroborated by Miller (2010), a professor at Olin College, one of the most innovative institutions in the United States, who argues that even in courses in exact areas, students have a better performance when the classroom environment resembles that of a preschool, where social interaction and sustainable thinking are stimulated.

Additionally, promoting interaction between students and organizing an appropriate environment with didactic resources are essential to add value to the educational process. In this space, the student should be encouraged to build knowledge based on their experiences and learning. For example, instead of limiting themselves to traditional, teacher-predefined tasks, students in programming disciplines could be motivated to develop more creative projects, such as simulations or games, that reflect their personal interests and motivations. In this model, the role of the teacher is similar to that of a researcher, who observes and analyzes the behavior of students, stimulating critical study and promoting deeper and more practical learning (PEREIRA, 2018). However, one of the main challenges faced is the resistance of teachers and students, who are often used to

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traditional teaching methods, such as the purely expository class (PEREIRA, 2018; FELCHER et al., 2022). For many educators, adopting collaborative methodologies implies a significant change in their pedagogical practices, which can be perceived as an overload of work.

As a contribution and in line with social transformations, including Education 5.0, this article proposes a methodology that allows students to experience the dynamics of projects during classes, integrating knowledge through modern teaching-learning methodologies, in an environment that stimulates critical and inclusive thinking. The rest of the article is organized as follows: Section 3 presents key concepts that are fundamental to understanding the proposal; Section 4 addresses related work; Section 5 details the methodology; Section 6 presents the discussions on the expected results; Section 7 presents discussions on the methodology and Section 8 discusses the conclusions and future work.

THEORETICAL FRAMEWORK

In this section, the conceptual basis that supports the proposal will be presented, including key concepts such as Peer Learning and Collaborative Learning.

PEER LEARNING

Peer Learning has stood out as a modern and effective pedagogical methodology in the current educational context (MAZUR, 2013). This approach was developed in 1991, after Mazur (2013), a professor at Harvard University, noticed the low performance of his students. Instead of continuing with the traditional expository class model, he implemented an innovative format, in which students studied the content independently at home and, during classes, answered questions and discussed the material with classmates, promoting more active and collaborative learning.

Peer Learning and Education 5.0 are connected, reflecting changes in the way teaching and learning are approached. Both approaches emphasize interaction, collaboration, inclusion, and the use of technologies to promote active learning. Peer Learning shifts the transmission of information outside the classroom and focuses on the most challenging aspect: making sense of information, promoting deep learning (MAZUR, 2013).

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Peer Learning can be defined as a teaching and learning methodology in which students learn from each other, without the immediate intervention of a teacher (BOUD, 2001). In this approach, students do not need to be the same age, which favors inclusion and fosters interaction between different groups. Students who learn through this methodology collaborate with each other, recognizing different points of view and increasing their chances of solving problems in different contexts. In addition, the development of interpersonal relationships in cooperative classrooms contributes to increased student participation and engagement, while reducing exclusion (FERGUSON-PATRICK, 2020).

The objectives of this methodology are to foster interaction between students during classes and direct their attention to the essential concepts, encouraging the connection with their own reality. Instead of following a traditional and detailed approach, such as the one present in textbooks, the classes are structured with brief presentations, focused on the key points of the content. After this stage, a conceptual evaluation is applied, containing points that encourage students to reflect on the concepts discussed.

COLLABORATIVE LEARNING

Collaborative Learning improves teaching by encouraging interaction and exchange of knowledge among students (JOHNSON; JOHNSON, 1987). The basis of Collaborative Learning lies in the creation of empathetic relationships among classroom participants, which can be strengthened by strategies that encourage interaction, partnership, and co-authorship. In addition, Collaborative Learning has an affective dimension, as the relationships formed are sustained by interpersonal bonds and bonds, contributing to a connected and meaningful learning environment. This methodology, aligned with Education 5.0, focuses on interaction between students, using technologies to promote more inclusive teaching and aimed at the development of socio-emotional skills.

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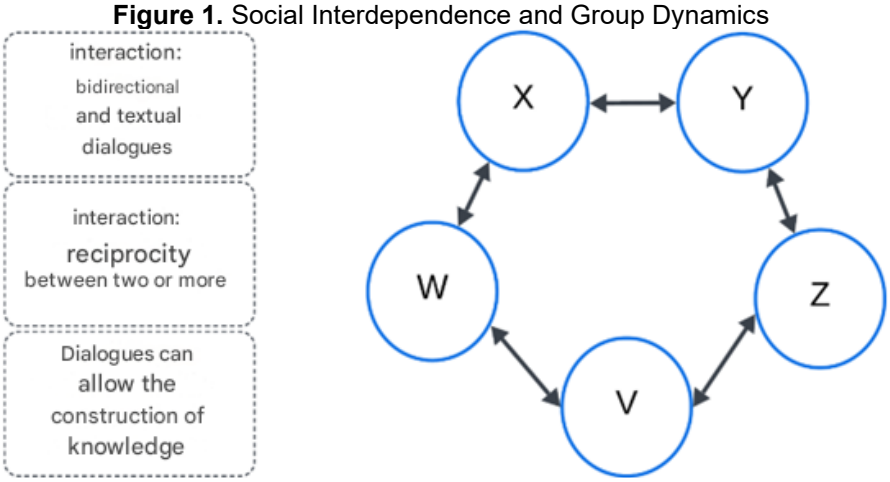
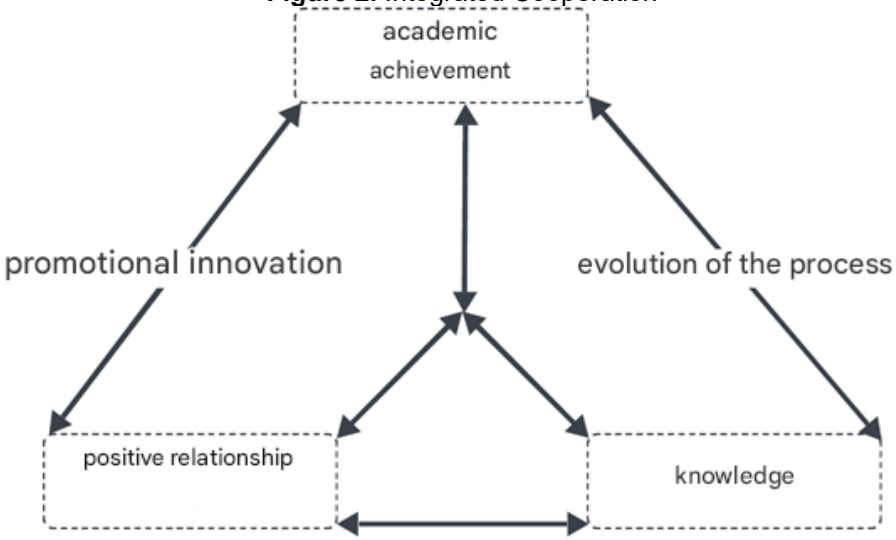
Figure 1. Social Interdependence and Group Dynamics



Source: Prepared by the authors

In a collaborative approach centered on students, it is essential to pay attention to the sociocultural aspects of the group so that collaboration effectively converts into learning, without being limited to making content and technologies available. It is necessary to guide the communicative processes and intervene in moments of doubt, perceive and implement adjustments. As illustrated in Figure 1, dialogues and interactions facilitate the construction of knowledge and promote reciprocity, favoring dynamic and motivating learning. The letters V, W, X, Y, and Z represent a person or a group of people. Figure 2 presents an adaptation to the integrated cooperation efforts proposed in (JOHNSON; JOHNSON, 1987).

Figure 2. Integrated Cooperation



Source: Prepared by the authors

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RELATED JOBS

This section examines and discusses some studies already conducted in the area, focusing on previous research that has addressed themes or problems similar to that of the research in question. Based on a theoretical foundation and practical experiences implemented in institutions such as the University of São Paulo (USP), two Colleges of Technology (Fatecs) and the Massachusetts *Institute of Technology* (MIT), the guidelines that underlie the object of study of this article are outlined: the relationship between teaching and learning in the context of Education 5.0, with emphasis on the Peer Learning methodology in programming education. To this end, this section presents a selection of studies that explore aspects such as educational tools, development of intercultural relationships, experience-based learning and collaborative learning.

The concepts related to Society 5.0 and Education 5.0 are based on studies by Grudowska and Zielinski (2022), Villiers (2024) and Felcher et al. (2022). According to Grudowska and Zielinski (2022), contemporary societies face global challenges, including digital transformation. Technological innovation plays a central role in this process, according to the principles of Society 5.0, a paradigm that sees technology as a solution to social problems and a driver of human development. For the authors, Society 5.0 represents a project of social change that involves a comprehensive transformation, affecting areas such as education and social relations. In the context of Society 5.0, Villiers (2024) discusses the objectives and premises of this approach, highlighting the need for a human-centred perspective and the emerging challenges, including the urgency of educational reform. The author proposes a reformulation of the curriculum in higher education, with an emphasis on technological, theoretical and practical literacy, aiming to prepare students for the advances of society.

For Vieira et al. (2023), Education 5.0 emerges in response to the transformations caused by technological advancement. These changes have impacted communication and social interactions, making it essential to understand that society is evolving. The transformation of the educational system is a priority to meet the demands of Society 5.0 and prepare students for contemporary challenges. Vieira et al. (2023) proposes a reflection on the topic, highlighting issues that require the attention of the scientific community and governments. In line with this view, Felcher et al. (2022) argue that the twenty-first century demands an education aligned with the needs of this new era,

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prioritizing an active and protagonist student, who seeks to learn and apply technology for the benefit of the community.

In a context of teaching focused on engineering, Klix (2014) states that, until the mid-1950s, training was predominantly practical, similar to the workshops of the Middle Ages, where masters guided their apprentices. With the advancement of the sciences, this approach has undergone significant transformations. Currently, the lack of practical experience among newly graduated engineers is recognized as a challenge by higher education institutions. For the innovation manager of the National Confederation of Industry (CNI), universities train engineers with a solid theoretical base, but who need to be inserted in the work environment to qualify. This process takes time, generates costs and impacts the productivity and competitiveness of the sector (KLIX, 2014). The scenario described by Klix (2014) reveals an academic reality in which trained professionals face increasing difficulties to work directly in the industrial environment. According to the author, traditional engineering courses in Brazil prepare students with a strong analytical capacity, which allows them to evaluate what has already been done, but limit their skills in synthesis and innovation.

Bispo Jr. et al. (2021) investigated the application of the Peer Learning method in a Logic course for Computer Science students in Brazil. The study revealed that the Peer Learning method contributed significantly to the improvement of student learning, based on absolute and normalized learning gain metrics. The method was widely accepted by the students, standing out for the interaction between colleagues and for the *feedback*, which facilitated the understanding of the concepts. However, the study identified challenges related to evaluation during group discussions, suggesting that adjustments will be necessary to improve the application of this methodology in the Brazilian educational context.

Oliveira and Rechia (2017) report an experience of applying the Peer Learning method, combined with mobile devices, in logic classes of a technical course in computer science integrated with high school. The study compared the performance of classes that used this methodology with those that followed the traditional expository model. The results showed that the combination of peer instruction with the use of cell phones increased student interaction and motivation, in addition to promoting significantly higher academic performance. The research also highlighted the potential of technological tools, such as

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Kahoot![6], to encourage collaboration and improve conceptual understanding in the classroom.

When discussing assessment in the Peer Learning methodology, Jones and Wheadon (2015) describe an exercise in which assessment criteria were intentionally avoided, but still the reliability and validity of the results were achieved. Based on this analysis, the authors present two main arguments: a comparative judgment approach, applicable to different contexts, and an alternative technique based on absolute judgment, which demonstrated low reliability and validity. The success of both approaches depends on how peer review is structured. In a related study, Hovardas et al. (2014) investigate the quality of *peer feedbacks* in high school, comparing them with feedbacks provided by experts.

Regarding educational tools, Loncar et al. (2014) conduct a literature review on the use of forums and asynchronous discussions in various educational contexts, ranging from undergraduate to graduate programs. In turn, Kwon et al. (2013) propose a *web* tool aimed at group coordination, an essential component for collaborative learning. The results indicate that groups that use the tool more actively are able to establish positive interdependence and engage in constructive interactions, which leads to greater collective productivity.

The literature also addresses studies on the development of intercultural relationships, experience-based learning, and collaborative learning. Strijbos and Fischer (2007) highlight the methodological challenges in collaborative learning research, offering an overview of the methods used and identifying opportunities and challenges when combining different methodological approaches. Kudo et al. (2017) review the development of relationships between international and local students, analyzing the interaction between individual and environmental dimensions in the learning process.

Incrementally to the previous approaches, the proposal of this article integrates several modern educational methodologies, aligned with the principles of Education 5.0, and involves students in real projects in the area of technology. This model allows students to experience the routine of a programming professional, developing critical thinking and active participation in real projects. With an emphasis on sustainability and integration with its own context. In addition, the proposal enables students to train other students,

[6] O Kahoot! It is an interactive learning platform that uses games to engage students in a dynamic and collaborative way. Accessed on 11/1/2024, https://kahoot.com/

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encouraging inclusion and knowledge sharing — fundamental concepts in the new pedagogical practices of teaching and learning in the contemporary educational scenario.

METHODOLOGY

The proposed methodology will, *a priori*, be conducted by higher education professors, with the expectation that, after consolidation, it will include high school professors and students from technological courses, such as Engineering and Technologists, who will act as tutors. The teachers involved may be from different areas, such as Computing, Mathematics, Humanities, Engineering and other sciences. These teachers will be responsible for supervising the tutors and, at a later stage, training teachers from the public network.

Student-tutors will participate in meetings with their advisors and produce detailed reports to monitor the progress of activities and identify potential difficulties. At the end of the program, each tutor must write a report of the work carried out, the results achieved and their perceptions of the difficulties faced. The methodology aims to provide the student with the ability to realize the importance of teamwork, learn to deal with pressure and experience situations close to the reality they will face after completing the course.

It is proposed to create a collaborative and inclusive space, aligned with the principles of Education 5.0, which strengthens the integration between methodology, theory and practice in real technology-based projects, making teaching more engaging. This environment will be inspired by MIT laboratories, such as the Media Lab and the Fab Lab[7], in addition to the application of the Peer Learning method (MAZUR, 2013) and Collaborative Learning (LAAL; GHODSI, 2022). To this end, the following actions are proposed:

I. Training of university professors for the implementation of the Interactive Instruction methodology[8] based on Peer Learning;
II. After teacher training, to make teaching more playful and engaging, it is essential to adapt the space and apply the concepts acquired during training in everyday classes. For this adaptation, it is proposed to create a laboratory

[7] They are interdisciplinary research laboratories that stimulate the unconventional combination of different areas of research. More information can be found at https://www.media.mit.edu/ and https://news.mit.edu/2023/how-mits-fab-labs-scaled-around-world-0605
[8] Interactive Instruction is a teaching approach that actively involves students in the learning process through activities, discussions, and interactions with the content (CABALLERO et al., 2014)

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dedicated to innovation in teaching, technology and creativity, inspired by initiatives already implemented at MIT. The focus will be to integrate the Peer Learning method to foster interactivity and collaboration in the educational environment;

III. Exposure of students to real programming projects, aiming to replicate the challenges of daily professional life, using the methodology of the Case Method[9];

IV. Students will act as tutors in the programming disciplines, playing the role of learners who teach and share knowledge. In this methodological model, the effectiveness of learning is maximized, reaching up to 95% retention, by involving students in the teaching of what they have learned (SUBRAMONY, 2003);

V. The evaluation will be conducted through detailed surveys, designed to capture students' perception of the methodology and its impact on learning. However, the proposal aims at continuity, with the objective of obtaining more significant results after the end of the student's permanence cycle at the university;

VI. After the consolidation of the proposal, partnerships will be established with schools to expand the methodology to elementary and high school teachers.

ORGANIZATION

For the methodology to become integrative and stimulating, it is necessary to propose situations that allow the student to develop their skills. Among them, the following stand out:

I. Propose projects and request suggestions for problem situations so that students are motivated and identify with the subject to be researched;

II. Establish criteria for all activities. For example: define a limit of pages or words, minimum number of references, language to be adopted, importance of spelling and application of technical writing standards, in addition to the quality of individual or group collaboration, using objective indicators;

[9] The Case Method is a pedagogical approach that involves the analysis and resolution of real problems, promoting active learning and the development of critical skills (HAN et al., 2022).

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III. Create discussion groups, monitor and mediate them during the meetings, intervening and assisting when necessary, in addition to reviewing and clarifying concepts;
IV. Promote activities that encourage collaboration, defining roles and dynamically rotating them throughout the process, so that students teach each other;
V. To provide individual and collective responses, promoting formative assessment and valuing the different contributions generated.

EVALUATION

The evaluation process aims to monitor learning gradually and continuously. For this, evaluative instruments can be used, such as Formative Feedback, Peer Evaluation and Learning Diaries. These instruments should be structured with indicators that allow the identification of the development of critical thinking, interaction skills, information generation, problem solving, and the promotion of self-regulation in the teaching-learning process.

EXPECTED OUTCOMES

As expected results from the proposed methodology, there are:

I. Lower number of student failures and better assimilation of theoretical and practical knowledge from the interdisciplinarity of teachers;
II. Improvement in interpersonal relationships between students, in addition to improving critical reflection on the contents studied, establishing connections with the life experience of each student;
III. Greater preparation of students for the job market, expanding their ability to work in teams and develop applied scientific research, from a critical view of the real world, based on validated empirical models;
IV. Better training of teachers, acquired from interdisciplinarity and the study of new methodologies, which can be a differential in the updating, recycling and scientific production of teachers;
V. Introduce students to a new way of learning, demystifying the prejudiced conceptions that are incorporated from their youth about the sciences, such as "difficult", "full of bills" or "irrelevant to everyday life";

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VI. Improvement of the level of learning and feeling of belonging to a student group, encouraging participation in student events. For example, the participation of students in competitions such as the Brazilian Mathematical Olympiad, the Programming Marathon, or the Portuguese Language Olympiad. These events promote the practice of concepts in a playful and competitive way, expanding interest in the area. In addition, they strengthen the bond between students and the institution, while developing fundamental skills such as problem-solving and teamwork;

VII. Construction of a humanistic, inclusive and sustainable vision based on the knowledge acquired, encouraging students to apply their skills in projects that benefit society, respect diversity and promote responsible practices.

DISCUSSION

The Collaborative Learning methodology fosters positive interdependence, where individual success depends on group success, and reinforces both individual and collective responsibility, requiring each member to contribute to the outcome. The diversity in the groups favors the exchange of experiences and different perspectives, creating a more enriching and collaborative learning environment. Leadership is shared, allowing different members to take on responsibilities as needed, which favors the development of coordination skills and autonomy.

There is constant attention to the learning of all members, focusing on solving the task, which favors the development of social skills such as communication and teamwork. Productivity is monitored during group dynamics, while mutual support strengthens the self-motivation of the participants.

The benefits of the methodology using Collaborative Learning can be highlighted: positive interdependence, individual and collective responsibility, heterogeneity, shared leadership, concern with the learning of others, focus on solving the task, social skills, accompanied productivity and self-motivation.

FINAL CONSIDERATIONS

This work proposed a methodology that combines Peer Learning, Collaborative Learning and interdisciplinarity to integrate theory and practice. The objective is to provide

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the student with an experience with real projects that represent the daily life of professionals in the programming area.

This allows students to share this knowledge with other students, stimulating them in the search for new knowledge. At the same time, the methodology improves the learning and professional training of future university graduates, better preparing them to enter the job market.

Education 5.0 seeks to prepare students not only for the job market, but also to face complex social, cultural, and environmental issues, promoting a more humanized education. Education 5.0 integrates seamlessly with these methodologies, combining the use of technologies, collaboration, and creative solutions to the challenges of the contemporary world. As future works, the integration of new methods, such as *Digital Storytelling*, *Problem-Based Learning*, Observation Groups and Technical Visits, can be incorporated into the methodology to add more value to learning.

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