SEMINARS AS CATALYSTS FOR ACTIVE LEARNING IN A CASE STUDY OF TECHNOLOGICAL UNIVERSITY EXTENSION PROJECTS

SEMINÁRIOS COMO CATALISADORES DA APRENDIZAGEM ATIVA EM UM ESTUDO DE CASO DE PROJETOS DE EXTENSÃO UNIVERSITÁRIA TECNOLÓGICA

SEMINARIOS COMO CATALIZADORES DEL APRENDIZAJE ACTIVO EN UN ESTUDIO DE CASO DE PROYECTOS DE EXTENSIÓN UNIVERSITARIA TECNOLÓGICA

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Abstract. This study explores the role of seminars in fostering active learning within technological university extension projects. Using the study of methods such as Problem-Based Learning (PBL), Project-Based Learning (PjBL), and STEAM approaches, seminars serve as dynamic platforms for enhancing student engagement, critical thinking, and collaboration. Key elements include the integration of direct activities, interdisciplinary teamwork, and community interaction. By leveraging Information and Communication Technologies, these initiatives bridge theoretical knowledge with practical applications, preparing students to address real-world challenges. The findings emphasize the promotional potential of seminars in fostering innovative educational practices and collaborative knowledge production in higher education extension programs.

Keywords: active learning methodologies; collaborative knowledge; problem-based learning (PBL); seminars; STEAM education

Resumo. Este estudo explora o papel dos seminários na promoção da aprendizagem ativa em projetos de extensão universitária tecnológica. Utilizando o estudo de métodos como a Aprendizagem Baseada em Problemas (PBL), Aprendizagem Baseada em Projetos (PjBL) e abordagens STEAM, os seminários servem como plataformas dinâmicas para aumentar o engajamento dos estudantes, o pensamento crítico e a colaboração. Elementos-chave incluem a integração de atividades diretas, trabalho em equipe interdisciplinar e interação com a comunidade. Ao aproveitar Tecnologias da Informação e Comunicação, estas iniciativas conectam o conhecimento teórico com aplicações práticas, preparando os estudantes para desafios reais. Os resultados destacam o potencial promotor dos seminários em práticas educacionais inovadoras e produção colaborativa de conhecimento em programas de extensão do ensino superior.

Palavras-chave: aprendizagem ativa; conhecimento colaborativo; aprendizagem baseada em problemas; seminários; educação STEAM

Resumen. Este estudio explora el papel de los seminarios en el fomento del aprendizaje activo en proyectos de extensión universitaria tecnológica. Utilizando el estudio de métodos como el Aprendizaje Basado en Problemas (PBL), Aprendizaje Basado en Proyectos (PjBL) y enfoques STEAM, los seminarios actúan como plataformas dinámicas para mejorar la participación de los estudiantes, el pensamiento crítico y la colaboración. Los elementos clave incluyen la integración de actividades directas, el trabajo en equipo interdisciplinario y la interacción comunitaria. Aprovechando las Tecnologías de la Información y la Comunicación, estas iniciativas vinculan el conocimiento teórico con aplicaciones prácticas, preparando a los estudiantes para enfrentar desafíos reales. Los resultados destacan el potencial promotor de los seminarios en prácticas educativas innovadoras y producción colaborativa de conocimiento en programas de extensión de educación superior.

1. INTRODUCTION

Active methodologies have gained increasing importance in higher education, particularly within the context of technological university extension projects, as they encourage active engagement and practical learning experiences (Teixeira et al., 2019a; Teixeira et al., 2019b). Methods such as Problem-Based Learning (PBL), Project-Based Learning (PjBL), and STEAM (Science, Technology, Engineering, Arts, and Mathematics) education have demonstrated significant benefits in fostering critical thinking, collaboration, and innovation among students (Cardoso et al., 2024; Nascimento et al., 2020;Vitorio & Exposito, 2024; Teixeira et al., 2020a; Teixeira et al., 2020b). Seminars and workshops play a vital role in applying these methodologies, offering platforms for students to engage with real-world problems, interact with industry professionals, and develop practical skills (Tseng et al., 2017). These interactive learning environments not only support the development of technical knowledge but also emphasize the importance of communication and teamwork in addressing complex issues (Astudillo, Nogueira, & Ortiz, 2020; Teixeira et al., 2019a; Teixeira et al., 2019b). Furthermore, the integration of digital tools and e-learning platforms enhances the accessibility and effectiveness of these learning experiences, especially in today's technologically driven academic landscape (Ros et al., 2020). By promoting student-centered, direct activities, seminars and workshops contribute significantly to the holistic development of students, preparing them for challenges in both academia and industry.

1.1 The Role of Active Methodologies in Technological University Extension Projects

Active methodologies in higher education, particularly within technological university extension projects, focus on increasing student engagement and providing practical learning experiences. Approaches like Problem-Based Learning (PBL), Project-Based Learning, and STEAM methodologies are key to developing critical thinking and teamwork skills among students. Workshops and seminars create spaces to apply these methods, enhancing the overall educational experience and preparing students for challenges in the real world.

Active Methodologies Overview:

- Problem-Based Learning (PBL): This approach encourages students to tackle real-world problems, fostering critical thinking and collaboration (Vitorio & Exposito, 2024; Cardoso et al., 2024).
- Project-Based Learning: By combining different disciplines, project-based learning enables students to apply their knowledge in practical settings, which is crucial in engineering education (Portillo-Blanco et al., 2023).
- STEAM Approaches: These methods emphasize interdisciplinary learning and promote creativity and innovation while addressing socio-scientific issues (Portillo-Blanco et al., 2023).

Role of Seminars and Workshops:

- Interactive Learning: Workshops provide direct activities, such as logic games, which help reinforce theoretical knowledge (Vitorio & Exposito, 2024).
- Community Engagement: Seminars can engage community members, fostering a collaborative learning environment and increasing the relevance of academic projects (Vitorio & Exposito, 2024).

Technology Integration:

- Digital Tools: The use of Information and Communication Technologies (ICT) helps increase student engagement and supports active learning approaches (Astudillo et al., 2020; Ros et al., 2020).
- E-Learning Platforms: Online platforms facilitate communication and collaboration among students, making learning more accessible (Astudillo et al., 2020).

While active methodologies have a strong impact on learning outcomes, some educators argue that traditional teaching methods remain valuable, especially for foundational knowledge acquisition. A balanced approach combining both methods can provide a more well-rounded educational experience.

1.2 Active Methodologies in Technological University Extension Projects: Enhancing Student Engagement and Real-World Problem-Solving

Active methodologies in technological university extension projects are designed to increase student engagement and develop real-world problem-solving abilities. These approaches emphasize active participation, collaboration, and the integration of technology to create rich learning experiences. Below are several key active methodologies applied in these projects.

Problem-Based Learning (PBL):

- PBL encourages students to solve real-world problems, promoting critical thinking and teamwork.
- At the Faculty of Technology, students developed logic games and shared their findings through community workshops (Vitorio & Exposito, 2024).

Collaborative Learning:

- This approach fosters teamwork, allowing students to learn from one another while tackling shared tasks.
- The combination of collaborative learning and new technologies has proven to enhance student autonomy and critical thinking (Aparicio-Gómez et al., 2024).
  - Project Methodology:
  - This approach follows several phases that guide students in producing knowledge and engaging in active learning.
  - It emphasizes meaningful learning experiences that align with the principles of Critical Meaningful Learning (Borille et al., 2020).

Although these methodologies significantly enhance learning outcomes, challenges such as limited resources and the need for proper training for educators may hinder their effective implementation in certain contexts (Ros et al., 2020).

1.3 Active Learning Methodologies in Higher Education: Enhancing Engagement and Skill Development

Active learning methodologies in higher education, especially in seminars and workshops, focus on increasing student engagement and fostering collaboration. Approaches like Problem-Based Learning (PBL), flipped classrooms, and peer instruction promote critical thinking and practical skills, preparing students for real-world challenges. The use of these methodologies improves the educational experience and equips students with the tools they need for future success.

Key Active Methodologies:

- Problem-Based Learning (PBL): This method encourages students to solve real-world problems, improving their critical thinking and teamwork skills (Cardoso et al., 2024; Vitorio & Exposito, 2024).
- Flipped Classroom: In this approach, students study content outside of class and engage in direct activities during class time, deepening their understanding of the material (Cardoso et al., 2024; Teixeira et al., 2019a).
- Peer Instruction: Peer instruction allows students to learn from one another by teaching and sharing knowledge, which works effectively in both physical and online learning environments (Santos et al., 2024).

Benefits of Active Learning:

- Improved Retention: Active learning strategies have been shown to enhance students' comprehension and retention of the material (Vîșcu, 2024).
- Skill Development: These methodologies help develop essential skills such as creativity, problem-solving, and interpersonal communication (Vitorio & Exposito, 2024).

Although active learning has clear benefits, some educators still value traditional lecture-based methods, especially in subjects that require a heavy focus on content delivery. However, the shift towards active learning is part of a larger trend in education, aimed at creating a more engaged and capable student body.

1.4 Enhancing Engineering Education: The Role of Seminars and Workshops in Skill Development and Career Preparation

Seminars and didactic workshops play a vital role in enriching the educational experience of engineering students and preparing them for their future careers. These events provide opportunities for students to engage with contemporary industry practices, develop essential skills, and explore various engineering fields. The following sections discuss key aspects of these educational initiatives.

Workshops and seminars play a vital role in education and professional development, offering students opportunities to acquire practical skills and gain exposure to emerging industry trends. Workshops focus on skill development, particularly in areas such as communication and problem-solving, which are essential for engineering professionals (Alam & Mohanty, 2023). Meanwhile, seminars introduce students to industry-relevant topics, including sustainable manufacturing and the Internet of Things (IoT), ensuring they remain informed about evolving challenges (Tseng et al., 2017; Tseng et al., 2016).

The structure and format of these events contribute to their effectiveness. Interactive learning techniques, such as group discussions and direct activities, are commonly integrated into workshops to enhance student engagement (Fosmire et al., 2015). Additionally, seminars and workshops often feature diverse presentations, with speakers ranging from faculty members to industry professionals, providing students with a broad spectrum of perspectives on engineering topics (Duncan et al., 2012).

Student feedback highlights the positive impact of these initiatives. Participants frequently report that workshops and seminars enhance their knowledge and skill set, with many expressing increased confidence in their abilities (Tseng et al., 2017; Tseng et al., 2016). Furthermore, career preparation is a significant benefit, as these events help students explore potential career paths and develop the competencies required for success in the engineering field (Ganapati & Ritchie, 2021).

Despite their numerous advantages, some critics argue that workshops and seminars may not fully address the diverse needs of all students, particularly those who require more personalized support in their learning journey. However, with continuous improvements and adaptations, these educational formats can become even more inclusive and impactful.

2. METHODOLOGY

The seminar activity was an integral part of the academic requirements for two courses: EMTi17 (Introduction to Materials Engineering) in 2019 and EMTi26 (Biomaterials) in 2019 and 2024. Coordinated by the instructor of these courses, from the Integrated Engineering Institute (IEI) at the Federal University of Itajubá, Campus Itabira, the seminar aimed to connect theoretical concepts with practical applications. Its primary goals included fostering interdisciplinary collaboration, promoting innovation, and encouraging problem-solving among students.

The activity involved undergraduate students from the Materials Engineering program: 32 students in 2019 (EMTi17 and EMTi26) and 10 students in 2024 (EMTi26). Students worked in small groups of three to four members. Each group selected a topic related to biomaterials (Teixeira & Silva, 2024; Teixeira et al., 2023), ensuring that it addressed technical, economic, and social aspects. The seminar's implementation followed three structured stages:

1. Topic Selection and Introduction to the PM Canvas Framework: Students were introduced to the Project Model Canvas framework (Finocchio Júnior, 2016), a project management tool designed to simplify planning and execution. This framework revolves around five core questions: Why? What? Who? How? When and how much? With faculty supervision, students completed the Canvas collaboratively, setting clear objectives and aligning their deliverables with course goals.
2. Monitoring and Progress Tracking: Groups used a control panel to record progress, identify milestones, and incorporate faculty feedback. This step ensured that deadlines were met and that the work maintained the required quality standards.
3. Seminar Preparation and Presentation:
    a. Seminar Structure: Each group prepared a presentation lasting between two and seven minutes to summarize their findings. They also created video content, uploaded it to YouTube, making it accessible to a broader audience beyond the university.
    b. Interactive Sessions: After each presentation, a five-minute Q&A session encouraged active participation and deeper discussion of the topic.
    c. Timeline and Venue: The seminar preparation phase began on October 10, 2019, and culminated in the final presentation on November 22, 2019, held at the José de Alencar Auditorium, Building 1.
    d. In 2019 and 2024, the teacher coordinator shared the scientific extended abstracts and videos, which were meticulously prepared by each participating student group, through their professional profile on the internet; these materials, carefully curated and intended to highlight the outcomes of the students' collaborative efforts, are accessible via Ricardo L.P. Teixeira's profile page online, where they serve as a resource for academic and professional reference (Teixeira, 2024a; Teixeira, 2024b).

The evaluation comprised two components: the seminar presentation and the extended abstract. A detailed grading system ensured a fair and comprehensive assessment:

Seminar Presentation (8.0 points):

- Objectivity, clarity, and use of technical language (10%).

- Adherence to time limits (10%).
- Visual representation of processes (10%).
- Effective use of data visualization tools, such as graphs and tables (30%).
- Verification of group collaboration (10%).
- Analytical depth and relevance of discussions (30%).

Extended Abstract (2.0 points):
- Objectivity, clarity, and technical language (30%).
- Technical graphics and documentation (30%).
- Analytical depth and relevance of discussions (40%).

The final score was the sum of the seminar (8.0 points) and the extended abstract (2.0 points), totaling 10 points.

The seminar served as a valuable learning opportunity for students from EMTi17 and EMTi26, allowing them to apply theoretical knowledge in a practical and collaborative setting. By addressing real-world challenges in biomaterials, students improved their teamwork, critical thinking, and technical communication skills. Moreover, the use of the PM Canvas framework provided direct experience with project management methodologies, preparing them for professional scenarios.

Additionally, the external reach of the seminar was significant, with an estimated audience of over 4,000 internet users accessing content via the coordinator's website. These numbers are based on data from Ricardo L.P. Teixeira's Workshop and blog statistics (Teixeira, 2024a; Teixeira, 2024b; Teixeira, 2024c).

2.1 Seminar Format in the Biomaterials Seminar 2024

The seminar format for the Biomaterials Seminar 2024 follows a structured and interactive approach to encourage student engagement and interdisciplinary collaboration. The seminar is part of the EMTi26 (Biomaterials) course and takes place from November 7 to December 20, 2024, involving one instructor and 10 Materials Engineering students. It is designed to enhance the understanding of biomaterials in healthcare applications through a combination of theoretical and practical learning experiences (Teixeira, 2024c).

The seminar is divided into two main components for evaluation: a written summary and a video presentation. Each component accounts for 50% of the final grade. The written summary should demonstrate clarity, objectivity, and technical accuracy, while the video presentation, published on YouTube, offers an opportunity for students to present their findings in an accessible format to a broader audience (Teixeira, 2024b, Teixeira, 2024c). The video presentation is shared through the instructor's personal webpage, allowing for the dissemination of knowledge within and beyond the academic community.

Throughout the seminar, students select topics of technical, economic, and social relevance related to biomaterials, focusing on their innovative applications in medical fields. The seminar encourages active participation through collaborative discussions and direct activities, facilitating both individual and collective learning. By exploring current challenges and advancements in the biomaterials sector, students are prepared to contribute to the development of sustainable and practical solutions in healthcare (Teixeira, 2024c).

This format emphasizes the integration of emerging technologies, the development of communication skills, and the application of critical thinking in real-world scenarios, reflecting a modern approach to higher education seminars in the field of biomaterials.

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2.2 Workshops Format in Materials Processing and Engineering 2019

The extension workshop, designed as part of the disciplines EMTi17 (Metallic Materials Processing) and EMTi26 (Biomaterials), involved 32 students from the Materials Engineering course, one coordinating professor, and eight collaborating professors (tutors). The coordinating professor asked the 32 presenters to form groups of three (with a maximum of four members), led by a group leader, to carry out the proposed workshop, which included seminars and extended abstracts based on topics chosen by the students, under the guidance of the coordinating and collaborating professors (Teixeira, 2024a; Teixeira et al., 2020).

The students were asked to choose a topic related to either Metallic Materials Processing (EMTi17) or Biomaterials (EMTi26). The selected topics needed to have technical, economic, and/or social relevance, preferably with an innovative and practical character. The workshop was divided into three phases: Explanation of the Project Model Canvas ; Creation and correction of the progress panel (Progress Spreadsheet); Presentation and evaluation of seminars and extended abstracts (on November 22, 2019).

The "Project Model Canvas" method focuses on explaining the five fundamental questions that guide the methodology: (Why?, What?, Who?, How?, and When/How much?), as well as the relationships between all the components (Finocchio Júnior, 2016). The Canvas was completed step by step, following the sequence of these questions, and the work produced by the groups was reviewed by the coordinating and collaborating teachers.

A spreadsheet was provided to the student groups to record their progress, along with deadlines for answering each question of the PM Canvas. The final presentation and abstract submission deadline were November 22, 2019.

The seminar presentations were required to be between two and eight minutes long. The assessment criteria for the seminars, as established by the coordinating professor, included the following: time adequacy, clarity and technical language, graphic records of the process, the use of appropriate graphs, tables, and equations for data presentation, and analysis and discussion of the issue. The seminar evaluations were carried out by the coordinating professor and, additionally, each group leader also evaluated the performance of the group and collaborators.

At the end of the seminar presentations, a grade out of 10 was assigned to each group. The YouTube video links for the seminars were submitted via email to the coordinating professor by November 22, 2019, along with identification information for the title and group members.

To assess the students' learning, they were asked to complete a final individual evaluation form, which analyzed their activities during the workshop, including the use of the PM Canvas. This assessment aimed to evaluate motivation, the perception of transdiciplinarity, and other aspects observed through the final Learning Survey (APE).

2.3 Assessment of Student Learning

To evaluate student learning, participants were required to complete an individual learning evaluation form, referred to as the final Student Learning Assessment (APE), as described by De Rezende Júnior et al. (2013). This form aimed to analyze various aspects of the students' experiences during the workshop, including their contributions to the preparation of projects using the PM Canvas methodology. Additionally, the survey sought to measure motivation, perception of transdiciplinarity, and other related factors (see Table 1).

The APE served as a quantitative assessment tool, encompassing seven criteria evaluated through an online survey. Students rated their responses according to the Scoring Guide provided in Table 1. The final APE result, reflecting the end-of-term assessment, was determined at the semester's conclusion. Radar charts were utilized to illustrate changes in student motivation across the EMTi17 and EMTi26 courses. The analysis yielded valuable

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insights into the effectiveness of the workshop activities in enhancing engagement and meeting the educational objectives of both courses.

Table 1. Student Learning Assessment Questions

Question	Rating Scale (1 to 5)
1. Do you feel motivated to complete the proposed project?	
2. Do you consider the proposed project relevant for learning in Materials Engineering?	
3. Do you perceive the integration of knowledge in the proposed project?	
4. Do you consider the characterization of the material for this project to be straightforward?	
5. Is the time allotted to complete the activities appropriate?	
6. Did you understand the proposed format for presenting results and evaluation?	
7. Do you believe the proposed educational objectives will be achieved?	

Note: Scoring Guide: 1.0: No, definitely not; 2.0: No, partially; 3.0: Yes, partially; 4.0: Yes.; 5.0: Yes, definitely; 0 or NA: Not available.

Source: Teixeira et al (2020, p. 25)

3. RESULTS

The seminars conducted as part of the Introduction to Materials Engineering (EMTi17) and Biomaterials (EMTi26) courses at UNIFEI demonstrated significant improvements in student engagement and collaborative learning. A total of 42 students participated across the two iterations of the seminar: 32 in 2019 and 10 in 2024. The activities integrated Problem-Based Learning (PBL), Project-Based Learning (PjBL), and STEAM methodologies to enhance critical thinking and technical skills.

Key findings include the following:

- Student Performance: Groups were assessed on both their seminar presentations and extended abstracts. Presentations were evaluated based on clarity, technical accuracy, and the use of data visualization tools. Extended abstracts highlighted the depth of analysis and documentation quality. The average scores exceeded 7.0 out of 10.0, indicating strong overall performance.
- Skill Development: Students reported improvements in teamwork, critical thinking, and technical communication skills. The integration of the Project Model Canvas provided hands-on experience with project management methodologies.
- Community Impact: Seminar presentations were shared via online platforms, reaching an estimated audience of over 4,000 internet users. This dissemination not only broadened the scope of the activity but also connected academic projects with community and industry needs.
- Interdisciplinary Collaboration: The topics selected, including biomaterials and metallic materials processing, encouraged students to explore technical, economic, and social dimensions of real-world challenges.
- Despite these positive outcomes, challenges such as time constraints and material characterization difficulties were noted. These findings highlight the importance of structured planning and sufficient resources for successful implementation.

The results underscore the transformative potential of integrating active learning methodologies into engineering education. By bridging theoretical knowledge with practical

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applications, these seminars contribute to preparing students for real-world challenges and professional growth.

4. DISCUSSION

The extension project Biomaterials Seminars, conducted in 2024 as part of the Biomaterials course (EMTi26) in the Materials Engineering program at UNIFEI, fostered interdisciplinary collaboration and facilitated the dissemination of knowledge in the field of biomaterials. This initiative involved the active participation of 6 to 10 undergraduate students and addressed innovative and healthcare-relevant topics, including dental composites, coronary stents, 3D-printed biological materials, and hybrid drug delivery systems.

As an academic outcome of this extension project, four academic articles were produced. Although these articles were not presented at scientific conferences, they were evaluated as part of graded activities in the virtual learning environment (SIGAA-AVA) for EMTi26. The evaluations adhered to the course plan established by the instructor, Prof. Ricardo Luiz Perez Teixeira.

The first article, titled Biomaterials in Dentistry: Applications of Innovative Dental Composites, examined the use of polymeric matrices and ceramic particles in dental materials, highlighting advancements in mechanical resistance, biocompatibility, and longevity achieved through nanotechnology (e.g., silica and zirconia). The second article, Stents: Endoprostheses, explored the development of stent technology, covering metallic, pharmacological, and bioresorbable stents. It focused on innovations aimed at improving biocompatibility and reducing complications such as thrombosis and restenosis.

The third study, FDM Printing of Biological Materials, investigated the fabrication of scaffolds made from poly(vinyl alcohol) (PVA) and beta-tricalcium phosphate (β-TCP) through 3D printing for bone tissue engineering. The research highlighted enhancements in mechanical properties and bioactivity, emphasizing their potential for partial load-bearing and personalized bone regeneration. The fourth article, Hybrid β-Cyclodextrin-Synthetic Polymer Systems for Complexation of Hydrophobic Drugs, proposed a hybrid system combining β-cyclodextrin and smart polymers to improve the solubility and stability of hydrophobic drugs, particularly antitumor agents.

Under Challenges and Student Feedback, student performance was evaluated using a detailed rubric that highlighted key difficulties, as shown in the results of the Educational Process Evaluation (APE) in Figure 1. The most significant challenge identified was material characterization, followed by time constraints for completing assignments. Despite these obstacles, aspects such as motivation, relevance, integration of knowledge, and understanding of educational objectives received high ratings, with scores ranging from 4.0 to 5.0. These results reflect overall satisfaction and recognition of the activity's value in enhancing the learning experience.

Regarding Broader Impacts, the project effectively fostered innovation and practical applications in biomaterials research. Students showcased their findings through written summaries and explanatory videos, which were publicly shared on platforms like YouTube. This initiative significantly contributed to advancing research and practical knowledge in the field of biomaterials, emphasizing their critical role in clinical applications and technological advancements.

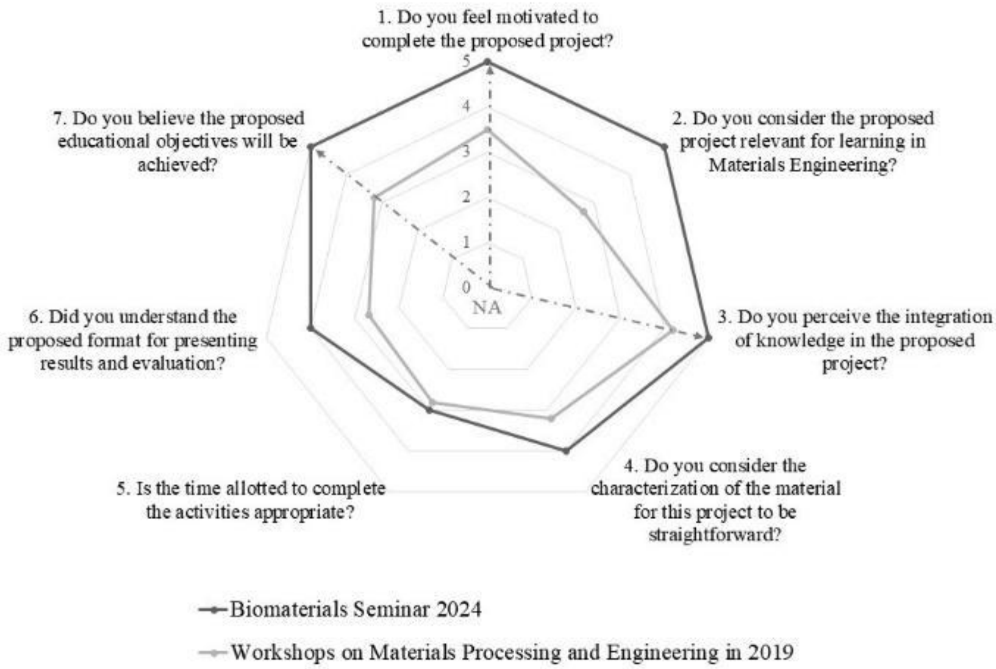

Figure 1. Radar Chart of Student Learning Assessment.
Author's data (2025).

The workshop held on June 25, 2019, at UNIFEI Itabira presented a variety of significant themes related to the steel industry and corrosion prevention (Teixeira, 2024a). In the first session, from 8:00 to 10:00, Group 1 focused on the theme "Reduction of SET UP time for valve production," exploring strategies to streamline production processes. Group 2 addressed the topic of "Quick Tool Change (QTC) for SET UP reduction in steel industries," highlighting techniques to improve tool changeover times and increase operational efficiency. Group 3 presented on "Optimization of supply logistics in a steel industry," offering solutions to improve material handling and reduce lead times. Group 4 discussed "Wear in mining: the case of grinding media," examining wear mechanisms and their impact on mining operations. Finally, Group 5 presented their work on the "Effects of replacing AISI type 1020 steel with AISI type 4130 steel in the BAJA SAE UNIFEI Campus Itabira team car," evaluating the performance and advantages of using AISI 4130 steel in automotive applications.

The afternoon session, from 13:30 to 15:20, as described by Teixeira. (2024a), shifted focus to corrosion-related topics. Group 1 discussed "Natural corrosion inhibitors," presenting alternative methods to reduce corrosion using environmentally friendly substances. Group 2 explored "Paint schemes for maritime structures," emphasizing coatings that provide long-lasting protection against corrosive marine environments. Group 3 analyzed the "Efficiency of inhibitors against chloride-induced steel corrosion," providing insights into the effectiveness of various inhibitors in preventing corrosion in steel exposed to chloride environments. Group 4 presented "Zinc coating for wind turbines," detailing how zinc coatings can enhance the durability of wind turbine components in harsh weather conditions. Each presentation provided valuable insights, and videos of the talks are available online, allowing further exploration of these innovative solutions to industry challenges (Teixeira, 2024a; Teixeira et al., 2020).

The outcomes of the work presented during the 2019 workshop were made accessible to students via the institutional system (SIGAA UNIFEI, 2024) and via Ricardo L.P. Teixeira's profile page online (Teixeira, 2024a; Teixeira, 2024d). SIGAA UNIFEI (2024) provides an

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academic activities management system for the Federal University of Itajubá. The performance of participants, organized into nine groups comprising a total of 32 students, was commendable, with scores exceeding 70% (minimum grade of 7.1) when combining evaluations of written assignments and video presentations (Teixeira et al., 2020).

The assessment of learning and student performance, as reflected in the results of the Educational Process Evaluation (APE) in Figure 1, demonstrated significant achievements across all 32 students. Since the workshop's inception, students have recognized the attainment of educational objectives and the clarity of the proposed tasks. However, regarding other indicators outlined in Table 1, students expressed partial agreement, particularly concerning motivation, the time allocated for presentations, and the overall workshop objectives. The coordinating teacher observed some degree of student demotivation, attributable to external socioeconomic factors, which may have influenced the final evaluation of the workshop.

5. CONCLUSION

The seminar activity, integral to the EMTi17 (Introduction to Materials Engineering) and EMTi26 (Biomaterials) courses at the Federal University of Itajubá, effectively bridged theoretical knowledge with practical application. By engaging undergraduate students in exploring relevant topics related to biomaterials, the seminar cultivated essential skills such as teamwork, critical thinking, and technical communication. The structured methodology, centered around the Project Model Canvas (PMC), facilitated student collaboration and project management, while the comprehensive assessment approach ensured a well-rounded evaluation of both individual and group contributions.

Throughout the seminar, students selected topics that addressed not only the technical aspects of biomaterials but also their economic and social impacts, enhancing the interdisciplinary nature of the learning experience. The inclusion of written summaries and video presentations, shared through platforms such as YouTube, broadened the seminar's reach, allowing for the dissemination of research findings to a global audience.

Additionally, the success of the workshop and the accompanying extension project in 2024 underscored the importance of applying theoretical concepts in real-world contexts. The four academic articles produced by the student groups contributed significantly to advancing knowledge in the biomaterials field, particularly in healthcare applications such as dental composites, coronary stents, 3D-printed biological materials, and hybrid drug delivery systems. Although student performance was challenged by material characterization and time constraints, the feedback collected through the Student Learning Assessment (APE) revealed high levels of motivation, engagement, and satisfaction, reinforcing the seminar's impact on both individual development and academic growth.

This seminar and the associated workshops not only fostered the development of students' professional and technical skills but also emphasized the role of biomaterials in driving innovation in healthcare and other technological fields. Through a collaborative and innovative approach, students are better prepared to contribute to the advancement of biomaterials, meeting the complex challenges of the modern world.

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